

## Deliverable 7.13

# 15 Related Articles on Passipedia or other online platforms (Task 7.5)

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#### **OUTPHIT – DEEP RETROFITS MADE FASTER, CHEAPER AND MORE RELIABLE**

outPHit pairs such approaches with the rigour of Passive House principles to make deep retrofits cost-effective, faster and more reliable. On the basis of case studies across Europe and in collaboration with a wide variety of stakeholders, outPHit is addressing barriers to the uptake of high quality deep retrofits while facilitating the development of high performance renovation systems, tools for decision making and quality assurance safeguards. [outphit.eu](https://outphit.eu)



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## 1. INTRODUCTION

This deliverable aims to disseminate the project's findings and results through established and reputable online platforms. Passipedia, the wiki-based resource of the International Passive House Association (iPHA), will be a primary channel for publishing these articles. This will ensure that the project's innovative retrofit concepts and results reach a wide and relevant audience within the Passive House and sustainable building community.

By leveraging Passipedia's extensive reach and credibility, the OutPHit project will showcase its in-depth research, case studies and successful implementations. This will not only increase the visibility of the project's achievements, but also ensure the long-term sustainability and continued relevance of its findings. In addition to Passipedia, other relevant platforms may be used to maximise the dissemination and impact of the articles.

In addition, the existing Passive House database will be expanded to include detailed data on the refurbishment systems used, certifications achieved, financial support and performance monitoring results. This will provide a comprehensive resource for stakeholders seeking to understand and replicate the successful strategies used in the OutPHit project.

This deliverable is a detailed report summarising all published articles, including screenshots, the number of people reached, and the names of the platforms involved. This report will provide a thorough overview of the dissemination efforts and their effectiveness in promoting the project's innovative and cost-effective renovation approaches.

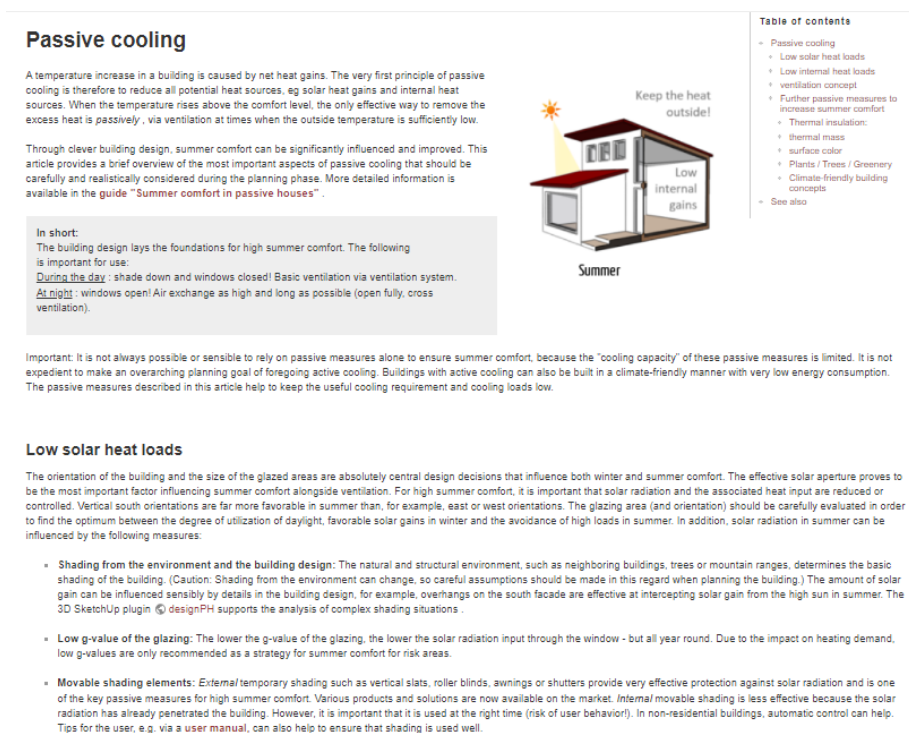
## 2. ARTICLES

### 2.1. ARTICLE 1 – PASSIVE COOLING

**Summary:** Passive cooling in buildings aims to minimize internal and solar heat gains while using ventilation when outside temperatures are cooler to naturally regulate indoor temperatures. Key strategies include careful building orientation, shading, insulation, and ventilation design. Shading through architectural features, low-g-value windows, and external movable elements like shutters can significantly reduce solar heat gain. Internal heat sources should be minimized by choosing efficient building equipment, including LED lighting and low-heat-emission appliances. Effective ventilation, especially at night, is crucial for passive cooling. This requires bypass systems in ventilation units to allow cool outside air to enter directly, or passive measures such as cross-ventilation by opening windows. Mechanical night ventilation can be used where open windows are impractical but requires careful planning to optimize energy use.

Additional measures like thermal insulation, thermal mass, and reflective or light-coloured exterior surfaces further aid in passive cooling. Insulation reduces heat transfer from hot exteriors, while thermal mass absorbs and releases heat gradually, damping indoor temperature peaks. Light-coloured surfaces reduce solar absorption, which can be further enhanced by reflective coatings, and greenery provides both shade and evaporative cooling, aiding comfort and reducing the urban heat island effect. These design elements, particularly when adapted from traditional warm-climate architectures, support a climate-friendly, low-energy approach to maintaining summer comfort in buildings.

#### Screenshot:



**Passive cooling**

A temperature increase in a building is caused by net heat gains. The very first principle of passive cooling is therefore to reduce all potential heat sources, eg solar heat gains and internal heat sources. When the temperature rises above the comfort level, the only effective way to remove the excess heat is passively, via ventilation at times when the outside temperature is sufficiently low.

Through clever building design, summer comfort can be significantly influenced and improved. This article provides a brief overview of the most important aspects of passive cooling that should be carefully and realistically considered during the planning phase. More detailed information is available in the guide "Summer comfort in passive houses".

**In short:**  
The building design lays the foundations for high summer comfort. The following is important for use:  
**During the day:** shade down and windows closed! Basic ventilation via ventilation system.  
**At night:** windows open! Air exchange as high and long as possible (open fully, cross ventilation).

**Important:** It is not always possible or sensible to rely on passive measures alone to ensure summer comfort, because the "cooling capacity" of these passive measures is limited. It is not expedient to make an overarching planning goal of foregoing active cooling. Buildings with active cooling can also be built in a climate-friendly manner with very low energy consumption. The passive measures described in this article help to keep the useful cooling requirement and cooling loads low.

**Low solar heat loads**

The orientation of the building and the size of the glazed areas are absolutely central design decisions that influence both winter and summer comfort. The effective solar aperture proves to be the most important factor influencing summer comfort alongside ventilation. For high summer comfort, it is important that solar radiation and the associated heat input are reduced or controlled. Vertical south orientations are far more favorable in summer than, for example, east or west orientations. The glazing area (and orientation) should be carefully evaluated in order to find the optimum between the degree of utilization of daylight, favorable solar gains in winter and the avoidance of high loads in summer. In addition, solar radiation in summer can be influenced by the following measures:

- **Shading from the environment and the building design:** The natural and structural environment, such as neighboring buildings, trees or mountain ranges, determines the basic shading of the building. (Caution: Shading from the environment can change, so careful assumptions should be made in this regard when planning the building.) The amount of solar gain can be influenced sensibly by details in the building design, for example, overhangs on the south facade are effective at intercepting solar gain from the high sun in summer. The 3D SketchUp plugin © designPH supports the analysis of complex shading situations.
- **Low g-value of the glazing:** The lower the g-value of the glazing, the lower the solar radiation input through the window - but all year round. Due to the impact on heating demand, low g-values are only recommended as a strategy for summer comfort for risk areas.
- **Movable shading elements:** External/temporary shading such as vertical slats, roller blinds, awnings or shutters provide very effective protection against solar radiation and is one of the key passive measures for high summer comfort. Various products and solutions are now available on the market. Internal/movable shading is less effective because the solar radiation has already penetrated the building. However, it is important that it is used at the right time (risk of user behavior!). In non-residential buildings, automatic control can help. Tips for the user, e.g. via a user manual, can also help to ensure that shading is used well.

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**Keep the heat outside!**

**Low internal gains**

**Summer**

Link to article:

[https://passipedia.de/grundlagen/sommerfall/passive\\_kuehlung](https://passipedia.de/grundlagen/sommerfall/passive_kuehlung)

## 2.2. ARTICLE 2 – RISK ANALYSIS: ROBUST PLANNING FOR HIGH SUMMER COMFORT

**Summary:** In buildings without active cooling, controlling overheating is essential to ensure summer comfort. Effective planning is critical; using calculations to assess potential overheating allows architects and engineers to design with resilience in mind. However, real-world use, like occupant behaviour with shading and ventilation, can vary from design assumptions, and future climate change increases the likelihood of warmer, more frequent heat waves.

To address these uncertainties, the PHPP software includes a "summer comfort stress test" that simulates different scenarios of user behaviour and weather patterns. By adjusting variables such as window ventilation, shading use, internal heat sources, and outdoor temperature, the stress test predicts overheating risks, guiding adjustments in window size, shading, or ventilation to improve resilience. The goal is for all test variants to remain below the 10% overheating threshold; however, active cooling might still be needed in high-risk cases, like elderly housing.

Moreover, PHPP provides a simplified climate adjustment feature to account for microclimates, such as urban heat islands, and projected climate change effects. Clear documentation and guidance for occupants on optimal summer comfort practices, such as shading use and night ventilation, can also help maintain comfort and support the building's passive cooling strategy.

Screenshot:

### Risk analysis: Robust planning for high summer comfort

In buildings without active cooling, the frequency of overheating provides information about the summer comfort achieved. In order to successfully limit this, the planning of a building is particularly important. With the help of calculations, it can be ensured that the temperatures in the building are in a comfortable and healthy range even in summer.

However, the constraints used to calculate summer comfort during the design phase for a typical use may be different for actual building use. For example, the behavior of occupants or users will strongly influence temperatures in the building, in particular the use of shading (during the day), ventilation (at night when it is cooler outside than inside the building) and the level of internal heat sources e.g. from household appliances or home entertainment. Summer weather will also vary slightly from year to year, with temperatures occurring both above and (less significantly) below the average typical climatic conditions used as the primary constraint for building design. In addition, climate change will mean that temperatures will generally be higher and overall warmer summers and more frequent and longer heat waves are to be expected in the future.

