REPORT
DELIVERABLE 2.7

D2.7_Description of a whole house renovation system certification concept (Task 2.6)

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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**

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INTRODUCTION

EnerPHit is an international high efficiency standard for building retrofits, based on Passive House principles for renovation components. The EnerPHit standard offers immense benefits. These include significantly increased supply and crisis security and improved residential health and domestic value creation. The low heating load relieves the grid in the sustainable supply structure of the future.

A building that fulfils the EnerPHit criteria as defined by the Passive House Institute can be certified by an accredited Passive House certifiers, and will, after the certification, receive a seal as Certified EnerPHit Retrofit:

Climate zone according to PHPP	Heating	Cooling
	Max. heating demand	Max. cooling + dehumidification demand
	[kWh/(m²a)]	[kWh/(m²a)]
Arctic	35	equal to Passive House requirement
Cold	30	
Cool-temperate	25	
Warm-temperate	20	
Warm	15	
Hot	-	
Very hot	-	

EnerPHit seal

EnerPHit Energy Demand Criteria

For deep renovation projects, it is not always possible to achieve a low energy demand as required by the Passive House Standard. Due to challenges for thermal bridges, airtightness, compactness or solar aperture of the existing building, the building´s energy efficiency cannot be improved to Passive House Standard. Furthermore, the impact of these problems that cannot be solved in a renovation project with reasonable measures, differs with the climatic challenges. The EnerPHit standard has foreseen for this fact by describing climate zone dependent criteria for EnerPHit retrofits. The fulfilment of this criteria can be achieved by fulfilling the energy demand requirements, as shown in the diagram above. The other certification path follows the component method, where minimum component qualities for the building components have to be met.

These minimum component ambitions for EnerPHit retrofits, which follow the component requirement certification method, are derived from the climate-zone dependent criteria for Certified Passive House Components and are described in the table below:

Climate zone according to PHPP	Opaque envelope[1] against... ...ground	...ambient air			Windows (including exterior doors) Overall[4]			Glazing[5]	Solar load[6]	Ventilation	
	Insulation	Exterior insulation	Interior insulation[2]	Exterior paint[3]	Max. heat transfer coefficient ($U_{D/W,installed}$)			Solar heat gain coefficient (g-value)	Max. specific solar load during cooling period	Min. heat recovery rate[7]	Min. humidity recovery rate[8]
	Max. heat transfer coefficient (U-value)			Cool colours							
	[W/(m²K)]			-	[W/(m²K)]			-	[kWh/m²a]	%	
Arctic	Determined in PHPP from project specific heating and cooling degree days against ground.	0.09	0.25	-	0.45	0.50	0.60	$U_g - g^*0.7 \le 0$	100	80%	-
Cold		0.12	0.30	-	0.65	0.70	0.80	$U_g - g^*1.0 \le 0$		80%	-
Cool-temperate		0.15	0.35	-	0.85	1.00	1.10	$U_g - g^*1.6 \le 0$		75%	-
Warm-temperate		0.30	0.50	-	1.05	1.10	1.20	$U_g - g^*2.8 \le -1$		75%	-
Warm		0.50	0.75	-	1.25	1.30	1.40	-		-	-
Hot		0.50	0.75	Yes	1.25	1.30	1.40	-		-	60 % (humid climate)
Very hot		0.25	0.45	Yes	1.05	1.10	1.20	-		-	60 % (humid climate)

EnerPHit component requirements for PHI climate zones @ PHI

CERTIFIED PASSIVE HOUSE COMPONENTS

As a rule, Certified Passive House Components are two to three times more efficient than the corresponding commonly used products. This high level of efficiency is critical to not only achieving the Passive House Standard, but also climate neutrality of the building stock.

However, for building professionals or other stakeholders it is often very difficult to assess the energy-efficiency, durability and the necessary energy parameters of a component, as the available standard parameters are frequently unrealistic or are not accurate enough. Reliable project planning using manufacturers' information alone is thereby often not possible.

As an independent authority, the Passive House Institute tests and certifies products in respect of their suitability for use in Passive House or EnerPHit projects. Products that carry the Certified Passive House Component seal have been tested according to uniform criteria; they are comparable in terms of their specific values, and are of excellent quality regarding energy efficiency. Their use facilitates the designer's task to assure high energy performance and contributes significantly to ensuring the faultless functioning of the resultant Passive House building, EnerPHit renovation, or other nearly Zero Energy Building (nZEB) or Zero Emission Building (ZEB) approaches. All these high performance Buildings require high quality components: highly insulating window frames and insulation levels, highly efficient ventilation units, thermal bridge free connection details, glazing that allows solar gains, compact heat pump units or airtightness. Certified Passive House suitable products allow users to verify and compare the relevant parameters of the respective products.

For the certification of such building components, practice-oriented, easily verifiable and clearly identifiable criteria has been developed by the Passive House Institute, which must be met by Passive House suitable products. These criteria are based on two categories:

- health and living comfort ("comfort criteria")
- the energy balance in practice ("energy criteria")

It is the objective of the Passive House Institute to base the standard of these requirements on the physically or physiologically verifiable, objectively determinable criteria (e.g. maximum radiation temperature difference of 5 K between the half spaces, derived from ISO7730). Additional efficiency categories have been introduced (e.g. for Passive House windows) where this alone is not sufficient for formulating the criteria. All criteria can be expressed by using measurable quantities and tested by using established methods. The specific values of the respective products which are relevant for the energy balance, as well as those for determining comfort, have been given in the certificate. These can thus be entered directly into the PHPP.

Criteria for Certified Passive House Components is available for 3 main component categories:

- **Transparent building envelope**
- **Opaque building envelope**
- **Building services**

The quality requirements are based of component certification process, which is offered to any manufacturer providing those products. For certified products those key parameters are published, so anybody can apply for the information needed for design, planning, and tendering:

- Quality assurance for planners of high-performance and Passive House buildings
- Presentation in Passive House Institute component database
- Increased market visibility and product recognition
- Independently tested and certified
- Use of Certified Passive House Component seal
- Announcement to Passive House stakeholders in monthly newsletters

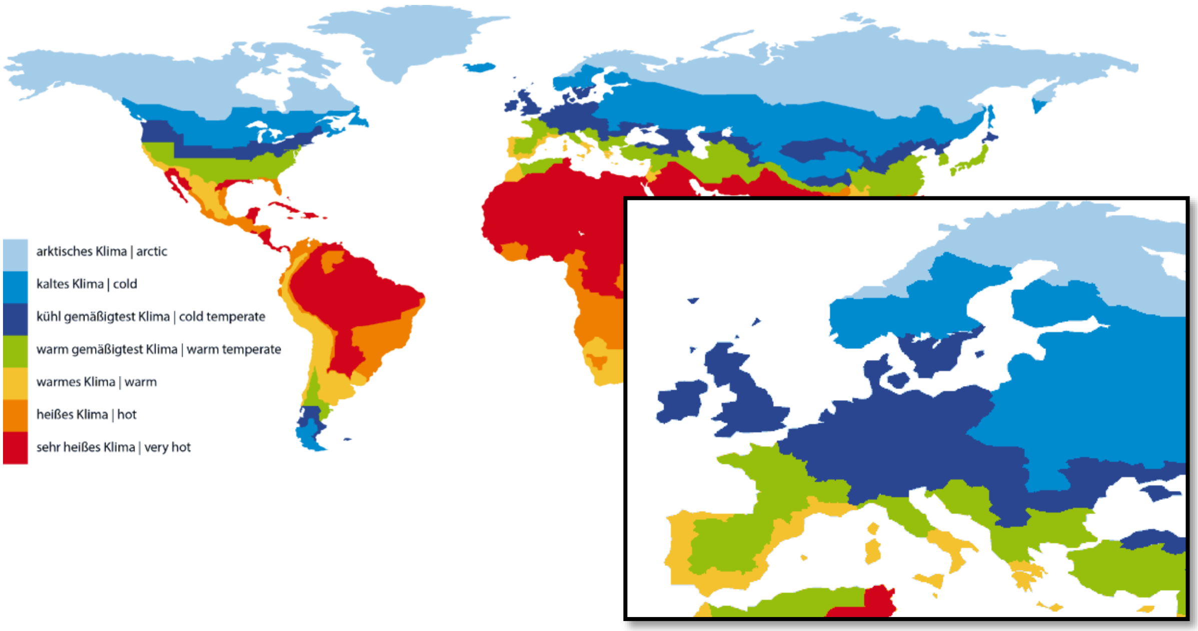
ASSIGNMENT OF CLIMATE ZONES (REGIONS WITH IDENTICAL REQUIREMENTS)

The requirements of the PH or EnerPHit standard for the overall efficiency of the building are essentially defined by the heat losses via the building envelope to the surroundings. Milder climates therefore require less thermal insulation of the building, which is directly reflected in the required U-values of the building envelope components. However, the values mentioned for the various climatic zones usually are significantly more ambitious than the legal minimum standards currently in force in the respective regions. Furthermore, the actual qualities of the existing building stock is usually significantly worse. In this respect, the EnerPHit standard represents a significant improvement in the energy efficiency of buildings worldwide.

Where possible, Certified Passive House Component criteria has been specified for different climate zones, that have been defined by the Passive House Institute. The climate zone is assigned based on the location of the manufacturer's headquarters, or any other facility where the manufacturer conducts its operations. The nearest PHPP climate data set will be used;

further climate data sets can be requested from PHI where this is uncertain, e.g. in regions with wide variations in altitude. The certification criteria and a certificate that is issued based on them are valid for the assigned climate zone and also for climates with lesser requirements, bearing in mind however that more economical solutions may be possible.

These climate zones are as follows:



Assignment of regions with identical component requirements @ PHI

The seven climate zones defined by the Passive House Institute range from arctic to very hot climate. As can be seen, the climate regions relevant for Europe are mainly the cool-temperate and warm-temperate, with some cold regions in Northern Europe and warm regions in the Mediterranean areas. These climate zones are described with the following component certification seals and indicate the suitability for a certain component for this climate region with identical component requirements:

Component seals according to PHI climate zones @ PHI

The criteria for Certified Passive House Components can be found here:

https://passiv.de/en/03_certification/01_certification_components/02_certification_criteria/02_certification_criteria.htm

WHOLE HOUSE RENOVATION SYSTEMS

The outPHit project explores and supports streamlined deep renovation processes, such as prefabricated renovation elements (e.g. insulated wall panels) or one-stop-shop models for conventional retrofits. In such fast renovation approaches, changes to the energy efficiency properties of the components or connection details during on-site construction works are or may not be possible any more. This fact demonstrates the importance to provide reliable renovation systems to the renovation market, with well-designed and quality assured renovation packages that can be applied easily to most of typical renovation projects and will still achieve the projects ambitions to reach highest building efficiency after the renovation.

Through a certification process of such renovation systems, the quality of the system, the overall component performance, but also including critical points such as thermal bridges, airtightness or ventilation heat recovery, can be assured to fulfil the ambitions required for deep renovation projects, such as EnerPHit retrofits. Furthermore, through the examination by the certification process, specific performance values of the renovation systems are determined and made available, by transparently describing U-Values, thermal bridge coefficients or ventilation heat recovery efficiency within the certificate so these values can reliably be used for the energy efficiency planning of the renovation projects. By additionally offering approved descriptions of the airtightness concept and further information about the systems, stakeholders applying such renovation concepts have a better basis to select a renovation system.

ENERGY EFFICIENCY REQUIREMENTS

The goal of this whole hose renovation system requirements would be to enable renovation projects to reliably achieve the EnerPHit standard for renovation projects of typical building typologies, if the system can be applied completely to the existing building. The energy efficiency requirements for whole house renovation systems is thereby derived from the component requirements described for the different component categories, which also match the EnerPHit component requirements. Thereby, buildings renovated with such a whole house renovation system would be able to meet the criteria of EnerPHit retrofits certified by the component method in many cases, if all building elements (walls, roof, floor, windows and ventilation system) have been renovated in component qualities as described by this preliminary criteria.

However it is important to understand, that the average specific component quality, or better, the average U-Values, of windows or opaque components do considerably depend upon the geometry of the building elements. Thereby the average values calculated by PHPP may be slightly better or worse than the U-Values determined for the components for standard geometries in the certification. On the other side, the U-value requirements for the opaque building envelope to the ground may differ from the requirement described by the certification criteria, based on the assessment of the project specific heating or cooling degree days against the ground determined in PHPP, based on the floor slab or basement ceiling geometry of the specific project. In both cases, the renovation project cannot automatically fulfill the EnerPHit certification by following the component method, even if the standard component U-values of the renovation components fulfil the requirements.

COMPLETE BUILDING RENOVATION APPROACH

Whole House Renovation Systems must be able to provide all the renovation elements for the renovation of the complete building envelope and the implementation of an efficient ventilation concept with heat recovery! In addition to these renovation elements, the Whole House Renovation systems consists of several obligatory and optional extension:

1. **Certified Deep Renovation Components:**

- Roof insulation
- Wall insulation
- Floor slab / basement ceiling insulation
- Window / Door replacement
- Ventilation with heat recovery implementation

These renovation components are required for a whole house renovation system. The component qualities are derived from the Certified Passive House Components criteria for each component category. The component qualities must be provided in form of detail drawings / descriptions / data sheets and will be approved by the certification process

2. **Obligatory additional descriptions / information:**

- Thermal bridge free connection details
- Dummy building test calculation
- Airtightness concept description
- Embodied energy information for all building envelope components
- User manual and inhabitant introduction

These concepts must be delivered in form of detail drawings / descriptions / data sheets and will be approved by the certification process.

3. **Optional system features / options**

- Step-by-Step retrofit connection concept
- RES implementation (PV or Solar thermal)
- Maintenance services
- Efficiency design (PHPP calculation) or funding application services
- Quality assurance services

It is optional to offer these concepts / services as part of the whole house renovation system package. The concepts must be delivered in form of detail drawings / descriptions / data sheets / certificates and will be approved by the certification process.

WHOLE HOUSE RENOVATION SYSTEM PACKAGE

The whole house renovation system package consists of these obligatory and optional elements:

Certified Deep Renovation Components


Roof


Wall

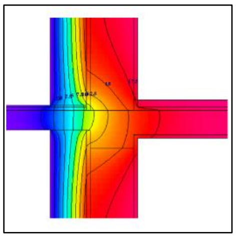

Floor


Windows


Ventilation

+

Obligatory additional descriptions / information


Thermal Bridges


Dummy project


Airtightness


Embodied Energy

User Manual

+

Optional system features / options


SBS concepts


RES systems


Maintenance


Efficiency design


QA services

=

Whole

House

Renovation

System

BOUNDARY ASSUMPTIONS

1. **Existing building Quality Assumptions**

The component quality of the existing building may also be relevant for the quality of the renovation components. Thereby a typical solid construction is chosen:

- 24cm brick wall with plaster on both sides, U-Value = 1,40 W/(m²K)
- 15cm concrete basement ceiling, U-Value = 1,00 W/(m²K)
- 15cm concrete ceilings
- 15cm concrete flat roof ceiling, insulated 8cm, U-Value = 0,45 W/(m²K)
- 16cm wooden rafters pitched roof, insulated 8cm, U-Value = 0,40 W/(m²K)

Any renovation components and connection details have to be tested under the assumption of these existing construction elements

2. **U-value calculation of windows and window installation**

U-values for windows are determined for vertical windows with a test size of 1,23*1,48 m. In addition to DIN EN ISO 10077-1, the thermal bridges for the window installation have to be considered in the U-value calculation of the installed window $U_{w,inst}$, as defined in the Passive House component Certification criteria for transparent components.