A risk analysis using stress testing is therefore absolutely essential for a robust strategy for summer comfort. Such a stress test in the design phase provides important feedback and a better understanding of the risk factors for overheating and thus leads to more robust and resilient designs. Such a stress test is integrated into the PHPP planning tool from version 10 onwards: It shows the calculated overtemperature frequency for various possible (usage) scenarios during the planning process.

### Summer comfort stress test in PHPP

The overheating frequency is calculated in the PHPP based on the information entered. The result is therefore the expected average temperatures throughout the building under the respective boundary conditions and assumptions entered in the PHPP. To better understand the risk of potential overheating frequency under a range of likely less favourable boundary conditions, the PHPP includes a pre-set summer comfort 'stress test'. By calculating summer comfort in parallel for 9 additional variants, each with different assumptions on summer weather and user interaction, the stress test provides valuable feedback on the potential risk of overheating, beyond the main result of the PHPP. It also helps to better understand the causes of potential overheating, thus leading to more robust and resilient design decisions regarding summer comfort (see Figure 1).

If the stress test results show a high frequency of overheating, countermeasures should be taken, e.g. smaller glazing areas, adjusted window orientation, more shading and/or improved night ventilation concept. Ideally, the building should be planned so that all variants of the stress test have an overheating frequency below the passive house certification limit of 10% (recommendation <5%). However, this will not always be possible and will not always be necessary. The assessment of the overheating risk must be analyzed in the context of the respective project. For vulnerable residents (e.g. in a retirement home) or for unknown and very mixed users (e.g. tenants in an apartment building), it is much more important to be able to reliably guarantee summer comfort than, for example, for a private single-family home with garden access. If summer comfort is on shaky ground, then active cooling should be planned.

The relevant influencing parameters are considered both individually and in combination in the preset PHPP stress test, as summarized in Table 1.

	Combined stress test	window ventilation	Temporary shading	Internal heat sources	Weather / Climate
<b>Influence of use</b>					
Basic summer ventilation through windows	= Winter air exchange	= Winter air exchange	-	-	-
Additional window ventilation at night <sup>1)</sup>	≤ 0.1 h <sup>-1</sup>	0 h <sup>-1</sup> (none)	-	-	-
Reduction factor for the use of temporary shading	automatic: 80% manual: 70%	-	0% (none)	-	-
Internal heat sources	125%	*	*	200%	-
<b>climate influence</b>					
temperature rise in summer	+ 1.5 K	*	*	*	+ 2.0 K

<sup>1)</sup> Air change rate at 1K difference between indoor and outdoor temperature, according to PHPP conventions



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Link to article:

[https://passipedia.de/grundlagen/sommerfall/risikoanalyse\\_sommerkomfort](https://passipedia.de/grundlagen/sommerfall/risikoanalyse_sommerkomfort)

## 2.3. ARTICLE 3 – THERMAL IMAGING IS ESSENTIAL FOR CONSUMERS, BUSINESSES, AND MUNICIPALITIES

**Summary:** To meet international climate goals, Europe’s building stock must achieve climate neutrality by 2050. However, the current pace of retrofitting falls far short of what’s needed to meet this target. Accelerating the retrofitting process and increasing renovation rates across Europe is now a critical priority. Within the outPHit project, we are focusing on finding retrofitting solutions that are not only faster and easier but also more cost-effective. In recent years, significant progress has been made in developing innovative retrofitting approaches, particularly through the use of prefabrication and streamlined processes that enhance efficiency. Additionally, digitalization in the building sector has emerged as a key factor in reducing costs and speeding up renovations. SaaS applications and digital tools, such as InfraredPlatform.com, play an essential role in raising awareness among building owners, encouraging them to upgrade their properties and embrace the outPHit standard. Through these advances, we are one step closer to achieving our climate goals. Thermal imaging, or heat scans, is an essential tool in the energy transition, raising awareness about energy efficiency for consumers, businesses, and municipalities. In the outPHit project, large-scale thermal imaging of approximately 5,000 residential homes was conducted across several Dutch municipalities to encourage sustainability efforts. This innovative approach, supported by digital tools like InfraredPlatform.com, effectively visualizes energy loss, prompting action for better insulation and energy-saving measures. The process has proven successful, increasing public engagement, motivating energy efficiency improvements, and aligning with broader sustainability goals.

### Screenshot:

### Thermal Imaging is essential for Consumers, Businesses, and Municipalities

#### Introduction

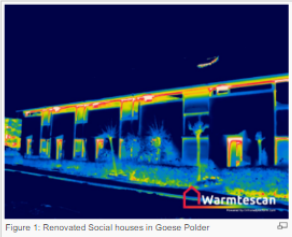


Figure 1: Renovated Social houses in Goese Polder

Thermal imaging, or heat scans, is a powerful tool in the energy transition. It offers numerous benefits for consumers, businesses, and municipalities. These scans are crucial in creating awareness, a vital step in the energy efficiency process, and ensuring quality assurance after implementing energy efficiency measures.

In the European outPHit (€ <https://outphit.eu>) project, thermal imaging was brought to the attention of several municipalities within the Netherlands, with different thermal imaging scan operations (in Dutch: Warmtescan) of residential houses. The main goal was to create awareness, hoping that residents would act to make their homes more comfortable and sustainable. These ‘heat scan’ activities were applied on a larger scale for approximately 5,000 residential homes. Helpful tools and digitalisation are essential for thermal imaging on a large scale, which was achieved with the SaaS application on [infraredplatform.com](https://infraredplatform.com), which [warmtescan.nl](https://warmtescan.nl) used in the Netherlands.

From the outPHit pilot renovation project in the Netherlands, there are some thermal images of the renovation of the Goese Polder project in Goes, demonstrating what a successful deep renovation looks like in thermal imaging.

Below, we explore why conducting thermal imaging is valuable, focusing on short-term and long-term impacts.

#### Creating Awareness and Insight

Thermal imaging is a process that helps consumers and businesses gain a clear understanding of the current insulation status of their property. This awareness is crucial because many people mistakenly believe their homes or buildings are already well-insulated. Thermal imaging:

- Visualizes Energy Loss: Heat scans vividly highlight problematic areas, such as poorly insulated walls or windows, or thermal bridges, making energy loss visible.
- Increases Awareness: Research has shown that thermal imaging significantly increases homeowners’ awareness of the need for energy efficiency improvements.
- Triggers Action: Seeing concrete areas of heat loss motivates residents and businesses to take corrective measures.

A study by the University of Groningen found that homeowners who received a thermal imaging report were up to 500% more aware of their home’s insulation needs than those who did not.

#### Motivating Energy Efficiency Improvements

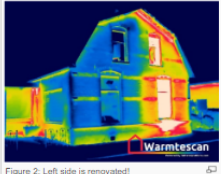


Figure 2: Left side is renovated!

Beyond creating awareness, thermal imaging actively motivates consumers, businesses, and municipalities to take tangible steps towards energy efficiency. This motivation occurs on both short-term and long-term scales. Short-term:

- Identifying Quick Wins: Thermal imaging makes it easy to spot immediately actionable improvements, such as replacing single-pane windows with HR++ glass.
- Providing Concrete Action Steps: Thermal imaging reports offer clear recommendations that are easy to understand and implement.

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Link to article:

[https://passipedia.org/planning/tools/thermal\\_image](https://passipedia.org/planning/tools/thermal_image)

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## 2.4. ARTICLE 4 – PV ECONOMY EVALUATION

**Summary:** The "PV Economy Evaluation" tool developed by Fabian Ochs, Georgios Dermentzis, Berthold Kaufmann, and Jan Steiger focuses on evaluating the economic viability of photovoltaic (PV) systems in residential buildings by assessing self-consumption, storage potential, and the financial returns from selling excess energy to the grid.

Key Aspects of the PV Economy Evaluation:

1. Energy Demand and PV Production Analysis: PV production fluctuates seasonally, with limited generation during winter when heating demand peaks. This "winter gap" requires additional grid energy, though annual PV production can offset energy costs in efficient buildings like Passive Houses. Using the Passive House Planning Package (PHPP), the tool calculates both the building's energy demand and PV yield with monthly accuracy.
2. Detailed Monthly Energy Demand with PVEcon: PVEcon, an add-on to PHPP, splits the building's annual energy demand for heating, hot water, and household appliances into monthly demands. It simulates monthly PV yield based on system orientation and specifications, providing insight into the extent to which PV production meets monthly energy needs.
3. PV Self-Consumption and Storage Potential: PVEcon calculates how much PV-generated electricity is used on-site versus sold to the grid. By simulating different storage sizes, it determines optimal battery capacities to maximize self-consumption and minimize grid dependence. Recommended storage sizes vary by building energy consumption and PV system capacity.
4. Economic Analysis of PV Implementation: PVEcon includes fields for economic input (PV system and storage costs, funding, electricity prices) and supports 10 financial variants. It calculates economic feasibility, helping users understand the cost-benefit of PV installation and storage under different scenarios. Energy cost reductions from self-consumption enhance the economic attractiveness of PV systems, especially in regions with high energy prices.
5. Limitations: Currently, PVEcon focuses on residential buildings and does not support energy storage in electric vehicles or energy use for cooling. These limitations restrict its application to residential buildings without cooling systems.

In summary, the PV Economy Evaluation tool provides valuable insights into the economic potential of PV systems by assessing self-consumption and storage feasibility. Through seasonal analysis and economic evaluation, it enables users to make informed decisions on the optimal PV setup for residential buildings, encouraging investments in PV as a sustainable and cost-effective energy source.

**Screenshot:**

## PV Economy Evaluation

Autor: Fabian Ochs, Georgios Dementzis, Berthold Kaufmann, Jan Steiger

### Introduction

The implementation of renewable energy sources plays a crucial role in increasing the energy efficiency of buildings. However, the evaluation of the possibility to directly use or store the gains within the building or sell the gains to a public grid is tricky, as these concepts depend on the energy demand of the building and the climate of the location considerably. Besides mere financial considerations, the ability to use or store PV energy within the building is also relevant for the future energy supply, when the energy storage within buildings will and the prices and funding for selling PV electricity or own use vary greatly from country to country. This tool to assess PV self-consumption potential of a building, the possibility to improve the self-consumption ratio by temporary storing PV electricity within a building, and supports to evaluate the economic potential of selling PV to the grid. It allows the user to receive information to which extend RES implementation makes sense to supply the building with energy, and) if the revenues of the PV electricity either saved or sold to the grid can compensate or exceed the investment costs.

### Energy Balance of Energy Demand and PV Energy Production

For the assessment how much PV energy can be used within a building, a simple energy balance of annual energy demand and annual energy production will not lead to reasonable results regarding the potential to cover the buildings energy demand with renewables generated by the building nor inform how much energy can still be sold to the grid. This is due to the winter gap that is created by the high heating demand and low PV production in the winter. During the heating season, even very efficient buildings / renovations may have to use energy from the grid to cover the demand, especially of the heating, even if, on an annual balance, the buildings may be able to compensate the electricity demand with the energy generated by the implemented PV system.

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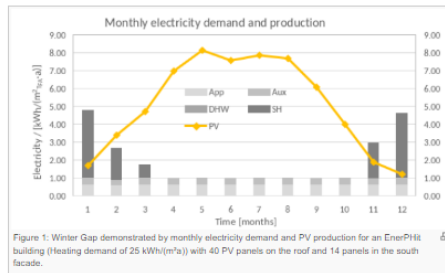


Figure 1. Winter Gap demonstrated by monthly electricity demand and PV production for an EnerPHit building (heating demand of 25 kWh/(m²a)) with 40 PV panels on the roof and 14 panels in the south facade.

The Passive House Planning Package (PHPP) allows to very reliably calculate the energy demand of building projects, especially very efficient projects like Passive Houses, EnerPHit renovations or NZEBs. In the Passive House Planning Package, both, PV electricity generation and the energy demand for heating, domestic hot water (DHW), auxiliary electricity and household electricity, can be very reliably calculated, as could be demonstrated in various new-built Passive Houses or deep renovation projects, described for example on Passipedia: © PHPP – Passive House Planning Package.

Link to article:

[https://passipedia.org/eu\\_projects\\_publications/pv\\_economy\\_evaluation](https://passipedia.org/eu_projects_publications/pv_economy_evaluation)

## 2.5. ARTICLE 5 - MEET - MANUFACTURING ENERGY EVALUATION TOOL

**Summary:** The article provides a detailed analysis of energy demand and CO2 emissions related to building materials and retrofitting, particularly within the framework of the outPHit project. It emphasizes the importance of life cycle assessments (LCAs) for buildings, which evaluate both the energy used during material manufacturing and the energy consumed during the building's operation. Adhering to standards such as ISO 14025 and EN 15978, the article considers all phases of a building's life cycle, from production through to disposal. In addition, the article explores the energy efficiency of various insulation materials, including EPS, cellulose, and straw, weighing their embodied energy against operational energy savings. It highlights that while some materials may require more energy upfront, their long-term benefits can be significant.

Screenshot:

# outPHit Manufacturing Energy Evaluation Tool (MEET)

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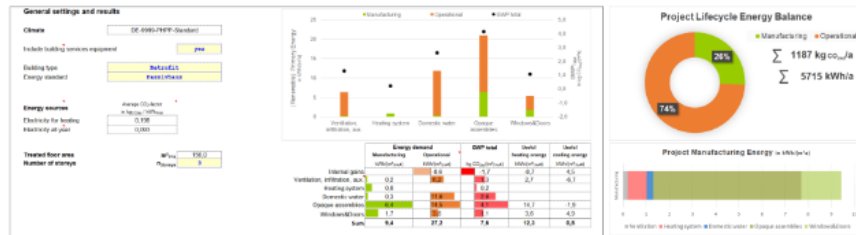


Fig. 1: Results of MEET in the worksheet BALANCE

Free Download\* the Manufacturing Energy Evaluation Tool 2 (MEET 2 beta) | Free Download\* the outPHit Manufacturing Energy Evaluation Tool (MEET)

\*Note: The download link will take you to the Passive House Portal, where you need to login in order to access the tools. Login details to the database may differ from your membership login details to Passipedia. Please sign up to the Passive House Portal in case you don't yet have an account. Registration to the Passive House Portal is free and can be canceled at any time. In case of questions contact info@passivehouse-international.org

The manufacturing energy influences the overall energy balance of a building. The Manufacturing Energy Evaluation Tool (MEET) was developed to evaluate the potential energy expenditures and greenhouse gas emissions (in CO<sub>2</sub> equivalents) that arise during the production of building materials and components, and to compare these with the operational energy of a building. This allows for a comprehensive analysis of both energy forms – manufacturing and operational – within a single tool.

MEET thereby is an essential tool for a holistic lifecycle assessment of a building's energy efficiency. It supports planners and architects in making well-informed decisions that consider both manufacturing and operational energy. It also demonstrates that a marginally higher manufacturing energy for products with superior thermal insulation qualities can be advantageous, as these products frequently result in substantial energy savings during operation. In practice, it is often shown that operational energy has a more decisive impact on the overall energy balance of a building.

For more information on the calculation methods, please refer to this [Passipedia page](#) and the attached report (or click on the image to the right).

## MEET: Manufacturing Energy Evaluation Tool

The tool is, along with the report, is available for download above. It is a standalone tool that provides a comprehensive evaluation of the manufacturing energy and the greenhouse gas potential of building materials. Simultaneously, it also approximates the operational energy of the building. It assists in the assessment and comparison of:

- Individual materials
- Window components and opaque assemblies
- Entire buildings under specific climatic conditions

## MEET 2: Next Generation of the Tool (beta)

With the introduction of the second version, the tool now offers enhanced functionality and a direct connection to the Passive House Planning Package (PHPP). Specifically, this means:

- User-Friendly Material Selection: The material input has been improved through an extensive building material list and a filtering mechanism. Additionally, the input for windows



Link to article:

[https://passipedia.org/planning/tools/manufacturing\\_energy\\_evaluation\\_tool](https://passipedia.org/planning/tools/manufacturing_energy_evaluation_tool)

## 2.6. ARTICLE 6 - DESICION MAKING SUPPORT TOOL

**Summary:** The DeSuTO (Decision Support Tool) is designed to enhance the energy efficiency of building renovations, particularly through the use of prefabricated façade elements. With a focus on sustainable renovation practices and industrial prefabrication, the tool aims to streamline the renovation process by providing efficient solutions for facade systems. Prefabricated facades can reduce installation time and costs, though their high initial investment can be offset by significant energy savings over time. The tool is intended to support architects, planners, and building owners in making informed decisions by offering a conceptual renovation approach based on assessments of existing buildings. The development of DeSuTO involves creating a software tool that integrates a database of façade systems with a structured question catalogue. This catalogue helps users build accurate models of their refurbishment projects. The tool uses a tree structure of questions to gather necessary information, supplemented by statistical data from the TABULA database, which includes detailed information on building types, construction specifics, and energy efficiency. The tool's design allows for future updates and expansion, with data stored in a machine-

processable format to facilitate ongoing improvements and statistical analysis. Programming for DeSuTo was carried out using Python, leveraging its extensive libraries and frameworks such as Flask and Pandas. This ensures flexibility and efficiency in handling data and user inputs. However, the current version of DeSuTo is limited to single-user operation and does not yet address multi-user scenarios or incorporate social and sustainability criteria. Future developments should focus on these areas to provide a more comprehensive and inclusive decision support system for building renovations.

## Screenshot:

### Decision Support Tool

Author: Sascha Hammes

Decision support tools play a key role in helping players such as architects, specialist planners, One-Stop-Shops (OSS) and building owners in the refurbishment process to identify and propose the most suitable concepts from the current variety of systems, depending on the given requirements, e.g. building typology, climate and degree of utilization.

#### Problem Definition

The utilization phase has the greatest energy demand over the life cycle of a building, resulting in particular from heating, cooling, ventilation and electrical consumers. Heat losses via the building envelope are among the most important consumers [Oliant 2021]. Improving the thermal building envelope in particular therefore proves to be an essential measure for reducing energy demand in the building sector. The greatest potential for improvement at EU level lies in single-family houses, followed by multi-family houses [Nemry 2010]. In the context of the building envelope, Nemry et al. identify additional roof insulation, additional façade insulation and better sealing to reduce ventilation as key measures for increasing energy efficiency.

Against the backdrop of current energy policy objectives, increased awareness of sustainability, high investment costs for new construction and the high number of existing buildings, refurbishment has become much more important in recent years. Refurbishment is usually the preferred solution compared to demolition [Ferreira 2013]. It has also been shown that refurbishment achieves comparable energy consumption levels to new builds, e.g., by implementing the EnerPHit standard.

However, the implementation of a building envelope refurbishment can be complex, as buildings usually have a high degree of variability resulting from individual building geometry, degree of utilization, application, climatic requirements and regional building regulations. As a result, the variety of potential refurbishment solutions that are more or less suitable for the object under consideration also varies [Kaman 2021]. As planners cannot map and compare all solutions, it cannot be ruled out that a suboptimal system selection will be made for the refurbishment measure due to this system diversity. This can have a negative impact on energy performance, user comfort and costs.

It has been shown that key decision-making processes regarding basic system selection usually take place in the early refurbishment phase, when not all relevant information is available. This is where the need for suitable tools to support decision-making arises [Ferreira 2013]. Some software-supported decision-making aids already exist in this respect, but these are mostly geared towards detailed planning rather than early design (cf. [Flourentzou 2002, Kaman 2021, Lanzarote 2021, Witchen 2000]). In order to provide planners and users with the best possible support in the early design phase and thus ensure the best possible achievement of defined objectives (e.g., energy efficiency), appropriate support solutions are required to handle this variability of potential system solutions. The first step in the renovation process is therefore to define the objectives and criteria, as all subsequent phases are aligned with these strategic and important aspects [Nielsen 2016].

#### Requirements

Sustainable refurbishment not only promises to reduce energy requirements, pollutant emissions and waste, but can also help to improve the quality of the property for users, particularly in the areas of air quality and comfort [Genre 2000]. The location proves to be decisive for the choice of refurbishment concept. This is because, depending on the location, there are different climatic conditions, which are reflected in particular in the design of the insulation thickness and thus the costs. Recording information on the building typology, degree of utilization and orientation also provides initial impressions for describing and classifying the existing building situation, as do the age and status of the building technology.