3. **Ventilation system air flow rates and efficiency of ventilation distribution**

The implementation of a ventilation system with sufficient heat recovery efficiency is an energy performance requirement for the whole house renovation system. However, ventilation concepts greatly differ in distribution concepts or air flow rates. To foresee for the average minimum and maximum use cases in either small or very big residential units, the ventilation units used within the whole house renovation system should thereby cover typical ranges of air flow rates:

- Small residential unit / 50 -150 m² / 60 – 120 m³/h
- Big residential units / 150 - 250 m² / 120 – 240 m³/h

Furthermore, ventilation systems may be installed inside or outside the thermal envelope. The specific heat loss coefficients of the insulated ventilation ducts, either ODA and EHA ducts within the thermal envelope, or SUP and ETA ducts outside the building envelope, have to be declared and approved by the certification.

4. **Ventilation system options**

For the implementation of the ventilation system, various options may be possible. To be able to select the most adequate solutions, the ventilation concept will be categorised into these options:

- Centralised ventilation concept
- De-centralised ventilation concept
- Conventional ventilation distribution concept
- Façade integrated ventilation distribution concept

Component requirements of whole house renovation systems

1. Arctic climate

- U-value opaque exterior building component — **$\leq$ 0,09 W/(m²K)**
- U-value opaque building component to the ground: — **$\leq$ 0,15 W/(m²K)**
- Absence of thermal bridges: — **$\leq$ 0,01 W/(mK)**
- Hygiene criterion: — **$f_{Rsi\,@\,0,25\,m^2K/W} \leq 0,80$**
- U-value of the installed window — **$\leq$ 0,45 W/(m²K)**
- Solar heat gain coefficient (g-value): — **$U_g\text{-}g*0,7 \leq 0$**
- Heat recovery efficiency of the ventilation system: — **$\geq$ 80 %**

2. Cold climate

- U-value opaque exterior building component — **$\leq$ 0,12 W/(m²K)**
- U-value opaque building component to the ground: — **$\leq$ 0,20 W/(m²K)**
- Absence of thermal bridges: — **$\leq$ 0,01 W/(mK)**
- Hygiene criterion: — **$f_{Rsi\,@\,0,25\,m^2K/W} \leq 0,75$**
- U-value of the installed window — **$\leq$ 0,65 W/(m²K)**
- Solar heat gain coefficient (g-value): — **$U_g\text{-}g*1,0 \leq 0$**
- Heat recovery efficiency of the ventilation system: — **$\geq$ 80 %**

3. Cool temperate climate

- U-value opaque exterior building component — **$\leq$ 0,15 W/(m²K)**
- U-value opaque building component to the ground: — **$\leq$ 0,25 W/(m²K)**
- Absence of thermal bridges: — **$\leq$ 0,01 W/(mK)**
- Hygiene criterion: — **$f_{Rsi\,@\,0,25\,m^2K/W} \leq 0,70$**
- U-value of the installed window — **$\leq$ 0,85 W/(m²K)**
- Solar heat gain coefficient (g-value): — **$U_g\text{-}g*1,6 \leq 0$**
- Heat recovery efficiency of the ventilation system: — **$\geq$ 75 %**

4. Warm temperate climate

- U-value opaque exterior building component — **$\leq$ 0,30 W/(m²K)**
- U-value opaque building component to the ground: — **$\leq$ 0,50 W/(m²K)**
- Absence of thermal bridges: — **$\leq$ 0,01 W/(mK)**
- Hygiene criterion: — **$f_{Rsi\,@\,0,25\,m^2K/W} \leq 0,65$**
- U-value of the installed window — **$\leq$ 1,05 W/(m²K)**
- Solar heat gain coefficient (g-value): — **$U_g\text{-}g*2,8 \leq 0$**
- Heat recovery efficiency of the ventilation system: — **$\geq$ 75 %**

5. Warm Climate

- U-value opaque exterior building component — **$\leq$ 0,50 W/(m²K)**
- U-value opaque building component to the ground: — **$\leq$ 0,83 W/(m²K)**
- Absence of thermal bridges: — **$\leq$ 0,01 W/(mK)**
- Hygiene criterion: — **$f_{Rsi\,@\,0,25\,m^2K/W} \leq 0,55$**
- U-value of the installed window — **$\leq$ 1,25 W/(m²K)**
- Solar heat gain coefficient (g-value): — **-**
- Heat recovery efficiency of the ventilation system: — **-**

OBLIGATORY ADDITIONAL DESCRIPTIONS / INFORMATION:

1. **Component Certification System**

The concept is based upon the Component Certification by Passive House Institute. However, it is not single components evaluated individually (eg. window frames, glazing, walls or ventilation units) but whole building renovation concepts. Thereby the components within this whole house approach should fulfill the criteria for individual component requirements (**https://passivehouse.com/03_certification/01_certification_components/01_information-regarding-certification.htm**), but also the connections should be thermal bridge free and air-tight, or a user manual should be provided and the embodied energy of each renovation component should be declared. Additionally, there are options for RES implementation or step-by-step renovation approaches. The construction systems to be addressed range from conventional methods with EIFS and traditional roof insulation to completely prefabricated wall or roof modules. The concept descriptions is set up in English at the moment. As soon, as the final criteria have been developed, these will be translated into partner languages

2. **Thermal bridge free connection details**

One of the more crucial aspects of this whole house renovation system certification is the thermal bridge free design of the renovation systems. As required for any climate region, the thermal bridge coefficients of all connection details have to be thermal bridge free, with Psi ≤ 0,01 W/(mK). However, for complicated connection details exemptions have to be made, as long as the connections still fulfil the hygienic requirements of the EnerPHit certification, to avoid mould or condensation risk. Usually, this occurs to inner wall edges which result in a Psi-Value that is not thermal bridge free. Thereby geometric thermal bridges, where the insulation thickness around the junction is consistent, but the calculation methodology results in a Psi-value of > 0.010 W/(mK), are exempt from this criterion.

Furthermore, in renovation projects, where penetrations of the thermal envelope cannot be avoided in case of balcony slabs or perimeter connections between insulated basement ceiling and external wall insulation, the thermal bridges can also exceed the Psi-value- requirement of > 0.010 W/(mK), as long as the hygiene criterion is fulfilled. In the particular case of prefabricated façade or roof modules it may occur, that the timber frame elements to stabilise the prefab panels become too dominant and result thermal bridges in special connections, that also exceed a Psi-value of > 0.010 W/(mK). For such cases, exemptions can also be made by the certifier, as long as the connection details with their specific thermal bridge coefficients are declared in the certification document.

The overall performance of the system will then be tested with the dummy building test, in order to ensure, that system specific impact of thermal bridges can be considered.

3. **Dummy Reference building Test**

The energy efficiency performance of all components of the building envelope will thereby be tested against a reference dummy building approach. This building will be of a typical end-of-terrace house building typology, 2 storey buildings strictly south orientated, and have the following specifications for the building envelope geometry:

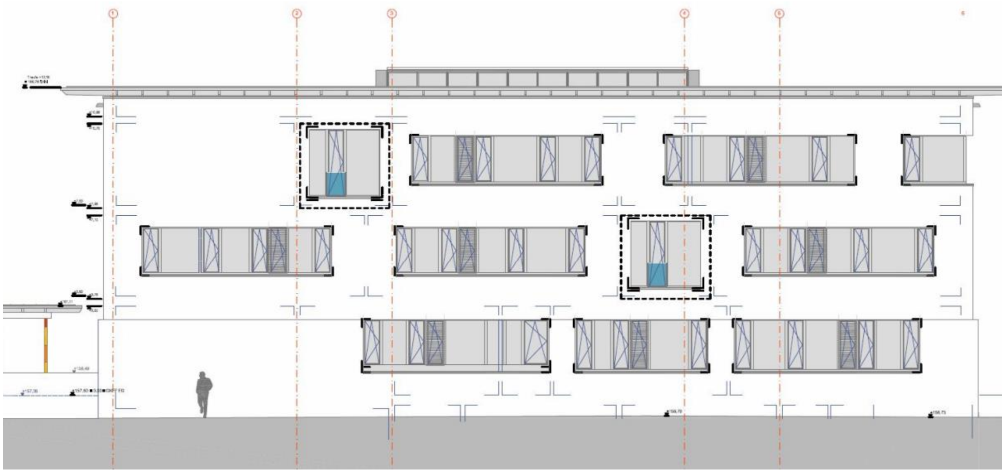
- two roof variants: pitched roof with 30 degrees inclination and flat roof
- unheated basement with external access stairs
- the north and south façade both have 1 wall recess each, depth 1m
- the south façade has a balcony over the recessed part of the façade
- windows with moderate dimensions, smaller than 1,23m*1,48m, except for balcony and terrace doors and entrance door

A building with such specifications offers various challenges to a renovation system:

- roof connection details for either pitched roof eaves or flat roof with parapet
- connection between insulated basement ceiling to external wall insulation
- 2 recesses mean 2 inner wall corners which will not be thermal bridge free
- Smaller dimensions of wall areas mean a increased share of timber frame elements in timber construction concepts like prefab or semi-prefab systems, which is a challenge for the thermal bridge free connection requirement
- The balcony slab penetrates the new thermal envelope; a connection detail that cannot be solved thermal bridge free
- Due to the smaller windows, the average U-value of the windows is higher than the U-value of the standard window

The certification for a whole house renovation system will only be awarded if the average U-values of all building envelope elements fulfils the component criteria described below:

- the opaque exterior building elements walls and roofs
- the basement ceiling and
- the windows and French windows



Example façade anchor certification with a reference facade @ PHI

4. **Airtightness concept between elements and connections to existing building**

A professional quality standard of airtightness must be ensured for the renovation to achieve the airtightness requirement of the EnerPHit renovation standard: The airtightness of the renovated building must not exceed a pressure test result of n50 = 1,0 1/h. This should be verified by detail representation, text descriptions of the creation of the airtight layer, the materials used for this and a general description of the overall system. The graphical representation should be such that the layers and connections of the membranes and sealing materials to the walls and windows frames are recognisable. All connection details must be planned and executed in a permanently airtight manner. The airtight layers must be clearly identified in the submitted documents (e.g. outlined in red ink).

If the ventilation distribution is planned façade integrated within the whole house renovation concept, the thermal bridge coefficients of these ducts have to be determined and approved by the certification. Condensation risk on ventilation ducts foreseen in façade integrated boxes must be avoided.

5. Embodied Energy information

In addition to the energy efficiency performance specifics of the renovation elements like roof, wall or windows, these renovation components have been produced through the investment of manufacturing energy. In order to enable building professionals to assess the impact of the embodied energy within the materials of the whole house renovation system and compare it to the energy savings expected by the renovation measures.

Thereby, the manufacturing energy of any building envelope component of the whole house renovation system must be declared in kWh/m². This declaration is informative only, but supports stakeholders to quicker understand the quality of the renovation systems in terms of embodied energy. By using the embodied energy evaluation tool developed within the outPHit project, building professionals can even assess the amount of energy used for the production of the renovation of the specific project and compare it to the amount of energy saved by the retrofit.

6. User manual and inhabitant introduction

Obligatory part of the whole house renovation project will be a short user introduction into the energy efficiency specifics of the renovated building, and an explanation of the features and maintenance requirements of the mechanical equipment like ventilation units or heat pumps.

Furthermore, a user manual for the renovated building has to be provided that enables the inhabitants to operate the highly efficient building adequately. A template for such a user manual must be approved by the certification process.

OPTIONAL SYSTEM FEATURES / OPTIONS:

Deep renovation projects applying such whole house renovation systems can reach the EnerPHit standard or at least come quite close to it and thereby consume very little energy for heating or cooling. This will enable the renovated buildings to considerably contribute to the transformation of a climate neutral building stock.

However, further features of whole house renovation systems may be interesting to the potential clients, beyond the mere energy efficiency performance specifics of the building envelope and the ventilation concept. The certification process for whole house renovation projects thereby should be able to inform about such options additionally:

1. **Step-by-Step retrofit connection concept ☒**

In many renovation projects, recent retrofit activities have already replaced an old component with a new one, for example windows in moderate quality only, so that these components will have to be replaced in the future. Also budget considerations may lead to renovation activities that do not lead to a one-shot-retrofit of all building components, but to a step-by-step renovation, either component by component, or building section by building section.

The whole house renovation systems, that offer step-by-step connection concepts, can be labelled as step-by-step renovation systems. The connection details describing the intermediate connection details will then also be checked and calculated, the thermal bridge coefficients of the intermediate connections will be added to the documentation.

2. **RES Implementation ☒**

The whole house renovation system renovation include the installation of renewable energies as BIPV or solar thermal systems. In this case, the additional heat losses caused by the support structure for the PV or solar thermal panels on either roofs or facades have to be determined during the certification.

The additional heat losses potentially caused by the sub-structure of RES implementation have to be declared as U-value supplement in W/(m²K) to the regular U-values of the roof or wall components of the renovation system.

3. **Maintenance services ☒**

If the provider of the whole house renovation system offers maintenance options for the technical equipment implemented by the renovation, for example ventilation units, compact ventilation units or heat pumps, this can be declared and presented as optional service by the provider.

Maintenance options can also be offered for transparent building envelope components like windows or doors, which may need to be adjusted every few years to guarantee reliable airtightness qualities.

4. Efficiency design and funding application ☒

The provider of the whole house renovation system can also offer the energy efficiency calculation for the renovation project with the Passive House Planning Package. The Passive House Planning Package (PHPP) is an affordable energy balance tool ideal for high performance building standards with extremely accurate result and the verification tool for Passive House projects and EnerPHit retrofits.

When offering the whole house renovation, the provider can include the energy efficiency design of the project with PHPP as optional service, if a Certified Passive House Designer works in the company who is qualified to carry out such PHPP calculations.

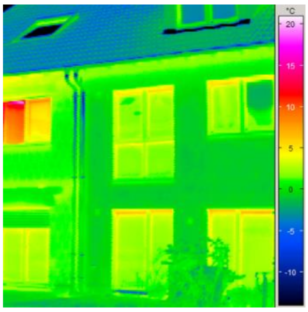
Furthermore, In case of funding applications, a qualified or accredited energy expert may be required to submit the funding application documents Application for funding. The provider of the whole house renovation system can offer accredited funding expert

5. Quality assurance services ☒

The provider may also offer quality assurance services for the renovation projects. These services will also be listed as optional services to the whole house renovation system:

- blower door tests – to be executed by an external expert
- leakage search – to be executed by an external expert
- thermal imaging
- ventilation adjustment





To be accepted for the EnerPHit certification, quality assurance services like blower-door-tests and leakage search can only be conducted by external experts.