As the objectives of building owners can vary greatly, these must be taken into account when selecting the system solution. These include requirements for energy efficiency (e.g., EnerPHit standard), high comfort and low investment costs. In the context of the objective, the target criterion of energy efficiency also proves to be important, as numerous system solutions also allow the integration of renewable energies, e.g., photovoltaics and/or solar thermal energy in the building façade (e.g. [Torres 2021]). In the context of sustainability, the use of wood as a building material in particular is proving to be a future-oriented, environmentally friendly resource (see [Sandberg 2016]). In addition, the duration of the refurbishment measure is also relevant for the system selection. For reasons of cost and user comfort, it is preferable to let residents live in the existing building. In order to reduce disruptive interventions during refurbishment to a minimum, concepts of serial refurbishment with prefabricated elements have proven themselves in practice. The situation is similar when it comes to accessibility. The dimensions of the façade elements are usually linked to access options for transport vehicles and the possibility of erecting cranes.

#### Solution approach

The tool development DeSuTo (Decision Support Tool) from outPHit is currently limited to the renovation of the building envelope of residential buildings. In addition, the number of integrated solutions is currently still very limited and restricted to concepts from the literature. Modular expandability ensures the cyclical addition of solutions in the future. To ensure this expandability, a software solution with a standardized data structure was used. This is the only way to ensure long-term usability in the software. The effectiveness of a measure is measured in particular by the resulting energy demand. To do this, it is necessary to record relevant building information and carry out an energy assessment. The © PHPP passive house project planning package is used for the assessment. Users work through a list of questions in order to obtain the necessary information for the PHPP and thus generate a sufficiently accurate model of the existing building and at the same time guarantee a high level of usability.

As hardly any detailed information is available during the early building design phase, DeSuTo relies on supplementing missing information with statistically validated data. If a necessary information field can be used by the user, missing information is compensated for by comparing it with statistically validated data from TABULA (Typology Approach for Building Stock Energy Assessment [Loga 2016]) and distroPH. TABULA comprises a database of around 500 buildings from various countries. Questions in the decision tool are used to classify and assign the object under consideration to the TABULA building classes using categories such as building size, age class and location. Missing information on construction, u-values and heating systems is also obtained. In order to reduce the number of potential variants and thus reduce the calculation time, the question structure already excludes individual concepts. For example, individual systems are defined by the required firing points, installation conditions and module size. Questions are therefore used to identify potential firing points and the capacity of existing supporting structures. In addition to site accessibility, these also provide information about possible module sizes for prefabricated façade elements. To achieve a high level of user-friendliness, the support tool was implemented as a web application © Decision Support Tool.

The tool provides users with an initial assessment for a potential refurbishment concept. The output includes a brief description of the concept, a link to the relevant literature source and a compact overview of the most important energy performance indicators, which come from the PHPP working in the background.

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- Decision Support Tool
- Problem Definition
- Requirements
- Solution approach
- LIMITATIONS
- Conclusion
- Availability
- References
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## Link to article:

[https://passipedia.de/planung/tools/outphit\\_decision\\_support\\_tool](https://passipedia.de/planung/tools/outphit_decision_support_tool)

## Link to tool:

<https://desuto.outphit.eu/>

## 2.7. ARTICLE 7 – GROUND TUBES

**Summary:** The article outlines the use of ground tubes and district heating as key components for sustainable energy in the context of the outPHit project. The approach focuses on harnessing renewable energy sources, such as excess summer electricity from photovoltaic (PV) and wind, converting it for storage as liquid or gas for winter use. It highlights the effectiveness of using district heating networks to distribute heat from renewable energy systems, including combined heat and power (CHP) plants, to surrounding buildings.

Key elements covered include:

1. Heat Distribution and Losses: The document emphasizes the importance of minimizing heat loss in distribution networks, especially when supplying heat to Passive House and EnerPHit standard buildings, which have low energy needs. Insulation quality, pipe length, and optimized design are critical for efficient energy distribution, with a recommendation for

specific network lengths below 6 meters per unit. An Excel tool assists users in calculating network losses, which can be integrated into the Passive House Planning Package (PHPP) to assess primary energy input.

2. Cold District Heating: Low-temperature district heating, termed “cold local district heating,” significantly reduces distribution losses by maintaining pipe temperatures around 15°C. Heat pumps within each residential unit then raise temperatures for heating and domestic hot water, leveraging efficient heat sources such as ground probes or waste heat. This system benefits from high efficiency and reduced heat loss while supporting future renewable energy integration.

3. Efficiency and Economic Considerations: The report compares multiple distribution scenarios, showing that reduced feed temperatures, increased housing density, and enhanced pipe insulation can improve network efficiency up to 80%. Additionally, while central systems face higher heat losses, decentralized systems with individual heat pumps reduce these losses. However, this shift also impacts investment costs, requiring economic analysis to balance efficiency with capital expenditure.

The document thus provides a foundation for using district heating networks in sustainable building renovation, contributing to energy efficiency while addressing investment and operational challenges.

### Screenshot:

**Ground Tubes**  
Author: Berthold Kaufmann

**Heat distribution via underground pipes – district heating in the neighborhood?**

The power plants that will be operated with renewable energy sources in the future, as well as heating systems in residential areas that may work with combined heat and power (CHP), will be supplied with surplus energy from the summer half-year into the winter half-year. These summer surpluses of electrical energy must therefore be stored temporarily, for example by converting PV and wind power into liquid or gaseous energy sources using electrolysis etc. (power-to-gas). These can then be used in the winter months in the same way as the fossil fuels natural gas and crude oil. The waste heat generated during combustion in CHP plants or fuel cells can generally already be used very well today to heat buildings and provide domestic hot water. The energy content can therefore be used almost completely, electrical energy from the generator for light, power and communication and the waste heat for heating. This will become all the more important in the future because the available budget for renewable energy sources is likely to be more limited and primary energy will therefore be significantly more expensive than it is today, especially in winter.

The at least partial supply of individual neighborhoods via district or local heating networks is therefore an important component of the so-called heat production transformation and is therefore an important option for heating and domestic hot water preparation.

Local heating networks are also interesting for the use of heat pumps (HPs) because the heat from larger central HP systems can be distributed to surrounding buildings via a local heating network. In this context, however, a warning should be issued about the heat distribution losses that then occur in the local heating networks: the prerequisite for the use and distribution of heat via heat-conducting pipes laid in the ground is that the heat distribution networks are optimized the best possible. This means that all heat distribution losses must be consistently balanced and minimized as far as possible.

The heat losses occurring by the distribution of waste heat from combined heat and power plants (CHP) in so-called local and district heating networks are considerable compared to the final energy made available to the user at the house connections. It is therefore instructive to look at the amount of energy lost per year compared to the amount of final energy supplied for different building types.

For passive houses and buildings renovated to the EnerPHit standard in particular, the ‘energy density’ achievable in the grid is relatively low because the final energy requirement for space heating and domestic hot water is only around 50 kWh/m<sup>2</sup>a and possibly even less, i.e. only around 6 000 kWh/a of final energy is delivered per residential unit (120 m<sup>2</sup>). For typical old buildings with a consumption of around 240 kWh/m<sup>2</sup>a or 28 000 kWh/a, the turnover is significantly higher (JAKXP 48 FV). These figures already include the heat distribution losses within the building.

In (JAKXP 48 FV), various scenarios for the configuration of district heating and local heating distribution networks were drawn up and compared. Several different qualities of thermal insulation of the heat distribution pipes were compared with each other and the length of the distribution pipes in a network was varied. The results show that with a moderate improvement in the quality of the pipe insulation and an optimization (shortening) of the network length, acceptable heat distribution losses can already be achieved with today’s pipe technology. So passive houses and districts renovated to the EnerPHit standard can be supplied with heat economically. The specific network length in meters/residential unit (m/Unit) is an important factor here. The first goal of network optimization must therefore be to keep the specific network length low and thus the network connection density high, values below 6 m/Unit should be aimed for (JAKXP 48 FV).

A corresponding spreadsheet is provided as an Excel tool for this purpose, which makes the heat distribution losses and their effect on the regenerative supply visible. In the tool all the geometry of the grid i.e. length of underground tubes and quality of thermal insulation can be defined. The characteristic values determined in this way can also be used in the PHPP to ultimately estimate the primary energy input for the heat supply.

**Table of Contents**

- Ground Tubes
- Heat distribution via underground pipes – district heating in the neighborhood?
- Cold local district heating in underground pipes
- Literature
- See also

Figure 1: Example of a local heating network for a district with 8 buildings, 125 units, and 6 400 m<sup>2</sup> floor space. With two extra floors extension 208 WE, 14 000 m<sup>2</sup> Tube length route 650 m Branch lines 270 m/265 m (with extension 607 m) Flow 55- 65 °C For variants see Figure 2

Link to article:

[https://passipedia.org/planning/building\\_services/heating\\_and\\_dhw/groundtubes](https://passipedia.org/planning/building_services/heating_and_dhw/groundtubes)

## 2.8. ARTICLE 8 – AIRTIGHTNESS DURING RENOVATION

**Summary:** The article by Søren Peper emphasizes the significance of airtight building envelopes in energy-efficient renovations, especially under the Passive House (EnerPHit) standards. Airtightness is essential to prevent energy loss, structural damage, and indoor air

quality issues while ensuring comfort by avoiding drafts and cold spots. For Passive Houses, airtightness should not exceed an n50 value of 0.6 h<sup>-1</sup>, and for renovations with passive components, the n50 value must be below 1.0 h<sup>-1</sup>. Peper highlights that the energy demands of buildings increase significantly if airtightness is compromised. A comparative analysis shows that a passive house with lower airtightness (n50=3.0 h<sup>-1</sup>) would see its energy demand double. Data from the Passive House Institute (PHI) project database show that EnerPHit standards for airtightness (n50 ≤ 1.0 h<sup>-1</sup>) are generally achievable in practice. For renovations, various airtightness strategies are suggested depending on the scope and specifics of the project:

1. Interior Reinforcement: Strengthening interior plaster layers, with attention to electrical, window, and stairwell sealing, suitable for larger renovations.
2. Exterior Strengthening: Reinforcing external plaster prior to adding external insulation, ideal for occupied buildings.
3. Integrated Airtight Layers in Pre-wall Modules: A modular approach in cases where scaffolding is impractical, with pre-installed airtight layers to reduce on-site work.

Finally, the document provides a decision matrix to guide airtightness methods based on renovation needs and building conditions, helping to ensure energy efficiency and structural integrity in retrofitted buildings.