ANNEX I - CRITERIA AND ALGORITHMS FOR CERTIFIED PASSIVE HOUSE COMPONENTS: TRANSPARENT BUILDING COMPONENTS ANDOPENING ELEMENTS IN THE BUILDING ENVELOPE

Information. Criteria and Algorithms for Certified Passive House Components: Transparent Building Components and Opening Elements in the Building Envelope

Version 5.4, 2022-03-03 kk/el

This document includes the component categories window frames, frames with fixed glazing, window systems, entrance doors, sliding doors, folding door systems, mullion-transom façades, glass roofs, opening elements in glass roofs, skylights/dome lights, and roof windows.

Note: Certificates are currently only being issued for the ‘arctic’, ‘cold’, ‘cool, temperate’, ‘warm, temperate’ and ‘warm’ climate regions.
The criteria for climate zones ‘warm, temperate’ and ‘warm’ as well as the category ‘Window System’ are subject to specific changes as these criteria are in the trial phase.

Certificate: approved thermal quality

The market for highly energy-efficient buildings is expanding rapidly, and the demand for reliable high-performance components is growing. However, requirements and possibilities for achieving this are often unclear with some manufacturers specifying characteristic values which they cannot guarantee.

The Passive House Institute certifies highly energy-efficient components according to international criteria, in order to meet the requirements for comfort, hygiene and energy efficiency. In the context of the certification process, the Institute provides advice to manufacturers in relation to the optimisation of their products. This results in improved, future-proof products and reliable thermal characteristic values for input into energy balance software programmes.

Advantages of certification:

- Consultations relating to product development for highly efficient buildings
- Access to a growing market
- Increased market visibility and product recognition
- Independently tested & certified: use of the Passive House Component Seal
- Inclusion in the Component Database of the Passive House Institute
- Incorporation into the PHPP energy balance software programme for buildings

Passive House Institute

The **Passive House Institute** (PHI) is an independent research institute which has played a decisive role in the development of the Passive House concept. The Passive House Standard is the only globally recognised energy standard for buildings which stands for tangible and verifiable efficiency values.

www.passivehouse.com

All products certified by the PHI are accordingly listed in the **Passive House Component Database** and made accessible to the international public. Integrated tools and information offer a high added value for building owners, designers and manufacturers.

database.passivehouse.com

PHPP

The **Passive House Planning Package (PHPP)** is a cost-saving energy balance tool for highly energy efficient buildings. It has been validated on the basis of measured projects, provides precise results and can be used reliably by all.

www.passivehouse.com

iPHA

iPHA, the International Passive House Association is the PHI's network of experts which is committed to the propagation of the Passive House concept and the dissemination of the relevant expertise and information. It brings together scientists and building owners as well as architects, designers and manufacturers.

https://www.passivehouse-international.org/

Contents

1 Preface

Passive House buildings provide optimal thermal comfort with minimum energy expenditure; they lie within the economically profitable range with reference to their life-cycle costs. To achieve this level of comfort and low life-cycle costs, the thermal quality of the components used in Passive Houses must meet stringent requirements. These requirements are directly derived from the Passive House criteria for hygiene, comfort and efficiency as well as from feasibility studies. The Passive House Institute has established component certification in order to define quality standards, facilitate the availability of highly efficient products and promote their expansion, and to provide planners and building owners with reliable characteristic values for input into energy balancing tools.

2 Certification criteria

2.1 Verifying Passive House suitability, certificate

Passive House suitability is verified using the U-value of the components and the temperature factor at the coldest point of the component. The heat transfer coefficients (U-values) and the thermal bridge loss coefficients (ψ-values) are determined based on DIN EN ISO 10077, EN 673 and DIN EN 12631. Passive House suitability is verified for the specified dimensions of the products to be certified, see Table 3. Verification of the hygiene criterion is provided using 2-dimensional heat flow calculations of the standard cross-sections. The most unfavourable temperature factor shall be applicable. In addition, efficiency classes should be stated, see Section 2.3. Class phC must be achieved at least.

The certificate contains the product name, representation of a frame cross-section and the efficiency class as well as verification of certifiability and the relevant characteristic values, illustrations and drawings. Table 1 contains the requirements that need to be met for the various climate zones. The corresponding dimensions can be found in Table 3.

2.2 Verification of EnerPHit suitability

In addition, windows and window systems can be characterised as EnerPHit components if the certification criteria are also achieved for each step in modernisations that are carried out in a step-by-step manner. The hygiene criterion is also checked in the installed state. See Section 3.9 for further information.

2.3 Passive House efficiency classes

In addition, windows and all other glazed components are also allocated to efficiency classes, depending on the heat losses through the opaque part[1]. The frame U-values, frame widths, the glass edge Ψ-values and the glass edge lengths are included in these heat losses (see *Table 2*). The average values of the respective characteristic values are used. In the case of curtain wall façades and inclined glazing, the heat losses through the glass carriers (χ_{GT}) are included in the calculation of the losses similarly to Ψ_g. The same applies for heat losses due to screws. For the certification of window systems the heat losses through leaks are also included in the calculation as H_{ve}[2].

Table 1: Adequate certification criteria and U-values of the reference glazing

Climate zone	**Hygiene criterion**[1] $f_{Rsi = 0.25\ m^2K/W} \geq$	**Component U-value**[2] [W/(m²K)]	**U-value installed** [W/(m²K)]	**Reference glazing** [W/(m²K)]
1 Arctic	0.80	0.40	0.45	0.35
2 Cold	0.75	0.60	0.65	0.52
3 Cool-temperate	0.70	0.80	0.85	0.70
4 Warm-temperate	0.65	1.00	1.05	0.90
5 Warm	0.55	1.20	1.25	1.10
6 Hot	None	1.20	1.25	1.10
7 Very hot	None	1.00	1.05	0.90

1 For door thresholds the dew point criterion applies according to section 6.
2 The following applies for inclined (45°) and horizontal (0°) components: the actual U_g value of the glazing used for the reference inclination, determined according to DIN EN 673, alternatively according to ISO 15099, should be used. The limit value in the installed state is the same as the limit value of the uninstalled component. The limit value of the component U-value for inclined and horizontal building components see section 6.

Table 2: Passive House efficiency classes for transparent building components

Ψ_{opaque} [W/(mK)]	**Passive House efficiency class**	**Description**
≤ 0.065	phA+	Very advanced component
≤ 0.110	phA	Advanced component
≤ 0.155	phB	Basic component
≤ 0.200	phC	Certifiable component

$$\Psi_{opak} = \Psi_g + \frac{U_f \cdot A_f}{l_g} + H_{ve} + 2 \cdot \chi_{gc}$$

[1] As information on possible solar gains is not available, U_w does not adequately describe the effect of the window in the building. That is why the PHI uses Ψ_{opaque} which is a parameter for the heat losses via the opaque parts of the window. Solar irradiation is not included here either, but because all losses through the frame are specified, a reliable statement can be made about the possible gains and thus the window's energy balance: the smaller the Ψ_{opaque} is, the better the energy balance of the window will be.

[2] $H_{ve} = \left(\frac{\Delta p}{100Pa}\right)^{2/3} \rho \cdot c_p \cdot Q_{100}$ where $\Delta_p = 6Pa$, $\rho \cdot c_p$ = heat capacity of air: 0.344 Wh/(m³K), Q_{100} = air permeability coefficient (m³/hm) at 100 Pa

2.4 Certification categories and scope of certification

Table 3: Categories: Definitions and specifications

Category	External frame dimensions (b * h) [m]	Frame sections to be calculated: OB	OJ	OH	FB	FJ	FH	OT	DL	fm	2m	1m	0m	2t	1t	0t	Installation situations to be calculated[3]	Additional specifications
Window frame (wi)	1.23 * 1.48	**X**	**X**	**X**						*(x)*	*(x)*						EIFS + two others; Sliding doors: EIFS. Entrance door: Section bottom only EIFS.	/
Frame with fixed glazing (fx)					**X**	**X**	**X**						*X*					/
Window system (ws)	1.23 * 1.48, 2.46 * 1.48[4]	**X**	**X**	**X**	*X*	*X*	*X*	*X*	*X*	**(X)**	**(X)**	*X*	*X*	*(x)*	*(x)*	*X*		CE labelling[5], airtightness: $Q_{100} \le 0.25$ m³/(h*m)
Entrance door (ed)	1.10 * 2.20		**X**	**X**				**X**	**X**									Airtightness: ($Q_{100} \le 2.25$ m³/(h*m)), under climate load
Door system (ds)	1,10 * 2,20 2,20 * 2,20		**X**	**X**	**(X)**	**(X)**	**(X)**	**X**	**X**	**(X)**	**(X)**	**(X)**						As 'ed', with additional consideration of fixed glazed elements
Sliding door (sl)	2.40 * 2.50		**X**	**X**	**X**	**X**	**X**	**X**				**X**						Testing of airtightness
Curtain wall façade (cw)	Modulmaß 1.20 * 2.50 see section 3.7				**X**	**X**	**X**					*X*	**X**			**X**		Screws and glass carrier are to be considered
Glass roof (cwi) (45°)					**X**	**X**	**X**					*X*	**X**			**X**	Lightweight roof construction	/
Roof window (rw) (45°)	1.14 * 1.40	**X**	**X**	**X**														/
Skylight, roof light, access hatch (sk) (0°)[6]	1.50 * 1.50	**X**	**X**	**X**	(X)	(X)	(X)										Reinforced concrete flat roof, lightweight roof construction	For access hatches no efficiency class will be given
Continuous roof light	1.50 * 4.50				**X**	**X**	**X**						**2**					Three-dimensional thermal bridges are considered
Opening in glass roof (ocwi) (45°)	1.20 * 2.50	**X**	**X**	**X**													3 certified transom-mullion façades	/

X: included in the calculation; *X*: stated for informative purposes; (X): alternative. One option must be chosen and delivered by the manufacturer.
OB: frame section bottom (openable), **OJ**: frame section side (openable), **OH**: frame section top (openable, **F**: for frames with fixed glazing, **T**: threshold, **DL**: frame section side with window hardware, **fm**: flying mullion, **m**: mullion, **t**: transom, **1**: with one opening element, **2**: with two opening elements

[3] Installation situations are specified by the PHI, deviation from specifications is possible if required, and other installation situations can be calculated. The U-value of the walls/roofs may not exceed the maximum value permissible in the criteria for opaque building components. Additional installation situations will be calculated for verifying EnerPHit suitability, see Section 3.9. Elements, used for installation, are to be considered.
[4] Two elements linked to a flying mullion or fixed mullion
[5] Or equivalent including testing of airtightness, protection from driving rain, suitability for use.
[6] The criterion U_g must be verified for the actual geometry. The criteria U_{sk} and $U_{sk,installed}$ must be verified for glazing that projects horizontally.

2.5 Assignment of the climate zones (regions with identical requirements)

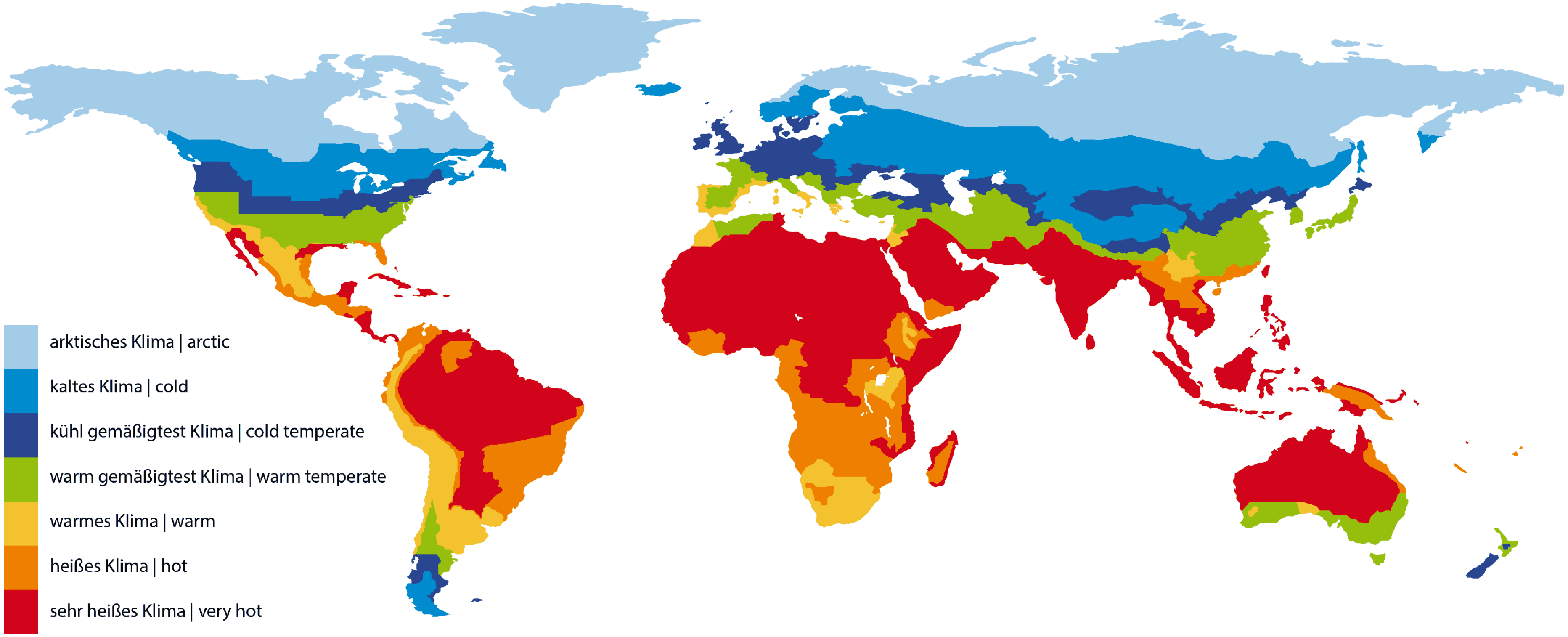


Figure 1: Assignment of regions with identical requirements

3 Functional requirements, boundary conditions, calculation

3.1 *Functional requirement for the Passive House criterion for hygiene*

Maximum water activity (interior building components): **$a_w \leq 0.80$**

This requirement restricts the minimum temperature at the window surface for health reasons. Mould growth may occur if water activity exceeds 0.80. Such conditions should therefore be consistently avoided. For boundary conditions, see 3.4. Water activity is the relative humidity either in a material's pores or directly on its surface. This results in the temperature factors $f_{Rsi=0.25}$ [7] given in Table 1 as acceptable certification criteria for different climates.

3.2 *Functional requirement for the Passive House criterion for comfort*

Minimum temperature of volume enclosing surfaces: **$|\theta_{si} - \theta_{op}| \leq 4.2$ K**

This temperature difference requirement limits the minimum average temperature of a window in heating climates for reasons of comfort. In contrast with the average operative indoor temperature, the minimum surface temperature may deviate by a maximum of 4.2 K. A greater difference may lead to unpleasant cold air descent and radiant heat deprivation. The operative temperature (θ_{op}) is the average obtained from the air temperature and the temperature of the space-enclosing surfaces. It is also known as the perceived temperature and is assumed to be 22 °C in the formula below.

The maximum heat transfer coefficients (U-values) of installed certified transparent Passive House building components under heating dominated situations can be calculated from this temperature difference criterion using the formula below:

$$U_{transparent,installed} \leq \frac{4{,}2K}{(-0{,}03 \cdot \cos\beta + 0{,}13)\ m^2K/W \cdot (\theta_{op} - \theta_e)}$$

Due to the additional heat losses from the installation-based thermal bridge, the requirement is increased by 0.05 W/(m²K) for the uninstalled components and by 0.10 W/(m²K) for the glazing, with reference to the heat transfer coefficients of the installed components.

In the context of feasibility studies it was shown that in warmer heating climates, the economic optimum is achieved with better heat transfer coefficients than are required for the comfort criterion alone. In these climate zones, heat transfer coefficients, which are based on the economic optimum are specified for the certification. The same applies for cold climates. This results in the heat transfer coefficients given in Table 1 as acceptable certification criteria for different climates.

3.3 *Passive House criterion: Limiting the risk of draughts: $v_{air} \leq 0.1$ m/s*

The air velocity in the living area must be less than 0.1 m/s. This requirement restricts the air permeability of a building component as well as cold air descent. For vertical surfaces, adherence to the temperature difference requirement means compliance with the draught requirement. This has not been examined conclusively for inclined surfaces. For vertical surfaces, compliance with the temperature difference requirement means that the draught criterion is also complied with. For inclined surfaces this has not yet been examined conclusively.

3.4 *Boundary conditions for heat flow simulation*

Table 4: Boundary conditions for heat flow simulation

Climate	**Heat transfer resistance R_S [m²K/W]**			**Temperature [°C]**
	Upward 0° ... 60°	Horizontal 60° ... 120°	Downward 0° ... 60°	
Inside (EN 6946)	0.10	0.13	0.17	20
Inside – sloped glazing	$R_{Si} = -0.03 \cdot \cos\beta + 0.13$ (ß = angle of inclination to horizontal)			
Increased on inside (at glass edge area)	0.20			
Inside determination of f_{Rsi}	0.25			
Outside (EN 6946)	0.04			-10
Outside (ventilated)	0.13			
Outside (against ground)	0.00			-10

[7] f_{Rsi} is the temperature factor at the coldest point of the window frame, as an alternative the coldest point in the installed state. At glass dividing sections, (e. g. mullions) the required temperature factor has to be met on at least one of the sections displayed.

3.5 Calculation of f_{Rsi}

Calculation of the temperature factor at the glass edge f_{Rsi}: $f_{Rsi} = \frac{\theta_{si} - \theta_e}{\theta_i - \theta_e}$

with θ_{si}: minimum interior surface temperature as per heat flow calculation [°C]

θ_e: outside temperature as per heat flow calculation [°C]

θ_i: inside temperature as per heat flow calculation [°C]

The result is calculated to 4 decimal places and stated to 2 decimal places.

3.6 Calculation of U-values

In order to obtain directly comparable thermal parameters, the same glazing U-values are used for individual components in the different regions, see façades. The actual glazing U-value is used for horizontal and inclined components.

U-value of an uninstalled transparent building component

$$U = \frac{U_g \cdot A_g + U_f \cdot A_f + \Psi_g \cdot l_g}{A_g + A_f}$$

U: Heat transfer coefficient of the uninstalled transparent building component [W/(m²K)] according to DIN EN ISO 10077-1:2009 Section 5.1.

U-value of an installed transparent building component

$$U_{installed} = \frac{U \cdot A_W + \sum l_i \cdot \psi_i}{A_W}$$

$U_{installed}$: Heat transfer coefficient of the installed transparent building component [W/(m²K)]

A_W: Area of the window ($A_g + \sum A_f$) [m²]

$\sum l_i * \Psi_i$: Sum of all installed lengths [m] multiplied by the respective installed Ψ-value [W/(mK)]. For determination of the geometric characteristic values, see Section 3.7; for determination of the installation-based thermal bridges see Section 3.8.

3.7 Geometric characteristic values

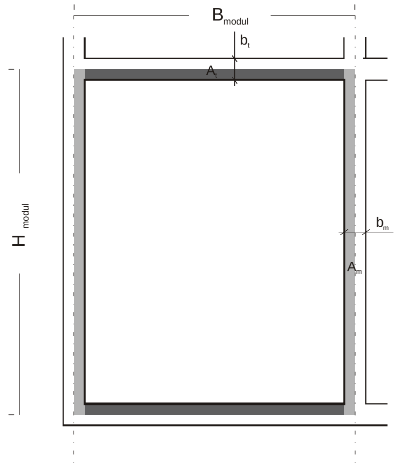
Façade and roof windows

See DIN EN ISO 10077-1, Section 4

In addition: profiles, for example for connecting window sills, are considered part of the frame.

Curtain-wall façades, glass roofs, and opening elements in glass roofs

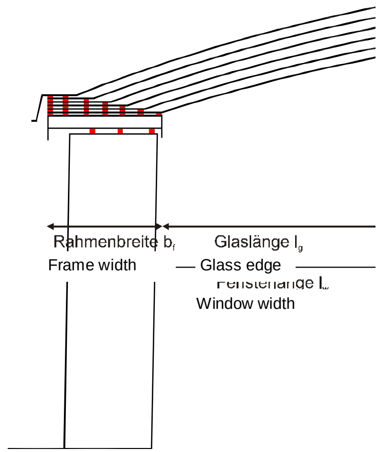
See DIN EN 12631. Variance: the unit size is the testing size ($B_{unit} * H_{unit}$ = 1.2 m * 2.5 m). The left and bottom sides are installed. Similarly to windows, the full width of the mullion/transom is used.



Skylights and dome lights

See DIN EN ISO 10077-1 Section 4. In addition or as variance: l_g is the clearance size between the frames; b_f is the horizontally projecting frame width. Fixing attachments etc. are not considered part of the frame width. Skylight frames and crowns are included in the installation-based thermal bridge. They are not considered part of the frame. 0.30W/(m²K) is specified as the maximum U-value for skylight frames/crowns. This value should be verified in accordance with DIN EN ISO 6946.

With curved dome lights, the actual length of the glass or its area differs from the horizontally projecting glass area to be entered in the PHPP. In the certificate and the data sheet, the projected area is given with a correspondingly increased U-value, adjusted for the reduced area. These values can be taken directly for the PHPP.



3.8 Thermal characteristic values

Frame U-value and glass edge Ψ-value

Ascertained by means of a two-dimensional heat flow simulation; see DIN EN ISO 10077-2 Appendix C. Deviation: profiles, for example for connecting window sills, belong to the frame. The actual glass insertion depth should be used.

Frame U-values are calculated to 4 decimal places and stated to 2 decimal places. Alternatively 3 decimal places can be stated.

Ψ-values are calculated to 5 decimal places and stated to 3 decimal places. Alternatively, 4 decimal places can be stated.

Installation Ψ-value

Ascertained by means of a two-dimensional heat flow simulation; the model for determining the Ψ-value at the glass edge is extended with the exact details of the connection situation. It should be ensured that the model is sufficiently large. As a rule, point attachments of the frame are not included.

$\Psi_{install}$ is determined as follows

$$\Psi_{install} = \frac{Q_{install} - Q_{glass-edge} - U_{wall} \cdot l_{wall} \cdot \Delta\theta}{\Delta\theta}$$

Since the exterior frame dimensions are used in the energy balance (PHPP), the same reference dimensions are used here. Accordingly, the installation gap is included in the installation-based thermal bridge.

Determining the influence of screws in curtain-wall façades

The influence of screws is represented by ΔU and can be determined by a measurement in accordance with DIN EN 1241-2 or by calculation using 3D heat flow software. Alternatively, for screws made of steel, an overall value of ΔU = 0.300 W/(m²K) is used for a distance between 0.2 and 0.3 m between the screws. ΔU, due to the influence of screws, is calculated as follows:

$$\Delta U = \frac{(Q_S - Q_0)}{l \cdot \Delta\theta \cdot b_t}$$

Q_S:	Heat flow with screws (determined numerically or by measurement) [W]
Q_0:	Heat flow without screws (determined numerically or by measurement) [W]
l:	Length of the calculation model [m]
$\Delta\theta$:	Temperature difference between the inside and outside (boundary conditions of the numerical method or the measurement) [K]

If the transoms and mullions have different widths, the smaller width should be used for calculation.

Determining the influence of glass carriers in curtain-wall façades

The influence of glass carriers is represented by the point thermal bridge coefficient of the glass carrier χ_{GT} and can be determined by measurement in accordance with DIN EN 1241-2 or through calculation using heat flow software. Alternatively, for glass carriers made of metal: χ_{GT} = 0.040 W/K, non-metallic glass carriers with screws: χ_{GT} = 0.004 W/K, non-metallic glass carrier: χ_{GT} = 0.003 W/K.

X_{gc} is included in the calculation of the U-value of the façade, multiplied with the number of glass carriers present in the unit. If the glass carriers are screwed in place or attached to bolts, then these screws or bolts must be included in the calculation. Glass carriers that are able to support triple glazing corresponding with the unit size should be used.

X_{gc} [W/(mK)] is calculated as follows:

$$\chi_{gc} = \frac{Q_{gc} - Q_0}{\Delta\theta} \cdot l$$

Q_{gc}:	Heat flow with glass carrier [W]
Q_0:	Heat flow without glass carrier [W]
$\Delta\theta$:	Temperature difference between the inside and the outside [K]

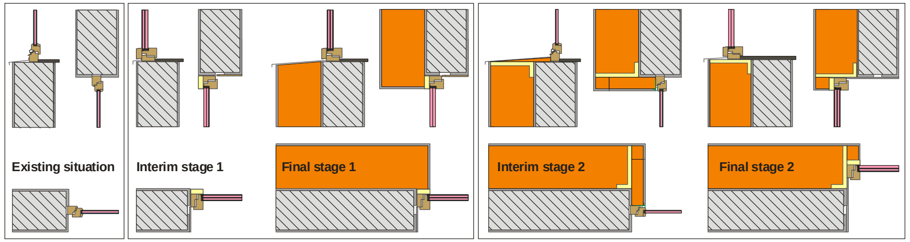
3.9 EnerPHit suitability

Windows and window systems can also be characterised as EnerPHit components. This distinction is made clear on the certificate and in the database by means of the EnerPHit Component Seal.

Suitability is verified if the certification criteria are also achieved for each step of a modernisation that is carried out in a step-by-step manner:

1. Window replacement as a first step:
    a. The new window is installed flush with the exterior wall (in terms of the installation criterion a slight deviation from the limit value is possible).

b. In a second step, the new insulation of the façade is extended to cover the window frame.



2. Window replacement as a second step:
   a. A mounting frame is installed all around the installation opening, the new insulation is joined to this. The old frame is improved by using reveal insulation.
   b. The old window frame is removed, the new window frame is inserted.

The PHI will provide further information relating to this modernisation procedure. A sample installation situation will also be made available. It is possible to derogate from these specifications upon request and a verifiably suitable alternative procedure and can be described and presented in detail. Suitability of the alternative will be checked by the PHI. The hygiene criterion will also be tested in the installed state with the interior boundary condition 0.25 m²K/W.

3.10 Additional consideration of shading elements

Window-integrated or other types of shading elements can be included in the certification. For this, verification of the shading factors of the elements must be provided and the shading elements must be calculated in the installation situations and/or the window (in addition). The possibility of shading will be shown prominently in the certificate and the component database of the Passive House Institute.

3.11 Special regulations

Compound and box windows

- Glazing U-value U_g to be used: the actual glazing U-value of the combined insulated glass unit, the intermediate space and the glazing in front. The reference U_g value that is best for the insulated glass unit is used.
- Thermal conductivity of the intermediate air space taken from the R-value in accordance with the table in DIN EN ISO 10077-2 Appendix C. The R-value for 50 mm given in the mentioned table can be used for intermediate air spaces larger than 50 mm. Alternatively, DIN EN ISO 673 can be used for calculation.
- Basic approach for the calibration plate of box windows: geometry of glass panes as calibration plate, intermediate air space as before, for compound windows: as stated in DIN EN ISO 10077-2.

Entrance doors

- The maximum allowable height of the threshold profile is 20 mm (see DIN 18040-1, -2, section 4.3.3.1).
- Under all the boundary conditions mentioned below, the entrance door achieves the airtightness class 3 in accordance with DIN EN 12207 (based on the joint length).
- Airtightness of a complete door element is determined through measurement in accordance with DIN EN 1026 under the following boundary conditions:
  - Laboratory conditions
  - Boundary conditions according to DIN EN 1121, test climate d: inside 23 ± 2 °C, 30 ± 5 % relative air humidity; outside -15 ± 2 °C, test climate e: inside 25 ± 5 °C; temperature load outside due to infrared source 55 ± 5 °C above inside temperature. Only for wooden entrance doors: test climate "C": inside 23 ± 2 °C, 30 ± 5 % relative air humidity; outside 3 ± 2 °C, 85 ± 5 % relative air humidity
  - In deviation from DIN EN 1121 the test must be carried out for a closed but unlocked door. For simplification of the test procedure, deformation of the door can be measured under the given climatic boundary conditions and re-adjusted during the measurement of the air permeability coefficient.
- Additional variants with glazing can be stated in the certificate. The U_g-value of the actually installed glazing can be used to calculate the U_D values.
- Additionally other frame sections can be shown for glazing at the side and skylights. The reference U_g-value can be used.
- The minimum temperature factor of the respective climate zone may be lower at the threshold profile.
- In special cases, 3D heat flow simulations may become necessary which must be agreed between the client and the PHI.

Plastic / vinyl windows

- In the case of plastic windows, adequate reinforcement shall be used for the respective reference size.
- The reinforcement must also be suitable for coloured window frames. Otherwise, the certificate will explicitly state a limitation to certain colours.
- The certificate state the maximum permissible element size with the reinforcement used.

Aluminium windows

- A window is only considered as an ‘aluminium window’ where the aluminium has a structural function.

Basic approach for thermal conductivities (λ)

- In principle, only the rated value of the conductivity is taken into account.
- If no rated value is available, the procedure in DIN EN ISO 10077-2:2012 Section 5.1 is to be followed.
- Anisotropic behaviour of materials is to be considered: λ in direction of the fibre = correction factor * λ perpendicular to the fibres. For timber, the correction factor is 2.2. For fibre reinforced materials, a correction factor of 1.5 is applied, as long as no other evidence is given.