### Screenshot:

#### Airtightness during renovation

Author: Soren Peper

An airtight building envelope is one of the basic pillars of energy-efficient buildings. It is necessary to make every building sufficiently airtight, especially for the following reasons.

Technical / energetic reasons	Comfort-related reasons
prevention of structural damage	Avoiding cold air pockets & drafts
avoiding energy losses	Lower temperature fluctuations
Prerequisite Function Ventilation System	prevention of odor transmission
	Prevention of radon entry from the soil

For passive houses, n<sub>50</sub> values ≤ 0.6 h<sup>-1</sup> are required; when renovating with passive house components (EnerPHit), the n<sub>50</sub> value of 1.0 h<sup>-1</sup> must not be exceeded. The installation of a serially designed thermally insulating building envelope usually includes the creation of an airtight layer and must therefore be assessed according to the new building requirements.

#### influence of airtightness

The great influence of airtightness is shown by the energy requirements of an example passive house in the figure: If the building is not built with the usual airtightness of n<sub>50</sub> = 0.4 h<sup>-1</sup> for passive houses, but with only n<sub>50</sub> = 3.0 h<sup>-1</sup>, the energy requirements of the building double. All other components of the building remain unchanged. The heating requirements increase from the still good airtightness of a renovation of n<sub>50</sub> = 1.0 h<sup>-1</sup> (EnerPHit) by almost 12 kWh/(m<sup>2</sup>a) if the building with n<sub>50</sub> = 3.0 h<sup>-1</sup> is inadequately planned and built.

#### Table of contents

- Airtightness during renovation
- Influence of airtightness
- Basic rules for good airtightness
- Airtightness concepts for renovation
- decision matrix:
- literature
- See also

n <sub>50</sub> (h <sup>-1</sup> )	Heizwärmebedarf (kWh/m <sup>2</sup> a)
n <sub>50</sub> = 3.0 (Mindestanforderung DE)	27.6
n <sub>50</sub> = 1.5 (Haus mit Lüftungsgasse Mindestanf. DE)	18.8
n <sub>50</sub> = 1.0 (EnerPHit Anforderung)	16
n <sub>50</sub> = 0.4 (Typischer Passivhaus Neubau)	12.7

Figure 1: Heating demand of identical buildings with varying air tightness [Peper 2024].

Link to article:

[https://passipedia.de/planung/luftdichtheit/luftdichtheit bei der sanierung](https://passipedia.de/planung/luftdichtheit/luftdichtheit%20bei%20der%20sanierung)

## 2.9. ARTICLE 9 – QUALITY ASSURANCE DURING (SERIAL) RENOVATION

**Summary:** The article on quality assurance (QA) for serial renovations outlines key lessons and recommendations for ensuring optimal performance and durability in retrofit projects, particularly in alignment with Passive House principles.

1. QA During the Planning Phase: This involves careful design and planning of the thermal and airtight building envelope to minimize gaps and thermal bridges. Specific attention is given to areas such as cellar insulation, roof seals, and transitions in façade elements. Optimization of façade components includes positioning windows effectively, minimizing structural weight, and ensuring airtight connections to reduce sound and odour transmission. Planning ventilation ducts to accommodate various apartment layouts is also essential to enhance installation efficiency and tenant satisfaction.

2. Execution Lessons and Real-world Examples: Practical experiences show common issues such as poorly insulated anchor points, inadequate window installations, and the importance of testing thermal bridge impacts. The use of flexible insulation materials has been found effective in accommodating wall irregularities in prefab installations.

3. Factory and On-site QA: Prefabricated elements should undergo factory checks for airtightness and insulation completeness. On-site QA focuses on ensuring proper sealing of joints, thorough filling of cavities, and immediate repairs to maintain airtightness. It's critical to protect elements from environmental factors during installation.

4. Project-specific QA Insights: The document emphasizes piloting QA processes with one building before large-scale implementation and highlights the need for multiple measurement checks of façades. Practical challenges include addressing unexpected misalignments from automated scans to prevent costly installation errors.

Effective QA measures in serial renovations not only reduce heat loss and improve building performance but also increase project efficiency and reliability, setting a solid foundation for sustainable, energy-efficient building retrofits.

**Screenshot:**

## Quality assurance measures during (serial) renovation

Author: Tanja Schulz

### QA during planning phase

#### Position of the thermally insulated and airtight envelope

The thermally insulated and airtight building envelope must be designed with as few gaps as possible. With regard to the position of the insulation layer, there are several options in old buildings, which must be evaluated differently with regard to thermal bridge effects.

- Course of the insulation layer in the area of the cold cellar
- Course of the insulation layer in the area of the upper building closure: top storey ceiling or roof
- Dealing with the heated staircase in the area of the cold cellar and the unheated roof space

For the position of the airtightness layer, see the separate airtightness checklist.

#### Thermal bridge analysis has to be done

- at the perimeter in combination with the basement ceiling
- at verge and eaves
- at the transition of the façade element – to the top storey ceiling. Only provide fire protection plates in the rear ventilation space of the outer skin. They must not pass through the insulation level.

#### Optimization of the façade elements

- Position of the supporting elements (timber frame) in the area of joints and transitions
- Optimization of the window installation (with and without external venetian blind box)
- Position and construction of the anchors
- Minimization of the weight of the refurbishment modules (timber content, clinker brick slips instead of clinker brick facing shell) to minimize anchorages
- The elements must be constructed in such a way that no gap remains between the existing wall and the element. This prevents convection in the gap and sound transmission.
- The windows should be connected to the façade element. This prevents sound and odour transmission. This applies regardless of where the airtight layer runs.
- Façade elements that already have the outer skin integrated as far as possible are advantageous. Scaffolding downtime for completing the façade can thus be shortened or the scaffolding can be dispensed with altogether.

#### Optimization of heat distribution

- Advice on insulating the heat distribution pipes in the ground
- Advice on the insulation and position of the heat distribution pipes within the façade elements (backpackers)
- Insulation and airtightness of external riser shafts (backpacker)

#### Planning / optimization of the ventilation distribution air ducts in the apartments

Smaller ventilation units with heat recovery can be easily integrated into the façade elements (backpackers). This allows them to be arranged outside the apartment to save space. From there, only ventilation ducts need to be routed into the apartments. Nevertheless, detailed planning must be carried out in advance for this air distribution ducts:

- The air distribution ducts must be planned in detail and, if necessary, in several variants for different apartment layouts so that the installation in the individual apartments can be carried out quickly and with as little inconvenience to the tenants as possible
- It must be expected that tenants will have individual built-in furniture in their apartments, which must be taken into account when routing the air ducts. Tenants may be able to refuse the installation of ventilation. This can then only be done when the next tenant moves in. However, this is not detrimental to the concept because the ventilation units will simply not be in operation until then.
- The connections of exhaust air ducts from the bathroom, toilet and kitchen must be planned in detail. Silencers must be provided in the exhaust air ducts. Space in the bathroom and kitchen may be very limited in small apartments. Detailed planning is therefore particularly important.
- The supply air ducts are best routed directly from the appliance to the hallway of the apartments. In the hallway, the air ducts can be concealed behind a suspended ceiling if necessary. Sufficient silencers must be provided in the supply air ducts. Openings from the corridor into all living rooms and bedrooms must be defined in the planning. Only supply air valves from the corridor must be placed in the living rooms. No further ventilation ducts are required in the living rooms.
- Alternatively, the supply air and exhaust air ducts can also be routed on the outside wall in the newly installed wall elements during serial refurbishment. This means that air ducts in the apartments can be largely avoided. The air ducts run along the outer wall and each living space is equipped with a supply air or exhaust air element.
- However, the arrangement of the ventilation units and the ducts in the façade elements must be planned with particular care.
- The length of the warm supply air and exhaust air ducts in the outside wall elements must be kept as short as possible to minimize heat loss. This is because covering the air ducts with around 20 cm of thermal insulation is good. However, the remaining heat losses are noticeable and may significantly reduce the heat recovery rate.
- Even if the ducts are routed outside, individual flats may not remain connected for the time being the ducts are laid and sealed at both ends. The pipes are only connected to the central ventilation units and the rooms when new tenants move in.

Link to article:

[https://passipedia.org/construction/quality\\_assurance/measure\\_serial\\_renovation](https://passipedia.org/construction/quality_assurance/measure_serial_renovation)

## 2.10. ARTICLE 10 – VENTILATION DUCTS WITHIN THE INSULATION LAYER

**Summary:** When installing ventilation systems with heat recovery in older buildings, placing the ducts outside, within the insulation layer, can reduce disruption within occupied flats and improve thermal management. This setup allows ducts to be installed on the building's exterior walls, covered by thermal insulation, and sometimes even prefabricated for efficiency. However, ducts installed in this way experience additional heat losses, affecting both transmission and ventilation performance.

The ventilation ducts, installed within the insulation layer, involve three main temperatures: the room temperature, the external air temperature, and the air temperature within the ducts. As air travels from inside to outside, it cools, impacting heat recovery efficiency and resulting in temperature changes when supply air re-enters the building. By carefully analysing heat flows, the additional heat loss can be quantified to better understand its effect on overall building efficiency. These detailed calculations were integrated into a spreadsheet tool, allowing precise heat loss assessments and optimized placement of ducts within the insulation layer, thereby improving thermal efficiency in retrofitted buildings.

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- Quality assurance measures during (serial) renovation
- QA during planning phase
- Position of the thermally insulated and airtight envelope
- Thermal bridge analysis has to be done
- Optimization of the façade elements
- Optimization of heat distribution
- Planning / optimization of the ventilation distribution air ducts in the apartments
- Examples and lessons learned
- Quality assurance (QA) during execution
- Façade element - QA in the factory
- Execution on site
- Experience with QA measures in specific projects
- See also

## Screenshot:

**Ventilation Ducts within the insulation layer**  
Author: Jürgen Schnieders

**Ventilation ducts under the exterior insulation**

If old buildings are equipped with ventilation systems with heat recovery as part of a refurbishment, it often offers advantages if the supply and extract air ducts can be installed outside the home for the most part. Among other things, less work is required inside occupied flats in this case. One option is to lay the ducts on the outside of the existing external wall and then cover them with thermal insulation. With prefabricated insulation elements, it makes sense to install the ventilation ducts in the elements at the factory. The heat recovery unit can be located either outside the thermal envelope, e.g. in an unconditioned attic, or inside the building / the flats. This type of installation results in additional transmission heat losses. It must also be taken into account that the air flowing in the ducts changes its temperature, which affects the ventilation losses. Based on a detailed analysis (see below) it was found that the following points must be considered:


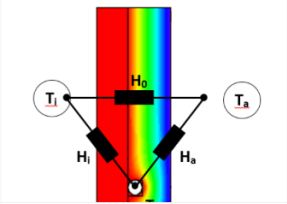


Figure 1 shows a section through a ventilation duct which is installed in the thermal insulation on the masonry, as described. Three temperatures are involved in the resulting heat flows:

- the internal temperature  $T_i$ ,
- the external temperature  $T_e$ ,
- the temperature in the duct  $T_{du}$ .