Reduced emissivities of metal surfaces

- In closed cavities these will be assigned according to DIN EN ISO 10077-2
- Lower values can be assigned following submission of sufficient evidence

Spacers

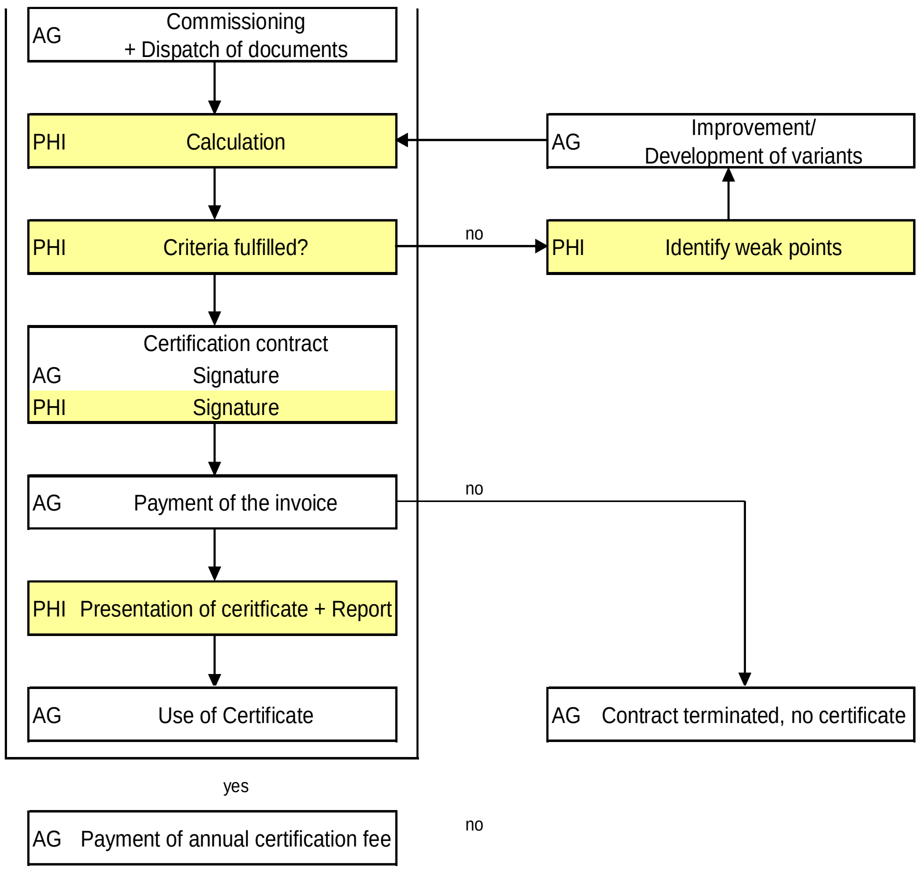
- Warm edge spacers can be chosen freely by the certificate holder. The 2-Box models of the “Warm Edge Working Group” should be referred to (Box 2 for spacers) for calculation.
- The secondary seal (Box 1)
  - Can also be freely selected, provided that it has been approved for the chosen spacer.
  - For categories in which the longest side of the reference element is less than or equal to 1.5 m, a 4 mm sealant thickness is assumed as standard; for larger elements this is 6 mm.
  - For structural glazing, 6 mm must always be used.
  - Where the manufacturer provides suitable evidence that their glass supplier uses a certain sealant thickness, then this can be used. Details of this will be noted in the ‘description’ section of the certificate.
  - If the selected spacer requires a greater sealant thickness, this should be used.
- Beyond this, there is the possibility of certification with a spacer category corresponding with the criteria for "Spacers in low-e glazing" of the Passive House Institute. The following reference spacers are acceptable for this purpose: Height of box 2: 7 mm, thermal conductivity of box 2: [W/(mK)]: phA: 0.2, phB: 0.4, phC: 1.0.

Other stipulations

- For windows and fixed glazing, the connection at the top of masonry walls with a compound insulation system is calculated without the concrete lintel.
- The bottom frame section must specifically provide the possibility of drainage. This draining facility is part of the window frame and is not part of the installation situation.
- Concealed and mounting frames are treated as part of the installation location.
- With the exception of the cold and arctic climates, a product must at least achieve the requirements of the climate zone of the address stated on the component certificate. The decisive factor is the climate zone of the respective PHPP climate data set. Exceptions to this rule can be made if the named location is located in the border area of two climate zones.

4 Formal aspects, services provided by the Passive House Institute

4.1 *Certification procedure*



4.2 *Documents required*

The following documents should be provided to the PHI by the manufacturer for the calculation.

1. **Sectional drawings** (for all different sections) of the window frames or mullion/transoms, including installed low-e triple glazing, as DXF or DWG files.

2. Information about the **materials and rated values of the conductivities** used (and the density, if necessary). It must be possible to assign the materials clearly on the basis of the drawings (legend; hachure). The rated values of the thermal conductivities of the materials used should be given in accordance with DIN V 4108-4, DIN EN ISO 10077-2 or DIN EN ISO 10456. If the thermal conductivity of a material is not listed in any of these standards, it can be substantiated on the basis of general building approval permits or by a general building approval examination. If a rated value for the thermal conductivity cannot be given, the PHI reserves the right to apply a security surcharge of 25 %.

3. Exact **product information about the spacer**. If necessary, exact information about the geometry and materials, if the spacer is as yet not known to the PHI.

4. **Drawings of installation variants** for installation in three Passive House suitable exterior walls with maximum U-values corresponding to the climate zone. Sectional drawings (for all different sections) as DXF- or DWG-files.

4.3 *Services provided by the Passive House Institute*

Frame sections and installation situations:

1. Processing of the relevant CAD drawings according to the documents to be provided, for further calculation in accordance with Table 3.
2. Calculation of the U-values and Ψ-values required for certification based on DIN EN 10077 and calculation of the temperature factor.
3. Calculation of variants for the thermal optimisation of the frame in consultation with the client.

The costs incurred for the calculation of variants will be invoiced to the client after prior consultation.

Documentation with the certificate report including representation of isotherms.

Certification:

4. Use of the certificate
5. Implementation of thermal characteristic values of the product in the Passive House Planning Package PHPP.
6. Use of the seal "Certified Passive House component" and if applicable, "EnerPHit Component" by the client.

Presentation in the component database of the Passive House Institute

The component will be presented in the component database of the Passive House Institute together with the certificate. In the category "Window System" the component can be shown as an actual image or a rendering (to be provided by the client). In this category an option is available for showing further information about the certified product, such as photographs, illustrations and technical documents.

Availability of the component in different countries can be indicated and shown. Furthermore, for an extra charge (in addition to the certificate fee) it is possible to show other production sites or distribution locations in addition to the head office of the certificate subscriber using a map.

4.4 Coming into effect, temporary provisions, further development

The certification criteria and calculation regulations for Passive House suitable transparent building components shall become fully effective with the publication of this document. All previously published criteria shall cease to apply with the coming into force of these provisions. Existing certificates will remain valid until further notice. The Passive House Institute retains the right to make future changes.

5 Abbreviations, indices, formula symbols

	English	Deutsch
A	area	Fläche
a_W	water activity	Wasseraktivität
OB	bottom section, openable	Rahmenschnitt unten, öffenbar
FB	bottom section for fixed glazing	Rahmenschnitt unten für Festverglasung
cw	curtain wall	Pfosten-Riegel-Fassade
cwi	glass roof	Glasdach
DJ	entrance door, jamb / hinge side	Eingangstür, Bandseite
DL	entrance door, locking side	Eingangstür, Schlossseite
ec	exterior corner	Außenecke
ed	entrance door	Haustüre
f	frame	Rahmen
FH	top section for fixed glazing	Rahmenschnitt oben für Festverglasung
FJ	side section for fixed glazing	Rahmenschnitt seitlich für Festverglasung
fm	flying mullion	Stulp
f_{Rsi}	temperature factor	Temperaturfaktor
fx	fixed window	Rahmen mit Festverglasung
g	glass edge	Glasrand
g	glass	Glas
gc	glass carrier	Glasträger
H	heat loss	Wärmeverlust
i	installation	Einbau
K	Kelvin	Kelvin
l	length	Länge
0m	mullion for fixed glazing	Pfosten für Festverglasung
1m	mullion with one opening element	Pfosten mit einem Öffnungselement
2m	mullion with two opening elements	Pfosten mit zwei Öffnungselementen
ocwi	opening element in glass roof	Öffnungselement im Glasdach
OH	top section	Rahmenschnitt oben
OJ	side section, openable	Rahmenschnitt seitlich, öffenbar
OJ2	side with handle	Seitlich mit Drückergarnitur
OT	threshold	Schwelle
Rse	heat transfer resistance - external surface	Wärmeübergangswiderstand Außenoberfläche
Rsi	heat transfer resistance - internal surface	Wärmeübergangswiderstand Innenoberfläche
rw	roof window	Dachflächenfenster
sk	skylight	Oberlicht, Lichtkuppel
sl	sliding door	Schiebetüre
0t	transom for fixed glazing	Kämpfer für Festverglasung
1t	transom with one opening element	Kämpfer mit einem Öffnungselement
2t	transom with two opening elements	Kämpfer mit zwei Öffnungselementen
U	heat transfer coefficient	Wärmedurchgangskoeffizient
ve	ventilation	Lüftung
W	window	Fenster
wi	window	Fenster
ws	window system	Fenstersystem
xx	folding window	Faltanlage
β	inclination	Neigungswinkel
Χ	thermal bridge coefficient, point	Wärmebrückenverlustkoeffizient, punktförmig
Ψ	thermal bridge coefficient, linear	Wärmebrückenverlustkoeffizient, linear

6 Selected boundary conditions for determining the hygiene and comfort criteria (informative)

Region No.	Name	Boundary condition for hygiene criterion		Hygiene criterion		Dewpoint criterion		Ambient temperature for comfort criterion [°C]	Maximum heat transmission coefficient			
		θ_a	rHi	$\theta_{Si,min}$	f_{Rsi} =0,25m²K/W	$\theta_{Si,min}$	f_{Rsi} =0,25m²K/W		Orientation	[°]	$U_{W,inst.}$	U_W
1	Arctic	-34,00	0,40	9,20	0,80	6,00	0,74	-50	vertical inclined horizontal	90 45 0	0,45 0,50 0,60	0,40 0,50 0,60
2	Cold	-16,00	0,45	11,00	0,75	7,80	0,66	-28	vertical inclined horizontal	90 45 0	0,65 0,70 0,80	0,60 0,70 0,80
3	Cool-temperate	-5	0,50	13	0,70	9	0,57	-16	vertical inclined horizontal	90 45 0	0,85 1,00 1,10	0,80 1,00 1,10
4	Warm-temperate	3,00	0,55	14,00	0,65	10,70	0,45	-9	vertical inclined horizontal	90 45 0	1,05 1,10 1,20	1,00 1,10 1,20
5	Warm	10,00	0,70	15,50	0,55	14,30	0,43	-4	vertical inclined horizontal	90 45 0	1,25 1,30 1,40	1,20 1,30 1,40
6	Hot	not relevant		not defined		not relevant		not relevant			1,25	1,20
7	Extremly hot, often humid	not relevant		not defined		not relevant		not relevant			1,05	1,00

ANNEX II - CRITERIA AND ALGORITHMS FOR CERTIFIED PASSIVE HOUSE COMPONENTS: OPAQUE CONSTRUCTION SYSTEMS

Criteria and Algorithms for Certified Passive House Components: Opaque construction systems

Version 3.1_en, 07.02.2022 kk/el

Contents

Note: Certificates are currently only being issued for arctic, cold, cool-temperate and warm-temperate regions (see Section 2.3). Criteria for all climate zones except the cool-temperate climate zone are subject to modifications as these criteria are currently in the experimental phase.

Legal note: For all construction details, only the heat flow shall be examined. The absence of condensation and internal moisture transport processes and protection from entry of moisture as well as other aspects relating to building physics, practical construction or structural stability are not covered by these investigations. The applicant, designer or manufacturer are responsible for this as necessary. The PHI assumes that the submitted documents are free of third-party rights. By submitting the documents for certification, the applicant declares that he or she is in possession of all rights to the full extent.

1 Preface

Passive House buildings provide optimal thermal comfort with very low energy costs, and they lie within the economically profitable range with reference to their life-cycle costs. In order to achieve this level of comfort and the low life-cycle costs, the thermal quality of the components used in Passive Houses must meet stringent requirements. These requirements are directly derived from Passive House criteria for hygiene and comfort as well as from feasibility studies. The Passive House Institute has established component certification in order to define quality standards, facilitate the availability of highly efficient products and promote their widespread application, and to provide planners and building owners with reliable characteristic values for input into energy balancing tools. The present document contains the criteria and algorithms for the calculation and certification of opaque building components.

2 Certification criteria

2.1 *Verifying Passive House suitability, certificate*

The Passive House suitability of products is verified using the U-values of the opaque building components (walls, floors and roofs), the linear thermal bridges (Ψ-values) and minimum surface temperature / temperature factor of the junctions listed in table 2, which are calculated in accordance with ISO 10211. All assemblies are then assessed according to DIN EN ISO 13788 to check the risk of interstitial condensation. The results are then compared against the criteria listed in Table 1; where the criteria are met, the system can be certified, see 4.3.2.

Documentation (see 4.2) provided by the manufacturer applying for a certificate form the basis for this. Opaque building systems can be certified in the categories construction system, floor slab system, wall system and roof system. The information contained in the certificate and the respective data sheets includes the manufacturer and system description, certificate category and suitability for the climate zones and the relevant characteristic values for input in the PHPP and designPH.