As shown in the illustration, this situation can be modelled using a delta circuit of conductance values  $H$  in  $W/(mK)$  between the temperatures mentioned above. Due to the linearity of the heat conduction equation, it is enough to determine the conductance values once using a 2D heat flow calculation for any temperature. In Figure 1 for example,  $H_0(T_i - T_e)$  heat flow over the surface of the ventilation duct is  $H_0(T_i - T_e)$ . For other temperature combinations, the heat flows can then be calculated using the same conductance values (superposition principle).

In the following calculations, it makes sense to use the difference to the regular heat flow instead of  $H_0$ , i.e.  $\Delta H_{D,0} = d \cdot U_0(T_i - T_e)$ , where  $d$  is the length of the internal or external surface in the 2D model.  $\Delta H_{D,0}$  together with  $H_i$  and  $H_e$  then yields the additional heat flow due to the duct in the insulation level. In the analysed examples,  $\Delta H_0$  was always negative (typically approximately  $-0.04 W/(mK)$ ), but the ventilation duct still leads to a slightly increased heat loss overall (typically approx.  $0.01 W/(mK)$ ) if the calculation is carried out via  $H_i$  and  $H_e$ .



Link to article:

[https://passipedia.org/planning/building\\_services/ventilation/ventilationducts](https://passipedia.org/planning/building_services/ventilation/ventilationducts)

### 2.11. ARTICLE 11 – FAÇADE INTEGRATED VENTILATION

**Summary:** The outPHit project explored multiple methods for integrating ventilation units into building façades during energy-efficient renovations, with particular attention to space-saving, ease of maintenance, and minimizing interior work in occupied apartments. Integrating ventilation systems into the building's exterior, such as near windows or within core-drilled wall holes, offers significant advantages. These placements reduce the interior footprint of the units, streamline maintenance (especially in rental properties where interior access is challenging), and enhance installation efficiency through prefabricated frames.

1. **Facade Ventilation Near Windows:** This approach positions units beside or below windows in newly insulated façades, saving indoor space and enabling swift installation. Air ducts can be pre-installed within the insulation layer, distributing fresh and exhaust air without extensive interior work. This method was showcased in a prototype at the International Passive House Conference.

2. **Core Hole Installation:** For buildings where window placement constraints exist, a cylindrical core-drilled hole offers an alternative, allowing a counter-flow heat exchanger to fit into a round opening. Different geometries maximize heat exchanger surface area for efficiency while preserving the building's structural integrity.

3. **Prototyping and Quality Assurance:** Prototypes of these ventilation systems were developed for testing, and tools were created to aid in planning and ensure quality control. Installation adjacent to windows is preferable for projects involving extensive exterior

insulation and window upgrades, while core hole installations provide a retrofit option for already-insulated buildings.

The document highlights that each installation approach's feasibility should be evaluated based on site-specific conditions, considering both cost-effectiveness and structural requirements.

### Screenshot:

**Façade Integration of Ventilation Units for Deep Renovation**  
Author: Rainer Pfleger

**Façade Integration of Ventilation Units – Options, Pros and Cons**

If old buildings are equipped with ventilation systems with heat recovery as part of a refurbishment, it often offers advantages if this device is not placed inside the dwelling, but integrated in the façade. This way the device takes less space inside the dwelling and less work is required inside occupied flats in this case. Within ouPHit a special tool for façade integration of units was elaborated, which will help you to quantify the heat transfer coefficient and the temperature factor (RSI) depending on the mounting position of the unit.

Moreover, the maintenance of the device has to be considered. One option is from inside, but many housing associations are reluctant to choose this option when building rental apartments because appointments must then be made to enter the apartment for maintenance work. The other version is the maintenance from outside. However, a lift is required for this from the first floor onwards, if the unit is not accessible from a balcony or pergola. With regard to prefabrication, complete integration into the façade modules would be advantageous, but the device depth is then limited by the thickness of the façade. If the device requires a greater installation depth, either radiator niches or window openings can be used. When integrating windows, it may be possible to work with existing opening widths. The use of radiator niches, however, requires chiseling work.

Another option is to install it in a core hole drilled through the existing wall, either horizontally or inclined 45° downwards. This variant is also described below. Which of the variants is ultimately preferred must be decided on a case-by-case basis. The fundamental difference is that in the latter variant, the external air filter must be placed on the outside, and the duct distribution for supply and exhaust air is then carried out on the room side. When installing the appliance next to or under the window, on the other hand, this can also be done on the outside of the existing wall under the thermal insulation.

**Ventilation Unit beside the window**

Provided that an EnerPHit renovation with correspondingly high insulation thicknesses and the replacement of the existing windows with highly efficient passive house windows is planned as part of the renovation, one option is to place the ventilation unit besides the window. In this case the size of the new window is smaller. If this is not acceptable, the position below the window (as it does not represent a load-bearing wall and can therefore be partially removed for horizontal installation without affecting the statics) or the mounting in a core hole drilling as described in the next chapter could be an alternative. Besides the heat recovery ventilation unit, all the required components can already be combined or pre-assembled in a prefabricated frame in the factory. But even during final assembly on the construction site, a mounting frame offers numerous advantages in terms of the quality of the connections. If a sun or privacy screen is installed above the window opening, there is no reduction in the free window opening, only one window per residential unit must be provided for the device width of 18 cm (or 20 cm including the soft panel), which saves money and construction time. A living space should preferably be selected for device installation. The device has a switching flap through which the supply air can be directed either into the living room (during the day) or into the bedrooms (at night). This allows the total amount of air to be reduced because the air is specifically supplied to where the residents are. Alternatively, if the floor plan allows this, you can of course also work with extended cascade ventilation. Compared to the installation and air flow in new buildings (hoses in the system ceiling), during renovation, both the supply air and the exhaust air are now led outwards from the device into the insulation level at the top and bottom. A star distributor is installed there to branch to the supply and exhaust air rooms. In this way, all duct routes on the room side are eliminated, except for rooms that do not have an external wall (these must be connected in the classic way with ducts or supplied via active transfer valves).

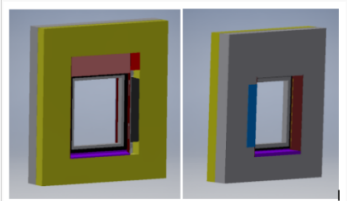


Figure 1: View of the prefabricated installation solution for the renovation. View from outside (left) with sun/privacy protection and window plate as well as ventilation device and outside/exhaust air outlets on the right in the window reveal. View from inside with window sill (right), the air outlet for the supply air would not be necessary for this window as the device itself has a supply air outlet.

Link to article:

[https://passipedia.org/planning/building\\_services/ventilation/facade\\_integration\\_of\\_ventilation\\_units](https://passipedia.org/planning/building_services/ventilation/facade_integration_of_ventilation_units)

## 2.12. ARTICLE 12 – ENERPHIT RENOVATIONS: HIGHLY EFFICIENT RENOVATION AS A SOCIAL NO-REGRET MEASURE

**Summary:** The path to achieving climate-friendly building stock is essential to international climate goals. Germany, through its Federal Climate Protection Act, aims for net greenhouse gas neutrality by 2045. The urgency of reducing fossil fuel dependence extends beyond climate protection; recent geopolitical events, such as the Russian gas crisis, highlight risks to supply security, economic stability, and national autonomy. Thus, maintaining low greenhouse gas emissions and pursuing climate neutrality are key priorities.

Achieving these objectives involves expanding renewable energy sources and significantly enhancing building energy efficiency. For instance, meeting Passive House standards in new builds and using EnerPHit components for renovations can slash heating requirements by a factor of four. Importantly, aligning upgrades with natural renovation cycles can control costs while improving energy efficiency, ensuring quality, and making high-efficiency buildings economically feasible.

Passive House and EnerPHit renovations not only reduce energy needs but also prevent over-reliance on renewable energy imports, which would be costly and logistically challenging.

Renovated buildings also reduce strain on energy grids and improve overall energy efficiency by reducing seasonal heating loads. As a result, fewer infrastructure adjustments are needed, cutting down the need for expansive wind and solar power investments.

By pursuing energy efficiency in alignment with the EnerPHit standard, countries can reduce their long-term energy demands, secure greater energy independence, and gain economic resilience in a climate-neutral energy system.

### Screenshot:

## EnerPHit renovations: Highly efficient renovation as a social no-regret measure

Author: Jürgen Schnieders

### framework and objectives

In the coming decades, the building stock worldwide will have to change so that it is compatible with a climate-friendly energy system. Many countries have signed corresponding declarations of intent. In Germany, for example, there is the Federal Climate Protection Act, which requires net greenhouse gas neutrality by 2045. At EU level, the ETS-2 provides that from the first half of the 2040s onwards, no more CO<sub>2</sub> certificates will be issued for the marketing of fuels. In order to comply with the internationally binding Paris Climate Agreement of 2015, according to which global warming should be limited to well below 2 degrees, an even faster pace would be required. In the long term, net greenhouse gas neutrality will definitely have to be achieved.

A country is well advised to actively reduce its consumption of fossil fuels for reasons other than climate protection. As the example of Russian natural gas showed again in 2022, concerns about security of supply, political blackmail and economically problematic cost fluctuations are by no means unfounded.

### Keep remaining greenhouse gas emissions low

Regardless of whether climate neutrality in the building sector can realistically be achieved by 2045, 2050 or only by 2070, all efforts must be directed towards keeping cumulative CO<sub>2</sub> emissions as low as possible by then, so that any remaining emissions ideally remain below the still available emissions budget.

In theory, there are many different ways to achieve the goal of greenhouse gas neutrality. An indispensable component is, of course, the generation of renewable energy; similarly important areas of action in the building sector are energy efficiency and the conversion of supply.