2.2 *Criteria for issue of the certificate*

For issue of the certificate, the following criteria must be complied with in the context of certification:

2.2.1 Criteria to be fulfilled depending on the climate zone

Table 1: Certification criteria

<table>
<tr><th>Climate zone</th><th>Hygiene criterion[8]</th><th>Comfort criterion</th><th colspan="3">Efficiency criteria</th><th colspan="2">Moisture criteria[6]</th></tr>
<tr><td></td><td>$f_{Rsi=0.25\ m^2K/W}$ ≥[3]</td><td>U-value of the installed window[1] ≤</td><td>U-value of the exterior building component $U_{opaque} * f_{R\ PHI}^{2}$ ≤</td><td>Purely opaque details $f_{Rsi=0.25\ m^2K/W}$ ≥[3]</td><td>Absence of thermal bridges Ψ_a ≤[4]</td><td>Condensation</td><td>Ma limit according to DIN EN ISO 13788 ≤</td></tr>
<tr><td></td><td>[-]</td><td>[W/(m²K)]</td><td>[W/(m²K)]</td><td>[-]</td><td>[W/(mK)]</td><td>[-]</td><td>[g/m²]</td></tr>
<tr><td>1 Arctic</td><td>0.80</td><td>0.45 (0.35)</td><td>0.09</td><td>0.90</td><td rowspan="7">0.010[5]</td><td rowspan="7">Condensation should be completely evaporated at the end of 12 months</td><td rowspan="7">200[7]</td></tr>
<tr><td>2 Cold</td><td>0.75</td><td>0.65 (0.52)</td><td>0.12</td><td>0.88</td></tr>
<tr><td>3 Cool, temperate</td><td>0.70</td><td>0.85 (0.70)</td><td>0.15</td><td>0.86</td></tr>
<tr><td>4 Warm,temperate</td><td>0.65</td><td>1.05 (0.90)</td><td>0.25</td><td>0.82</td></tr>
<tr><td>5 Warm</td><td>0.55</td><td>1.25 (1.10)</td><td>0.50</td><td>0.74</td></tr>
<tr><td>6 Hot</td><td>None</td><td>1.25 (1.10)</td><td>0.50</td><td>0.74</td></tr>
<tr><td>7 Very hot</td><td>None</td><td>1.05 (0.90)</td><td>0.25</td><td>0.82</td></tr>
</table>

1 applies for vertical windows with a test size of 1.23*1.48 m. The criteria for other transparent building components can be taken from the relevant certification criteria. Value in brackets: respective reference glazing.
2 $f_{R,\ PHI}$: Reduction factor: always 1, exception: areas in contact with the ground and towards the unheated basement in the climate zones 1-4: 0.6; e.g. for climate zone 3 the U-value criterion becomes 0.25 W/(m²K).
3 $f_{Rsi=0.25\ m^2K/W}$ ≥ see Section 3.8.
4 as a thermal bridge loss coefficient based on external dimensions and length. Specific constructions such as inner edges are exempted from this criterion.
5 Geometric thermal bridges, where the insulation thickness around the junction is consistent, but the calculation methodology results in a Psi-value of > 0.010 W/(mK), are exempt from this criterion.
6 These criteria are based on the Glaser Method and allow an assessment of the likelihood of the occurrence of interstitial condensation during the winter. This method brings more reliable results for lightweight and airtight components used in cool and non-humid locations away from the equator that do not contain materials with a large water or heat storage capacity. Where the criteria are not met following this approach, a dynamic simulation according to EN 15026 can be carried out to provide greater detail. It is the responsibility of the architect to ensure the appropriate assessments have been carried out for specific buildings, which may include more detailed analyses than those carried out for this certification. In addition on-site measurements like airtightness testing as well as trained tradespeople help to ensure construction quality.
7 The Ma limit (maximum accumulated moisture content) is based on the ISO 13788 and reflects the maximum amount of condensate in order to prevent run-off of liquid water from watertight surfaces. It may make sense in certain cases to calculate a more specific Ma limit according to the materials present in the wall, roof and floor constructions.
8 For door thresholds the dew point criterion applies according to section 6.

2.2.2 Airtightness of all standard building components and connection details

A professional quality standard of airtightness must be ensured in the building and at the connection details in terms of planning as well as execution, and will be checked during the certification process based on the documents submitted. Where conditions in the region of deployment require it, windtightness of the system should also be considered.

2.2.3 Special cases

Regularly occurring or recurrent penetrations and geometric features of the building components are taken into account in the U-value calculation of the standard building components. The criteria for the thermal bridge coefficients must be complied with under consideration of these special cases.

2.3 *Assignment of climate zones (regions with identical requirements)*

The climate zone is assigned based on the location of the manufacturer's headquarters, or any other facility where the manufacturer conducts its operations. The nearest PHPP climate data set will be used; further climate data sets can be requested from PHI where this is uncertain, e.g. in regions with wide variations in altitude. The certification criteria and a certificate that is issued based on them are valid for the assigned climate zone and also for climates with lesser requirements, bearing in mind however that more economical solutions may be possible. These climate zones are as follows:

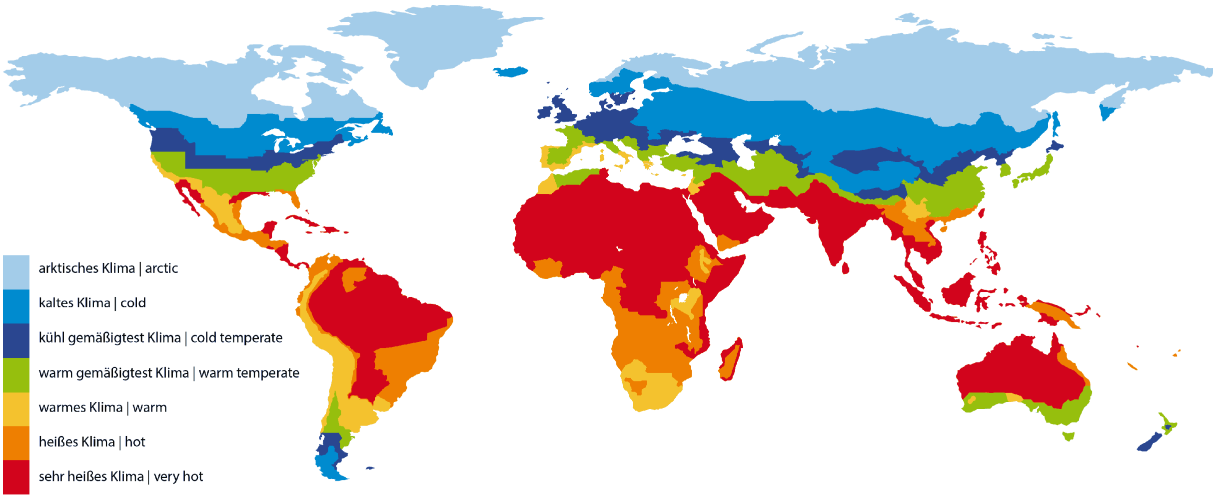
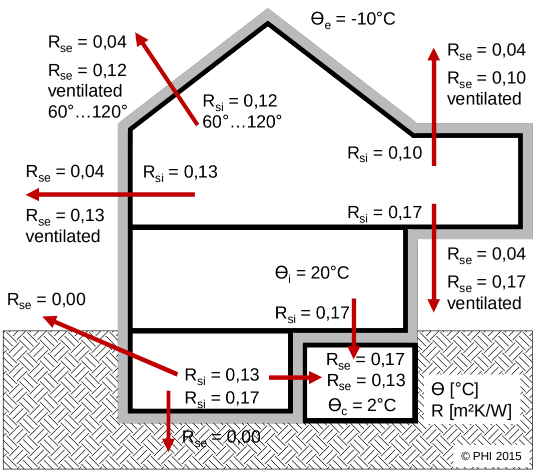


Figure 1: Assignment of regions with identical requirements, based on studies by the PHI

3 Boundary conditions, calculation

All calculations will be carried out by the Passive House Institute. Calculations performed by the manufacturer or third parties shall only be accepted in exceptional cases and after prior consultation.

3.1 *Temperatures and heat transfer resistances for heat flow simulation*



R_{si} is always set as 0.25 m²K/W for calculating the temperature factors.

3.2 *Minimum value of the thermal transmittance, thermal conductivities*

The U-value is calculated in accordance with general technical rules; interruptions of the insulation layers of the standard building component are included in its thermal resistance. The resulting U-value must correspond with the criterion.

In principle, the rated value of the thermal conductivity is taken into account when calculating the U-values. This applies unless other provisions have been made known by the Passive House Institute.

If there is no rated value, then a nominal value of the thermal conductivity determined by a recognised materials testing institute in accordance with the relevant norms can be used as a basis. Similarly to the rated value additions, this nominal value is normally multiplied by 1.20 and the result is used in the calculation, see Section 4.2.

3.3 *Thermal bridge calculation, absence of thermal bridges*

Absence of thermal bridges is verified by means of multi-dimensional heat flow simulations. The fundamental principles for this, especially regarding the specified calculation approaches for building components that are in contact with the ground, are to be found in the publications by the PHI.

In special cases, such as the connection situation of the internal edge to the exterior wall, the equivalent Ψ-value may exceed 0.01 W/(mK); the requirements of the hygiene criterion will remain unaffected by this. The Ψ-value for the installation thermal bridge of the window frame in the case of window and door installation situations can also exceed 0.01 W/(mK). The maximum thermal resistance of the installed element will remain unaffected by this. The final decision regarding the need for compliance shall be made by the Passive House Institute.

3.4 *Airtightness*

This should be verified by detail representation, text descriptions of the creation of the airtight layer, the materials used for this and a general description of the overall system. The graphical representation should be such that the layers and connections of the membranes and sealing materials to the walls and windows frames are recognisable. All connection details must be planned and executed in a permanently airtight manner.

The airtight layers must be clearly identified in the submitted documents (e.g. outlined in red ink).

3.5 *Doors, windows and French windows*

A reference Passive House frame specified by the Passive House Institute or an actual Passive House frame equipped with glazing corresponding to the reference glazing of the selected climate zone shall be used for window and French window connections in the submitted construction system.

French windows shall be tested in a connection situation in the area of the balcony connection without any influence by the ground.

Component size: window: 1.23 m * 1.48 m., French window: 1.10 m * 2.20 m, roof window: 1.14 m * 1.40 m.

Other specifications for certified French windows and patio doors: see "Criteria and algorithms for certified Passive House components: Transparent building components".

3.6 *Special regulations*

If selective penetrations form part of the construction system to be certified, a distinction should be made:

Dowels or other attachment elements occurring regularly across the area should be converted to the overall U-value of the wall system; this must remain below the required U-value. Selective thermal bridge loss coefficients are determined by means of 3-dimensional heat flow simulations.

Regularly occurring projections (e.g. in the foundation or base of the wall, balcony attachments etc.) should also be determined by means of 3D heat flow simulations and should be converted to the linear thermal bridge; the equivalent Ψ-value thus calculated must remain below 0.01 W/(mK).

In the context of certification of the system, the corresponding outdoor temperatures shall be adopted for opaque building components in the case of rooms or hollow spaces outside of the thermal envelope area. The unheated basement is the only exception.

3.7 *Geometric specification*

The external dimension is the reference dimension for effective lengths for U-value calculation.

3.8 *Calculation of f_{Rsi}*

The temperature factor $f_{Rsi=0.25\ m^2K/W}$ defines the coldest point which can occur on the interior surface of a construction system. For example, if the temperature factor is 0.7, then 70% of the temperature difference between the inside and outside air is still present at the interior surface. If the temperature factor is achieved, then mould and condensation formation can be safely prevented at normal outdoor temperatures, indoor temperatures and indoor air humidity levels. The colder the outdoor climate is, the higher the requirement for the temperature factor will be. 0.25 m²K/W in the index means that the heat transfer resistance to be used is 0.25 m²K/W.

Calculation of the temperature factor f_{Rsi}: $f_{Rsi} = \frac{\theta_{si} - \theta_a}{\theta_i - \theta_a}$

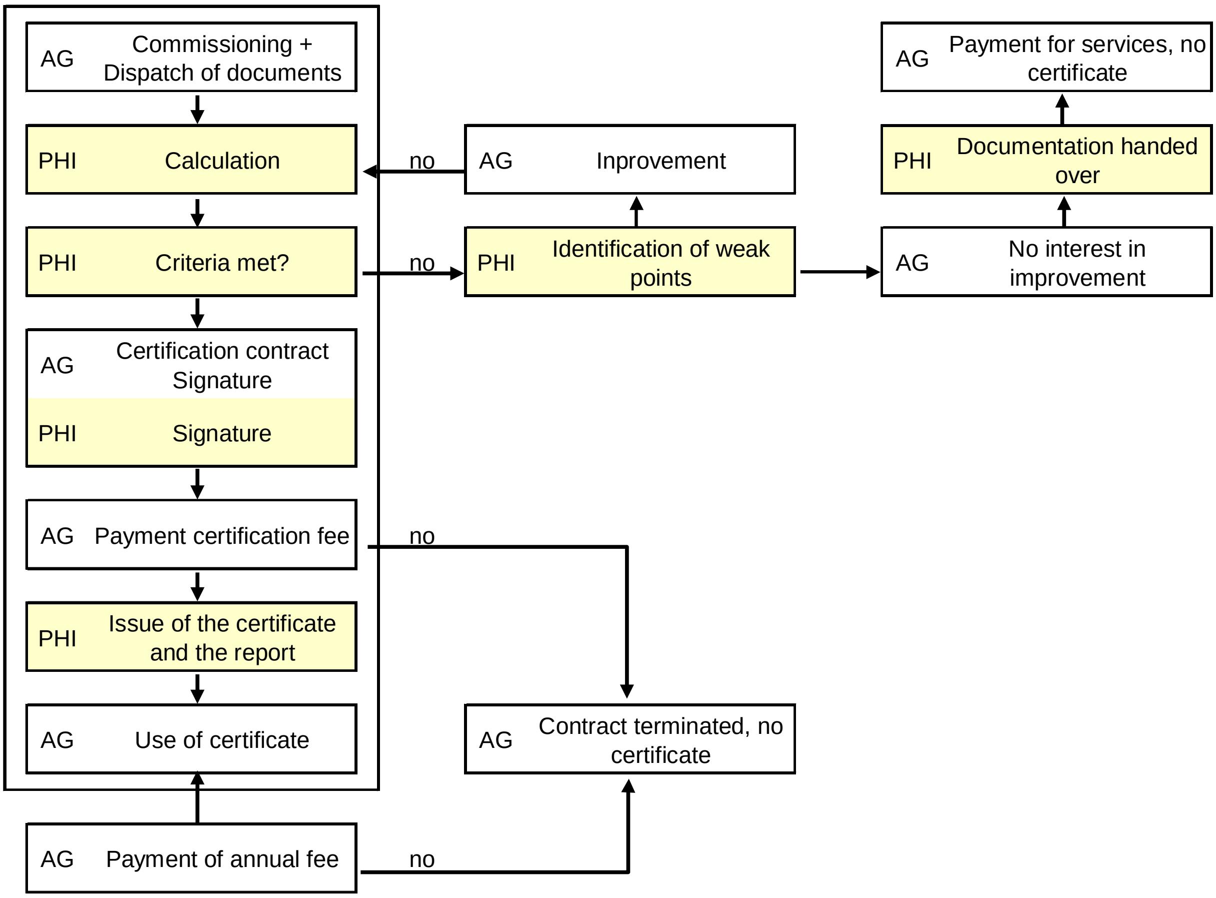
with θ_{si}: minimum interior surface temperature as per multi-dimensional heat flow calculation [°C]

θ_a: outside temperature as per multi-dimensional heat flow calculation [°C]

θ_i: inside temperature as per multi-dimensional heat flow calculation [°C]

4 General information, services provided by the Passive House Institute

4.1 *Certification procedure*



4.2 *Documents required*

The applicant should provide the following documents to the PHI for the calculation, and also any other documents requested.