The expansion of renewable energies in Germany should be accelerated as early as 2023 through various legislative changes. The following scenarios assume an increase in renewable electricity generation to over 1000 TWh/a in 2050 (total electricity generation in 2023: 514 TWh). Significantly improving the energy efficiency of existing buildings with the help of passive house components is a building block with a number of advantages. The EnerPHit standard defined by the Passive House Institute is the benchmark for appropriate renovation quality.

Based on the above assumption for renewable electricity generation, Figure 1 illustrates the scope for action in the building sector. According to the 2020 legislation, the still available budget (green bar) would be significantly exceeded. Further federal policy ambitions in 2021 aimed at improved thermal insulation in renovation and new construction as well as a higher share of renewable energies in heat supply. Assuming that this was implemented as planned - this did not happen - it would have been just within the available budget. However, with consistent use of the potential on the building side, i.e. a combination of passive house standard in new construction and passive house components in renovation ("EnerPHit"), things would be much better. Then the building sector could even stay within the budget if, for example, the expansion of renewables can only be implemented to 50%.

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Figure 1: Cumulative CO<sub>2</sub> emissions for heating and hot water from 2021 to 2070. The green band indicates the area of the greenhouse gas budget still available for the building sector. Graphic based on (PHI 2022)

### Link to article:

[https://passipedia.de/planung/sanierung\\_mit\\_passivhaus\\_komponenten/enerphit\\_sanierungen](https://passipedia.de/planung/sanierung_mit_passivhaus_komponenten/enerphit_sanierungen)

## 2.13. ARTICLE 13 - PASSIVE HOUSE AND ENERPHIT IN THE EUROPEAN TAXONOMY

**Summary:** The article explores the integration of Passive House and EnerPHit standards within the European Union’s taxonomy for sustainable building practices. It examines how these standards align with the EU’s goals for energy efficiency and climate neutrality. The Passive House standard focuses on achieving high levels of energy efficiency through rigorous design and construction practices that minimize energy consumption for heating and cooling. EnerPHit, on the other hand, applies these principles to existing buildings, facilitating deep retrofits to improve their energy performance while retaining their existing structures. The article outlines how the European Taxonomy, which provides a classification system for environmentally sustainable activities, incorporates these standards to support the EU’s

sustainability targets. It discusses the role of Passive House and EnerPHit in promoting low-carbon and energy-efficient buildings and highlights their significance in meeting the EU's climate and energy goals. By integrating these standards into the taxonomy, the EU aims to encourage widespread adoption of best practices in building energy performance and retrofit projects.

**Screenshot:**

## EU Taxonomy Regulation – Objectives, Obligations, Functioning and Classification of Passive House/EnerPHit

**Basically: What is the EU taxonomy?**

The EU Taxonomy is a cornerstone of the EU's sustainable finance framework and a market transparency tool. It helps to channel investments to the sectors that - from the EU's perspective - are most needed for the transition, in line with the objectives of the European Green Deal. The taxonomy is a classification system that sets criteria for economic activities that are consistent with a net-zero profile by 2050 and the broader environmental objectives in addition to climate action.

The BMUV © EU taxonomy and the legal basis provide the following information: The taxonomy is an EU-wide system for classifying sustainable economic activities. It is intended to provide investors with guidance and to encourage capital for the green transformation of energy production and the economy. The financial system plays a key role in the transition to a low-emission, resource-efficient economy. The European Commission therefore presented initial criteria in June 2021 to help direct more money into sustainable, climate-friendly activities in the European Union and to make the environmental balance more visible in company reports. The European Union itself issues a kind of checklist explaining what the taxonomy is and what it is not. An attempt, then, to clear up prejudices on the subject right from the start:

What the EU Taxonomy is	What the EU Taxonomy is not
A classification system to establish clear definitions of what is an environmentally sustainable economic activity	It's not a mandatory list to invest in
Tool to help investors and companies to make informed investment decisions on environmentally sustainable activities for the purpose of determining the degree of sustainability of an investment	It's not a rating of the "greenness" of companies
Reflecting technological and policy developments: The Taxonomy will be updated regularly	It does not make any judgement on the financial performance of an investment
Facilitating transition of polluting sectors	What's not green is not necessarily brown. Activities that are not on the list, are not necessarily polluting activities. The focus is simply on activities that contribute substantially to environmental objectives.
Technology neutral	
Fostering Transparency by disclosures for financial market participants and large companies related to the Taxonomy	

Figure 1: <https://ec.europa.eu/sustainable-finance-taxonomy/>

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The taxonomy, together with the Financial Disclosure Regulation (SFDR) and the Corporate Sustainability Reporting Directive (CSRD), forms one of the three pillars of the so-called "Sustainable Finance Strategy" and its aim is to inform investors, based on common EU-wide criteria, whether an economic activity is environmentally sustainable. The environmental objectives already mentioned relate to various ecological aspects, which are summarized in six objectives:

- climate protection;
- adaptation to climate change;
- the sustainable use and protection of water and marine resources;
- the transition to a circular economy;
- prevention and reduction of environmental pollution;
- the protection and restoration of biodiversity and ecosystems.

**Link to article:**

[https://passipedia.de/policy/eu-taxonomie\\_verordnung](https://passipedia.de/policy/eu-taxonomie_verordnung)

**2.14. ARTICLE 14 – LIVING QUALITY MONITORING**

**Summary:** Monitoring living quality indicators (LQI) is essential for assessing the success of building renovations, particularly for energy efficiency, thermal comfort, and indoor air quality (IAQ). Unlike energy efficiency, which can be evaluated with a single parameter, LQI requires multiple indicators, such as temperature, humidity, and CO<sub>2</sub> concentration. Each indicator must be carefully evaluated, as they can affect occupant health, comfort, and structural integrity differently. High energy standards, such as those in NZEB or EnerPHit renovations, require airtight building envelopes and efficient ventilation systems to minimize risks of overheating, high humidity, and poor air quality. For quality assurance, sensor-based monitoring systems are used to measure key indicators. During renovations, a before-and-

after monitoring approach helps establish a baseline for assessing improvements in LQI. outPHit has adopted a wireless LoRaWAN system to facilitate easy, non-invasive monitoring. Continuous data collection with high-resolution intervals supports long-term analysis, helping identify any performance gaps in indoor conditions and energy efficiency. Another crucial aspect of LQI monitoring is microbiological assessment, which evaluates bioaerosols to prevent health risks like mold from high humidity. Such assessments provide a broader understanding of IAQ by detecting bacteria and fungi levels that are undetectable by conventional sensors. Post-renovation evaluations can verify if the building meets health and comfort standards, with radial diagrams used to visually indicate IAQ status.

In conclusion, consistent LQI monitoring not only verifies the success of energy efficiency upgrades but also ensures a safe, comfortable indoor environment for occupants. Long-term monitoring and quality assurance measures are critical for adapting building operations, improving user experience, and meeting health, comfort, and energy efficiency standards.

### Screenshot:

**Living Quality Monitoring**  
 Author: Rainer Pfleger, Sascha Hammes, Jan Steiger, Wolfgang Hasper

Living Quality Monitoring can be used to monitor the success and quality assurance of renovation measures. It also provides learning opportunities for future projects and planning.

**The Need For monitoring Living Quality Indicators**

In addition to energy efficiency requirements, there are also target criteria for thermal comfort and indoor air quality. While energy efficiency can be easily assessed using one parameter, the quantitative assessment of health and comfort can be complex and requires the evaluation of several parameters. Indicators such as thermal comfort and indoor air quality must be considered separately as, despite their interdependence, they differ fundamentally both in their effects and in the measures taken to improve them.

Even if individual indicators can be standardized in their unit, many parameters must be evaluated individually in the respective application context and the existing framework conditions. Decisions on threshold values and comparisons of variants only appear appropriate if all indicators show the same trend. An objective comparison of variants is more difficult if individual indicators show opposing trends. At this point, it would then be necessary to combine the individual indicators into a single parameter, which in turn requires weighting. Weighting only proves to be scientifically justifiable if it has been comprehensively validated on the basis of subject studies, which can prove difficult due to the high level of user diversification. The Fanger model is a validated model for assessing thermal comfort (content of the ISO 7730 standard). Health indicators are standardized using the unit DALY (disability-adjusted life years) for various health-damaging effects. EN 18700-1 defines further requirements for indoor air quality, the thermal and visual indoor environment and acoustics. These are sometimes used as a basis for planning, especially for system dimensioning in buildings and for energy efficiency calculations.

However, the validity of individual validated and statistically based indicators can be limited when examining smaller buildings with a limited number of people. Especially if age, gender or behavior are unevenly distributed. This can falsify the assessments of the building envelope and building services. A case-by-case assessment would therefore be appropriate.

Individual behaviors have a significant impact on IAQ and energy consumption [Lopez 2011, Hong 2017]. Knowledge of user-centric targets in planning and operation can therefore help to improve IAQ and energy efficiency by considering the impact of user behavior. To move from existing concepts at an aggregate level to user-centered performance indicators, Han et al. identify requirements in Resolution of performance indicators by building type, Uniform scaling of performance indicators and Stronger quantification for performance quality assessments [Han 2020]. Living Quality Indicators are suitable for quantification and individual assessment, e.g.: CO2 concentration, temperature and relative humidity for the indoor climate.

In Nearly-Zero-Energy-Building (NZEB) or Passive House/EntPHit standards, a high level of airtightness is required to keep heat losses to a minimum. Efficient mechanical ventilation systems are therefore required in this context to minimize the risks of overheating, high humidity and air pollution. Indoor environmental quality (IEQ) is becoming increasingly important in buildings with high energy standards. However, there is currently no general consensus on the measurement, limitations of the assessment classes and weighting of individual categories for the assessment of IEQ [Heinzelinger 2013, Han 2020]. Due to the resulting variability in the assessment procedure, there are currently many degrees of freedom for the building assessment. This also applies to indoor air quality (IAQ) parameters. Although the CO2 concentration, as well as the concentration of particles and volatile organic compounds, are good indicators of IAQ, there is no general standard for the quantitative assessment of air quality. However, the CO2 concentration is often used as a quality indicator for IAQ and the calculation of air pollution [Pensly 2017, Baltimore 2019]. Correlations can be demonstrated between the CO2 concentration and certain gaseous compounds and bioaerosols [Lopez 2011]. EN 12779 sets specifications for the time in defined concentration ranges for IAQ assessments, e.g.: high IAQ for CO2 concentrations below 750 ppm or particularly low IAQ for concentrations above 1200 ppm.

**Solution approach**

Living Quality Indicators (LQI) are directly or indirectly influenced by the building envelope and building services. Despite a partial overlap, a distinction is made between health and comfort-related indicators. If people are exposed to inadequate comfort conditions in the building over the long term, this can have health consequences. This article is limited to temperature and humidity data for the statistical analysis of overheating frequencies and summer comfort.

Sensor selection proves to be fundamental for living quality monitoring and therefore for monitoring success and quality assurance. In accordance with ISO/DIS 7730, the analytical determination and interpretation of thermal comfort (PMV and PPD indices and local thermal comfort criteria) is based in particular on radiation temperature, air temperature, relative air velocity and humidity. If the air temperature and radiation temperature do not differ significantly, these can be formulated as the operative temperature using the arithmetic mean. For occupied rooms, the requirements for a high level of comfort (PPD < 6 %) are to be determined in particular by low fluctuations in the operative temperature (max. ±0.8 K), low draught risk (<0.08 m/s), low radiation temperature asymmetry (ceiling/floor < 6 K) and low vertical air temperature difference between head and foot when a person is seated (<2 K). The influence of temperature is of the greatest importance here. The EntPHit standard also ensures good airtightness with a maximum n50 < 1.0 h-1 and is systematically validated with pressure build-up and pressure relief tests in accordance with ISO 9972. This minimizes the unintentional risk of draughts.

In order to fully map the IAQ in addition to thermal comfort, the measurement of the indicators relative humidity and carbon dioxide concentration is used alongside temperature. However, in order to obtain reliable evaluations based on this very limited set of parameters, the measurement uncertainty must not exceed narrow limits [outPHit D.8.5]. Mobile sensors and local data storage with evaluation in post-processing are suitable for practical use, especially for temporary operation.

A before-and-after comparison is required to monitor success. For this reason, monitoring should be carried out for a few weeks in various locations and apartments in the unrenovated state of the building. Longer periods are necessary in order to take into account the influences of user behavior and individual targets in particular, as the validity of statistical target values may be limited, especially in smaller buildings with a limited number of people.

In the outPHit research project, a wireless system based on the low-power wireless network protocol LoRaWAN (Long Range Wide Area Network) has prevailed. However, there are several suitable approaches that need to be evaluated against the respective framework conditions. The aim should be to make installation easy for users and as non-invasive as possible for residents. Data series of max. 10-minute intervals ensure both a long service life for wireless systems, without battery replacement and thus maintenance interventions, which can have a disruptive effect on comfort, and at the same time this ensures a sufficiently precise resolution for data evaluation. This is because temperature developments are generally associated with a certain degree of inertia.

**Simplification of data analysis**

Performance indicators are generally limited to clearly defined areas and categories via standards and guidelines. With regard to the air quality parameter CO2, the effects are primarily limited to health and comfort during occupancy periods. In order to quantify how much and for how long certain environmental parameters in a building exceed defined limit values, the relative limit value deviation (RTD) is used. A distinction is first made between the heating period and the non-heating period. When planning based on the Passive House Planning Package (PHPP, based on the monthly method EN 17916/ISO 52016), a detailed energy balance model is created. The calculation results can be used to derive the typical heating and non-heating periods based on the climate data set. The measured parameters, e.g.: CO2 concentration, relative humidity and temperature in the room, are plotted as a cumulative distribution function for the evaluation period and only for hours with occupancy. The area between the limit value and this function shows the duration and extent to which the limit value was exceeded. This integral limit value deviation is set in relation to the maximum permissible deviation. It should be noted that a combination of parameters is not possible if different scales exist.

### Link to article:

[https://passipedia.org/planning/refurbishment\\_with\\_passive\\_house\\_components/living\\_quality\\_monitoring](https://passipedia.org/planning/refurbishment_with_passive_house_components/living_quality_monitoring)

## 2.15. ARTICLE 15 – HOUSING COMPANIES: SUCCESSFUL COST-EFFICIENT IMPLEMENTATION

**Summary:** Neue Heimat Tirol (NHT), a non-profit housing company established in 1939, has a strong legacy of delivering quality housing and now manages over 20,000 apartments across Tyrol, including 6,000 passive house units. Operated with 50% ownership by the State of Tyrol and 50% by the City of Innsbruck, NHT prioritizes social housing for economically disadvantaged families, the elderly, and vulnerable groups. The organization follows a cost-recovery model, ensuring that tenants only pay rents that cover building costs, which is facilitated by Austria's unique non-profit housing tax system. NHT's commitment to energy

efficiency began with its first passive house project in 2009, Lodenareal, which achieved a 95% satisfaction rate among tenants due to reduced maintenance needs and low energy costs. This success encouraged NHT to build exclusively to passive house standards, reaching a significant milestone in 2015 with Austria's first certified Passive House PLUS complex, Vögelebichl. Recognizing the long-term benefits of energy efficiency, NHT established an Energy Efficiency and Sustainability department in 2018 to advance cost-effective, sustainable housing. Since 2020, NHT has embraced the Passive House PLUS standard for all new and renovation projects, with goals to produce enough renewable energy on-site to meet building operations and even offer tenants the benefit of surplus solar power. To support this transition, NHT has developed in-house evaluation criteria using tools like designPH and PHPP to ensure architectural designs meet high energy standards from the competition phase through project development, creating more predictable and sustainable housing outcomes. In response to rising global energy demands and climate crises, NHT emphasizes the Passive House PLUS approach to ensure continued affordability and sustainability in housing, focusing on efficient design, optimized orientation, and strategic use of renewable energy, positioning it as a leader in socially responsible, low-energy housing.

### Screenshot:

**Housing Companies: Successful cost efficient implementation**  
 Author: Harald Malzer

**Introduction Neue Heimat Tirol (NHT)**

NEUE HEIMAT TIROL (NHT) was founded in the year 1939. This date and our name are steeped in history. The NHT was founded to create new housing for the many thousands of people displaced by the war (mainly from what was then South Tyrol). Several thousand homes were built throughout the province in the so-called "South Tyrolean settlements". They were characterised by a lack of materials but high quality architecture, so that people from small mountain villages could feel at home even on the outskirts of the cities of the time. The quality of the buildings is such that some of them are still in use today.

**History and purpose**

Today the shareholders are 50% the state of Tyrol, 50% the city of Innsbruck. However, the company is run as a private limited company. At the present NHT is involved in the real estate management of more than 20,000 apartments. This includes around 8,000 passive house residential units that have already been built. NHT is represented with approx. 1,500 buildings in over 200 Tyrolean communities. As NHT operates in the heart of the Alps, our highest building is located at over 1000 meters above sea level. These municipalities and cities are NHT's clients. NHT constructs buildings according to the needs of the municipalities, and owns and manages them for their entire life cycle (usually 60 to 80 years). Who lives and works in the NHT's buildings and apartments is decided solely by the municipality administrations. NHT is therefore a 100% non-profit property developer providing a service to the public.

NHT has 165 employees, which includes departments for new construction and major refurbishment (project management, building technology, construction management, construction accounting), property management, accounting and the legal department.

As a stand-out feature, NHT has its own working group for quality assurance in energy efficiency and sustainability as well as national and international research projects. NHT's social role as the largest developer, builder and manager of apartments in Tyrol and western Austria is characterised by a special concern for families, the economically disadvantaged, the needy and the elderly. In this sense, vulnerable groups also make up the majority of NHT's customers. NHT is willing to support and protect. NHT is 100% subject to the very strict and strictly controlled non-profit law for property developers in Austria. This non-profit law is now almost a standards feature in Europe. Similar systems have been privatised in many countries, which lead to overpriced rents, poor architecture, often poor building quality and materials and little interest in energy-efficient and therefore operating cost-optimised buildings.

In Austria, non-profit housing is co-financed by all Austrian Citizens through a small monthly tax. This is then transferred back to the social housing sector through a housing subsidy organised in a slightly different way by each of the federal provinces. The Tyrolean housing subsidy is one of the most progressive in Austria in terms of energy efficiency requirements. No non-profit housing developer is allowed to work for profit. However, they must always work according to the principle of cost recovery. This means that during the entire financing period (usually 30-35 years), our tenants only pay back as rent what the buildings actually cost. Of course, this is even easier if there are hardly any energy costs.

**Why combine energy efficiency and a high standard of living with social housing?**

Everything that can be saved in operating and energy costs can be invested in a better personal future. The high quality of NHT's buildings and facilities gives people from social disadvantaged backgrounds the best possible opportunity to open up socially. NHT's aim: living in an NHT flat does not exclude you, but makes you happy and proud. Social housing in the NHT means that my home has the same high standards as the economic average of the population (often higher): no social demarcation in residential practice. Children have a healthy home with ideal learning conditions to break through "inherited educational levels" and thus social barriers.

**What is the reason for NHT's Passive house experience and development**

For many years, ecological sustainability has been one of the three pillars of the corporate philosophy of the NEUE HEIMAT TIROL. Now NHT is taking a pioneering role in various energy-related areas. The motivation beside that: Low rents and at the same time stable operating and energy costs enable low-income earners to have a permanent, high-quality and healthy living environment.

**On the way to implement the Passive House Standard for every project**

After many lost years with half-hearted guidelines and efficiency requirements, the necessary climate protection in the building sector has finally arrived almost everywhere. ESG, EU Green Deal, Taxonomy Regulation, CSRD and the subsequent national and regional requirements suddenly present us with an almost insurmountable challenge in the building sector. The Passive House Standard, however, has been addressing many of these issues for 30 years!

It is the most consistent and, for us, the most honest efficiency standard for buildings. Why?

- It works (as shown by our many monitorings in research projects).
- It is also easily financed in social housing.
- It adapts continuously and realistically to technical developments and climate changes (renewable energies, heat pump supply, global warming).
- It offers solutions that also work in high-sun regions.
- It is economical.
- It is economical.
- It is economical.

So in 2010 it was not the decision of the NHT management to put on a "green cloak" - no, after and with our first certified passive house residential complex, "Lodenareal" it became quite clear that the maintenance costs of a passive house were much lower than before. No more complex mold remediation after moving houses and actually extremely low energy costs. The NHT always carries out a resident survey about a year after moving in. The "Lodenareal" achieved a satisfaction rate of 95% for the first time in the NHT's history. So the NHT decision "From now on only in passive house standard" was first and foremost an economic one.

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