1. Detail drawings of the required connection situations submitted as dxf or dwg files and as pdf files or publishable image files in the formats pdf, bmp, jpg or png. Materials with different thermal conductivities should be shown differently.
   The drawings of all standard building component assemblies should be shown with at least 3 recurrent interruptions or standard construction elements (if present) and the required connection situations formed with at least 2 metres of the respective building component and depiction of the sub-constructions or the assigned interruptions.
   Depending on the special features of the system specific to the manufacturer, construction elements or dummy constructions may be provided by the PHI if necessary. These may be specified for example for window frames, floor slab assemblies or basement constructions for use during the certification procedure.
   Tables should be provided with information relating to rated values of the thermal conductivities, layer thicknesses and descriptions of materials for all building component assemblies. The latest template provided by the PHI is to be used for this. All materials, including those outside of the standard assemblies of the building components should be listed and specified in detail.

2. The rated[1] values of the thermal conductivities of the materials used for the chosen assemblies and connections must be verified in advance of commencement of analysis, either in accordance with DIN V 4108-4, DIN EN ISO 10077-2 or DIN EN ISO 10456, or if different from these, based on the results of examination by a

[1] It is critical here to differentiate between the declared lambda value, λ_D, and the rated or design lambda value, λ_R – the former is determined under laboratory conditions, whereas the latter takes into account operating conditions and the ageing of the material.

recognised testing laboratory to ISO 8302; EN 12664, EN 12667, EN 12939, a general building permit or a general building approval examination (including CE marking, declaration of conformity or local equivalent if outside of the EU). The PHI reserves the right to apply a security surcharge of up to 25% of a given value if it is not possible to state a rated value for the thermal conductivity. Different thermal conductivities of anisotropic materials depending on the direction of heat flow shall be taken into account. For example, a factor of 2.2 shall be adopted for wood. Location specific variations due to fluctuations in humidity and temperature may also need to be taken into account for products intended for buildings in extreme climates.

3. It is necessary to provide exact information about the geometry and number of sub-constructions, centre distances, and spacers in system-related area units and the additional use of materials if such elements are used, and where necessary, these should be shown as additional detail drawings. In the case of systems with approvals, the assigned technical data sheets must be provided. In addition, it is necessary to mention separately the ascertained point heat loss coefficients in [W/K].

4. Verification relating to water absorption of insulation materials that are in contact with the ground when fully submerged in water for a long time, water absorption due to diffusion, closed cell structure and the calculated poorest value (rated value) of the thermal conductivity in [W/(mK)]) which is to be used.

5. Complete documents relating to general building permits or comparable documents for load-transferring insulation materials in contact with the ground.

4.3 *Services provided by the Passive House Institute*

4.3.1 Certification procedure

1. Processing of the CAD drawings and preparation of the calculation models of the available details for subsequent heat flow simulations.
2. Calculation of the U-values of the standard building component assemblies.
3. Calculation of the equivalent thermal conductivities according to the methodology set out in the supplement to this document and U-values of the standard building component assemblies, thermal bridge loss coefficients, temperature factors and surface temperatures based on the submitted documents with reference to compliance with the certification criteria.
4. Additional calculation of variants for checking thermotechnical improvement or checking the creation of airtight levels in submitted connection situations. The costs for calculating variants shall be charged to the client after prior consultation.
5. Documentation of the results of the certification using isothermal images, specific value sheets and final evaluation of the construction system to be certified, in German or English.

4.3.2 Certificate (after a successful certification procedure, payment of annual fee and provision of a signed, stamped and dated copy of PHI's contract concerning general terms and conditions and use of the component seal):

Issue of the certificate by the Passive House Institute. Inclusion of the certified product in the Institute's own component database and the Passive House Planning Package (PHPP) database, and in the newsletters issued by the networks iPHA and IG Passivhaus, permission to use the component seal in the form of a vector graphics image.

4.4 *Coming into force, temporary provisions, further development*

The certification criteria and calculation regulations for Passive House suitable opaque building components shall become fully effective with the publication of this document. All previously published criteria shall cease to apply with the coming into force of these provisions. Previously issued certificates have the right of continuance. Old certificates may be changed upon request and applied for. Changes in layout with adaption of the Seal only will be made without charge; new calculations will incur costs. The Passive House Institute retains the right to make future changes.

4.5 *Required two-dimensional connection details for the certification categories*

Two dimensional connection details form the majority of the calculations considered in construction system certification; the diagram below shows the standard connection details. There are different requirements depending on the certification category; for further details see section 5.

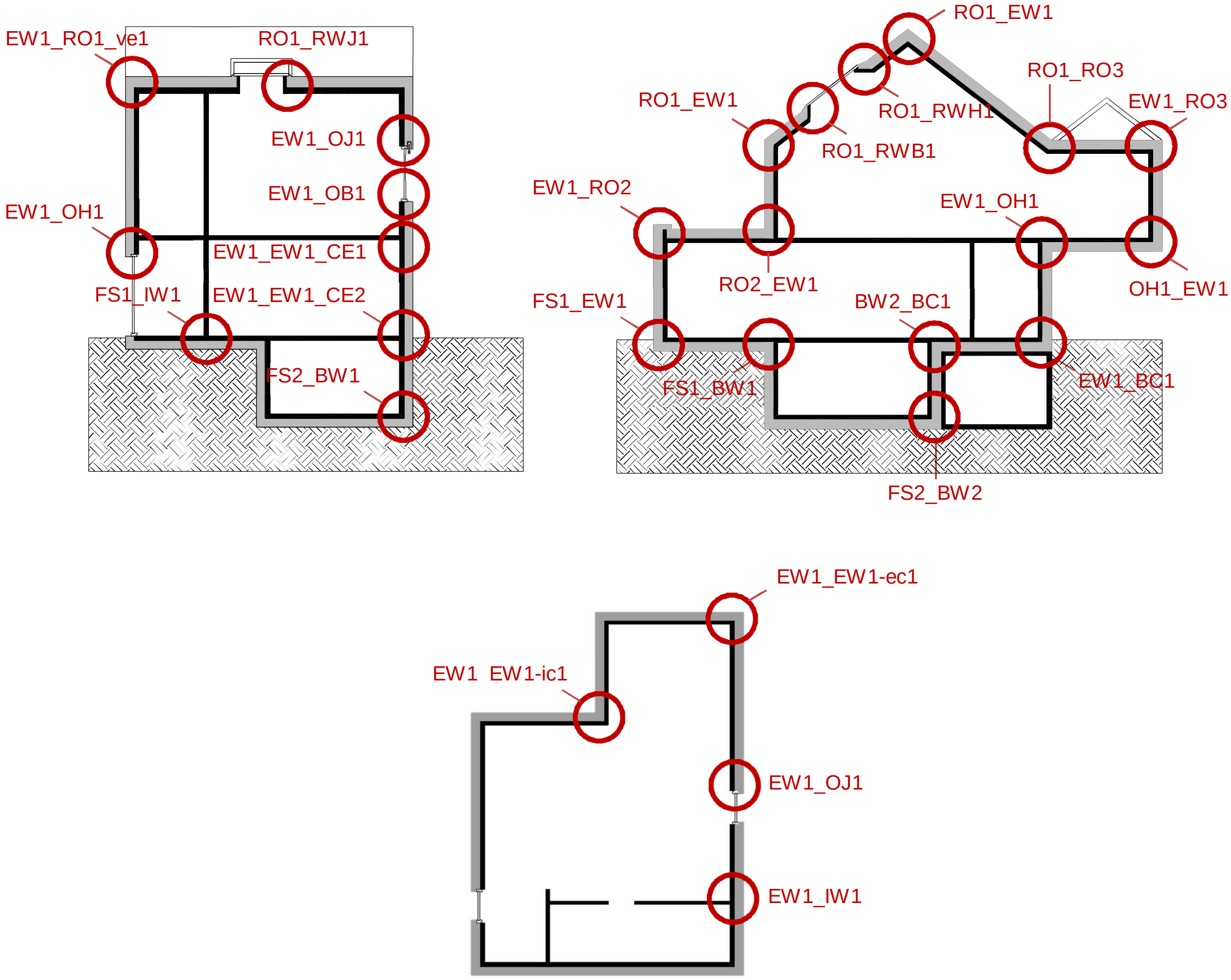


Figure 2: Required connection details

4.6 *Required three-dimensional connection details*

Where three-dimensional or 'point' thermal bridges exist in the standard construction of walls, floors and roofs, these must be taken into account in the U-value calculation as a ΔU or surcharge, based on the number of elements per m² of external area[2]. Depending on the complexity, this can be done in one of two ways:

- For ETICS systems using EPS with simple façade anchors, the values established in Appendix A of the Passive House Institute publication 'Protokollband Nr. 35: Thermal Bridges and Structural Engineering – the Limits of Thermal Bridge Free Construction' may be used, as long as the design is comparable.
- Where this approach is not applicable, the χ-value [W/K] of the element must be calculated by PHI using three-dimensional FEM software in accordance with ISO 10211.

Point thermal bridges can also occur as part of two-dimensional connections, for example where roof beams continue through the external wall to the outside; such penetrations must also be modelled in three-dimensions by PHI and taken into account in the linear heat loss value. These cases should be discussed with PHI prior to certification.

The values of components already certified by PHI can be used without the need for further analysis. Service penetrations are not taken into account in the certification, however these should be considered in the energy balance calculations of real world construction projects.

[2] This figure is to be provided by the manufacturer. Depending on the classification of the building and the climate for which the construction system is intended, the number of point thermal bridges required per square metre of external wall may vary; the most conservative figure should be used to ensure the resulting U-values are on the safe side.

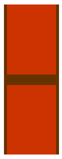
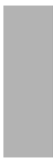
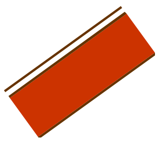
5 Acronyms for categories, building components and connections

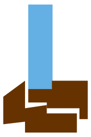
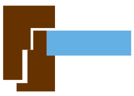
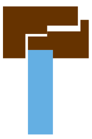
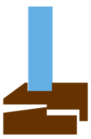
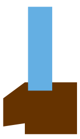
5.1 *Abbreviations for subgroups of opaque construction systems*

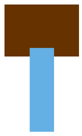
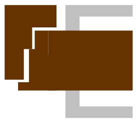
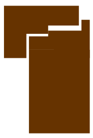
Description	Abbreviation
CONSTRUCTION SYSTEM	cs
WALL SYSTEM	wa
ROOF SYSTEM	rc
FLOOR SLAB SYSTEM	fs

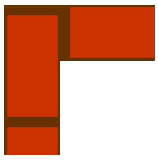
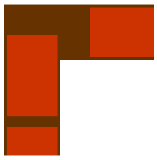
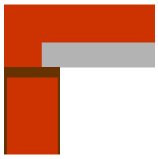
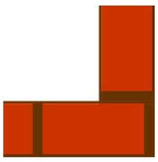
5.2 *Abbreviations for building components and specification of connections*

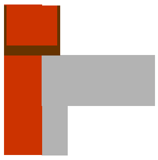
Table 2: Categories and two-dimensional connection details (individual details can be left out in agreement with the PHI). Abbreviations are explained below.

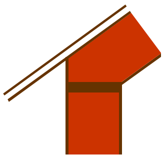
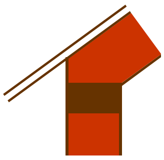
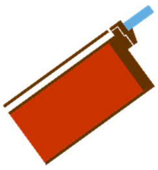
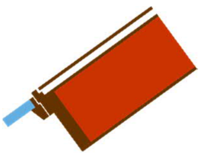
Element(s)	Image	Designation	Certification category				Note
			cs	wa	rc	fs	
External wall (e.g. EIFS)		EW1	X	X		X	For roof and floor systems standard wall constructions will be used (EIFS; lightweight timber and concrete formwork)
External wall (e.g. lightweight timber)		EW2	(X)	(X)		X	
Basement wall		BW1					
Separating internal wall		IW1	X	X			
structural internal wall		IW2	(X)	(X)			
Roof		RO1	X	X	X		

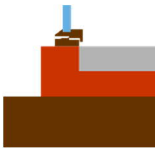
Floor slab		FS1	X	X		X	
Basement ceiling		BC1					
Overhang		OH1					
Ceiling		CE1	X	X			
Ceiling (thicker)		CE2					
Window bottom (openable)		OB1	X	X			
Window side (openable)		OJ1	X	X		X	
Window top (openable)		OH1	X	X		X	
Window threshold (openable)		OT1	X	X		X	
Window bottom (fixed)		FB1					

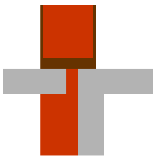
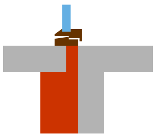
Window side (fixed)		FJ1					
Window top (fixed)		FH1					
Door threshold		DT1				(X)	
Door locking side		DJ1				(X)	
Door hinge side		DJ2				(X)	
Door top		DH1				(X)	
Roof window bottom		RWB1			X		
Roof window top		RWH1			X		
Roof window side		RWJ1			X		
Exterior wall exterior corner (e.g. WDVS)		EW1_EW1_ec1	X	X			

Exterior wall exterior corner (e.g. lightweight timber)		EW2_EW2_ec1	(X)	(X)			
Exterior wall exterior corner (e.g. lightweight timber, reinforced)		EW2_EW2_ec2	(X)	(X)			
Exterior wall exterior corner (e.g. hybrid)		EW1_EW2_ec1	(X)	(X)			
Exterior wall interior corner (e.g. WDVS)		EW1_EW1_ic1	X	X			
Exterior wall interior corner (e.g. lightweight timber)		EW2_EW2_ic1	(X)	(X)			
Exterior wall interior corner (e.g. lightweight timber, reinforced)		EW2_EW2_ic2	(X)	(X)			
Exterior wall interior corner (e.g. hybrid)		EW1_EW2_ic1	(X)	(X)			
Exterior wall, separating internal wall		EW1_IW1	X	X			
Exterior wall, structural internal wall		EW1_IW2	(X)	(X)			
Roof ridge		RO1_RO1	X		X		

Ceiling connection		EW1_EW1_CE1	X	X			
Ceiling connection (thicker ceiling)		EW1_EW1_CE2	(X)	(X)			
Ceiling connection (hybrid)		EW1_EW2_CE1	(X)	(X)			
Ceiling connection (hybrid, thicker ceiling)		EW1_EW2_CE2	(X)	(X)			
Floor slab edge (with EIFS wall)		FS1_EW1	X	X		(X)	
Floor slab edge (with EIFS-wall, plus insulation apron)		FS1_EW1_pv1	(X)	(X)		(X)	
Floor slab edge (with EIFS-wall, plus insulation apron)		FS1_EW1_ph1	(X)	(X)		(X)	
Floor slab edge (sunken slab)		FS2_EW1	(X)	(X)		(X)	
Floor slab edge (with lightweight timber wall plus insulation apron)		FS1_EW2_pv1	(X)	(X)		(X)	
Floor slab, separating internal wall		FS1_IW1	X			X	

Floor slab, structural internal wall		FS1_IW2	(X)			(X)	
Eaves		EW1_RO1_ea1	X	X	X		
Eaves		EW2_RO1_ea1	(X)	(X)	(X)		
Eaves		EW2_RO1_ea2	(X)	(X)	(X)		
Eaves (attic/cold roof)		EW1_RO1_CE1	(X)	(X)	(X)		
Verge		EW1_RO1_ve1	X	X	X		
Parapet		EW1_RO1_pp1	(X)	(X)	(X)		
Roof window bottom		RO1_RWB1_1			X		
Roof window top		RO1_RWH1_1			X		
Roof window side		RO1_RWJ1_1			X		

Window bottom connection (openable)		EW1_OB1_1	X	X			
Window bottom connection (openable, offset position)		EW1_OB1_2					
Window bottom connection (fixed)		EW1_FB1_1					
Window bottom connection (fixed, offset position)		EW1_FB1_2					
Window bottom, floor slab		FS1_OT1_1	X	X		X	
Window side connection (openable)		EW1_OJ1_1					
Window side connection (openable, covered with insulation)		EW1_OJ1_1a	X	X			
Window side connection (openable, offset position)		EW1_OJ1_2					
Window side connection (openable, offset position, covered with insulation)		EW1_OJ1_2a					
Window side connection (fixed)		EW1_FJ1_2					

Window side connection (fixed, covered)		EW1_FJ1_2a					
Window connection top (openable)		EW1_OH1_2a	X	X			
Window connection top (openable, venetian blind)		EW1_OH1_2a_V1					
Window connection side (openable, venetian blind)		EW1_OJ1_2a_V1					
Balcony connection		EW1_EW1_CE1_BC1					
Basement ceiling, balcony connection		EW1_EW2_CE1_BC1					
Basement ceiling, balcony connection, window threshold		EW1_EW2_CE1_BC1 _ST1_1					

The connection details contained in the table are only given as examples for understanding the nomenclature. If the corresponding connection situation is not present in the table, the appropriate designation must be agreed with the PHI before certification.

6 Selected boundary conditions for determining the hygiene and comfort criteria for transparent components (informative)

Re-gion No.	Name	Boundary condition for hygiene criterion		Hygiene criterion		Dewpoint criterion		Ambient temperature for comfort criterion [°C]	Maximum heat transmission coefficient			
		θ_a	rHi	$\theta_{Si,min}$	f_{Rsi} =0,25m²K/W	$\theta_{Si,min}$	f_{Rsi} =0,25m²K/W		Orientation	[°]	$U_{W,inst.}$	U_W
1	Arctic	-34,00	0,40	9,20	0,80	6,00	0,74	-50	vertical	90	0,45	0,40
									inclined	45	0,50	0,50
									horizontal	0	0,60	0,60
2	Cold	-16,00	0,45	11,00	0,75	7,80	0,66	-28	vertical	90	0,65	0,60
									inclined	45	0,70	0,70
									horizontal	0	0,80	0,80
3	Cool-temperate	-5	0,50	13	0,70	9	0,57	-16	vertical	90	0,85	0,80
									inclined	45	1,00	1,00
									horizontal	0	1,10	1,10
4	Warm-temperate	3,00	0,55	14,00	0,65	10,70	0,45	-9	vertical	90	1,05	1,00
									inclined	45	1,10	1,10
									horizontal	0	1,20	1,20
5	Warm	10,00	0,70	15,50	0,55	14,30	0,43	-4	vertical	90	1,25	1,20
									inclined	45	1,30	1,30
									horizontal	0	1,40	1,40
6	Hot	not relevant		not defined		not relevant		not relevant			1,25	1,20
7	Extremly hot, often humid	not relevant		not defined		not relevant		not relevant			1,05	1,00

ANNEX III - REQUIREMENTS AND TESTING PROCEDURES FOR ENERGETIC AND ACOUSTICAL ASSESSMENT OF PASSIVE HOUSE VENTILATION SYSTEMS < 600 M³/H FOR CERTIFICATION AS “PASSIVE HOUSE SUITABLE COMPONENT”

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Requirements and testing procedures for energetic and acoustical assessment of Passive House ventilation systems < 600 m³/h for Certification as "Passive House suitable component"

For the certification of a ventilation unit as a "Passive House suitable component" by the Passive House Institute, at least the following measurements should be commissioned to a PHI-approved independent inspecting authority. All measured data and documentation of that authority must be made available to the PHI.
The manufacturer must provide the independent authority with a serial unit for testing. Specially prepared appliances will not be accepted for testing and must be taken back at the cost of the manufacturer. The inspecting authority must guarantee a testing procedure in accordance with these testing regulations.

1. Experiment set-up
The siphon of the condensate drain is to be filled with water and the ventilation unit is to be installed and started according to the manufacturer's instructions.

The fine filter
Before the start of the testing the type and model of the built-in filters should be checked. On the outdoor air side a filter of efficiency ISO ePM1 50%, on the extract air side of efficiency ISO Coarse 60% is to be inserted. If it is not possible to insert an ISO ePM1 50% filter, an external filter box with an ISO ePM1 50% filter is to be specified and delivered by the manufacturer and integrated into the experiment. Any integrated outdoor air filter of lesser quality can then be removed.
An external filter unit is attached to the nozzles of the unit and treated as part of the apparatus for all tests. The decrease in pressure of the external filter unit, its leakages and heat flow through the filter housing all contribute to the experimental data for the unit: air conditions and flow rate are thus measured before entering the external additional attachment.

Anti-freeze protection of the heat exchanger

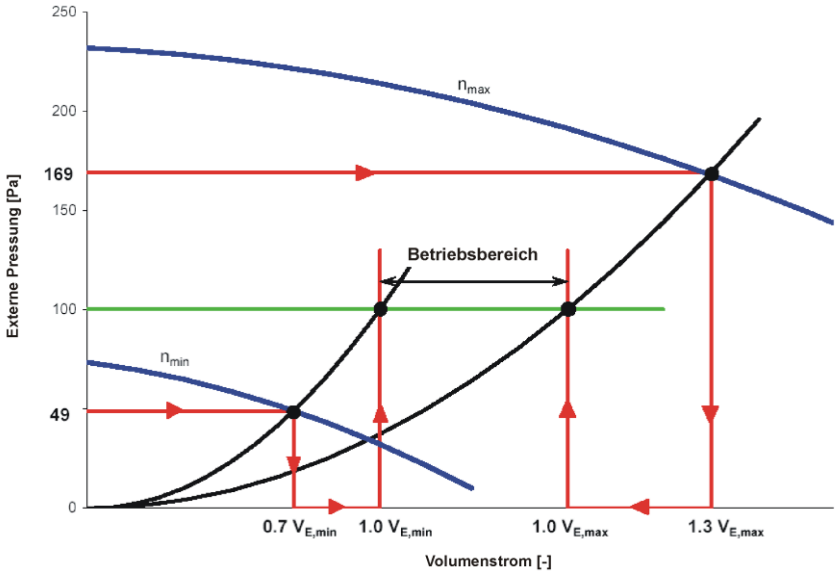
It should be checked that a frost protection device for the heat exchanger (i.e. heater coils) is installed. If this is not the case, an external frost protection with all relevant controls is to be specified and delivered by the manufacturer and integrated into the experiment set-up. An external unit is attached to the nozzles of the unit and treated as part of the apparatus for all tests. The decrease in pressure of the external frost protection unit, as well as its air leakage and heat flow through the housing all contribute to the performance of the apparatus: air conditions and flow rate are thus measured before entering the external additional attachment.

Emergency shutdown for frost protection

Likewise it should be checked that the ventilation unit has an integrated emergency shutdown for critically low supply air temperatures (to protect the heater coils from freezing up). If not, then an external appliance with its factory setting is to be delivered by the manufacturer, and this will be a part of the experimental set-up. If the emergency shutdown is only possible through an external device, it should be clearly and visibly set out in the assembly instructions that its use is compulsory for Passive Houses with hydraulic supply air heater coils.

2. Operational range and flow rates for the test

The limits of the operational range are defined with the experimental set-up according to 1 as follows:



a) The unit is operated at full speed with an external pressure of 100 Pa x 1,3² = 169 Pa. The flow rate measured divided by 1.3 gives the upper limit of the operational range.
b) The unit is operated with an external pressure of 100 Pa x 0,7² = 49 Pa at the lowest fan speed. The measured flow rate divided by 0.7 gives the lower limit of the operational range.
c) The flow rate for the test is computed from the average value of the upper and lower limits of the operational area.
d) If the proportion of the upper and lower limits is greater than 1.6:1, several test series are to be taken. The total operational range is divided up into equal parts which must be proportionally less than 1.6:1. Within these partial areas measurements should be made using mid flow rate values.

The rated flow rate in all cases is the supply air flow rate. The external pressure to be applied for the measurements is to be distributed evenly (i.e. 50% at a time) across the suction side and pressure side.

3. Testing of airtightness

The experiment set-up follows the Nordtest method [NT VVS 022 HEATRECOVERY Units, internal Leakage; NT VVS 023 HEATRECOVERY Units, external Leakage]. The internal and external airtightness of the test object is to be investigated. The airtightness test for negative pressure as well as for over-pressure is to be carried out before starting the thermo-dynamical testing. The measurements should be made for at least four testing pressures at a time in the range between 50 Pa and 300 Pa.

a) External leakage: the air flow rate which is necessary to maintain the static pressure difference between the apparatus interior and the surroundings is determined.
b) Internal leakage: The air flow rate between the extract air/exhaust air side and outdoor air/supply air side is ascertained by sealing the extract air/exhaust air side and putting it under negative/over-pressure. Between the surrounding air and the outdoor air/supply air side a pressure difference of 0 Pa is adjusted using an auxiliary fan. The internal leakage flow rate is represented by the input and discharge flow rates which are necessary for adjustment of the pressure difference of 0 Pa.

The leakage for both the over-pressure and negative pressure is given as standardised for 100 Pa by using the regression line computed from the measurement readings. As a result of the airtightness test the respective average value is calculated from the over-pressure and negative pressure tests. All readings are to be documented in the test report.
The leakages determined should not be greater than 3 % of the mid flow rate of the operational range of the ventilation equipment as defined in paragraph 2. The rated flow rate is the supply air flow rate.

4. Thermo-dynamical testing

The external pressure for the measurements is generally 100 Pa. The applied external pressure decrease should be evenly distributed (i.e. 50 % at a time) across the suction side and pressure side.

a) The mass flows of the outdoor air and exhaust air are to be balanced within the precision of the measurements by adjustment of the fans (except for automatically balanced fans).
b) All flow rates (outdoor air /exhaust air and supply air/extract air) are measured and logged.
c) The air temperature and humidity is measured and logged for all flows (outdoor air /exhaust air and supply air/extract air).
d) The outdoor air temperature is to be set as low as possible, but sufficiently high enough to ensure that no condensation can occur in the heat exchanger due to the humidity present in the outdoor air and extract air.
e) During the measurements the total electrical power consumption of the apparatus (including the controls and also of any necessary external systems etc) should be ascertained and logged.

The air flow rate/rates for the measurement(s) should be assessed according to the instructions in paragraph 2. The rated flow rate is the supply air flow rate. It should be ensured and substantiated through the recorded measurement data for all series of measurements that the whole experimental set-up has achieved a steady state.

Apparatus with manual mass flow balance

The effective dry heat recovery rate must be higher than 75 % with balanced mass flows of the outdoor air and exhaust air, at outdoor air temperatures between – 15 and + 10 °C and dry extract air (ca. 20 °C).

$$\eta_{WRG,t,eff} = \frac{(\vartheta_{AB} - \vartheta_{FO}) + \frac{P_{el}}{\dot{m} \cdot c_p}}{(\vartheta_{AB} - \vartheta_{AU})} \qquad [1]$$

From the documentation of the apparatus it should be clearly identifiable how the adjustment of fans for establishing the outdoor air/exhaust air side mass flow balance and the adjustment to the loss of pressure of a given duct system can take place.

Apparatus with constant flow rate fans

The mass flow balance for ventilation units with constant flow rate fans is automatically achieved on the outdoor air/exhaust air side, but there is a deviation of some per cent. An imbalance of less than 10% is acceptable. If the possibility of manual readjustment of the balance is available, this should be done before the start of the measurements.
The remaining imbalance should be dealt with in the following manner: In the case of an excess of outdoor air the exhaust air temperature is to be mathematically corrected by admixture at extract air temperature as follows:

$$\vartheta_{FO,korr} = \frac{(\dot{m}_{Dis} \cdot \vartheta_{AB} + \dot{m}_{FO} \cdot \vartheta_{FO})}{\dot{m}_{AU}} \qquad [2] \qquad \text{with} \qquad \dot{m}_{Dis} = \dot{m}_{AU} - \dot{m}_{FO} \qquad [3]$$

It applies that:

$$\eta_{WRG,t,eff} = \frac{(\vartheta_{AB} - \vartheta_{FO,korr}) + \frac{P_{el}}{\dot{m} \cdot c_p}}{(\vartheta_{AB} - \vartheta_{AU})} \qquad [4]$$

From the documentation of the unit it must be clearly identifiable, if necessary, how the readjustment of the fans to optimise the outdoor air/ exhaust air side mass flow balance and the adjustment to the loss of pressure of a given duct system can take place.

5. Electrical efficiency

The total electrical power consumption of the ventilation apparatus (all fans, controls, and any essential external systems) should at the upper limit of the operational range not exceed 0.45 W/(m³/h) for transported supply air flow. The freeze protection for the heat exchanger remains disabled. The test is carried out at external pressure of 100 Pa (see paragraph 2).

6. Acoustical testing

Emission spectrum

The measurement of the acoustic power emitted by the ventilation unit takes place according to DIN EN ISO 3743-1 (positioning of the unit in the testing room according to manufacturer's instructions). Additionally the acoustic power in the outdoor/exhaust/supply and extract air ducts is measured according to DIN EN ISO 5136 (Oct. 2003). The measurement readings are given in third octave bands (31.5 Hz – 8000 Hz). All tests are carried out at an external pressure of 100 Pa and using the upper limit of the operational range as the flow rate (see paragraph 2).

Sound emission of the apparatus

Entirely Passive House-suitable units have a noise level of ≤ 35 dB(A) in a room with an equivalent absorption area of 4 m². They can thus be operated without further measures in any functional room (e.g. kitchen, bathroom). If this value is exceeded, a certificate can only be issued with the restriction that the device should be installed in a separate utility room or the like.

Recommendation for silencers

Suggestions for appropriate silencers for the supply air and extract air ducts are to be made by the manufacturer on the basis of the measured emissions. Because the duct systems in Passive Houses are optimised and may be very short, silencers are to be dimensioned without accounting for a damping action by the duct system. The adoption of the damping action of a standard supply air or extract air outlet is tolerable.

In living areas (supply air) a noise level of ≤ 25 dB(A), while in functional rooms (extract air) a noise level of ≤ 30 dB(A) is stipulated.
If there is no recommendation by the manufacturer, exemplary guidelines on the basis of standard values of typical silencers are provided by the PHI.

7. Frost protection shutdown for hydraulic heater coils in the supply air

In order to avoid frost damage to any downstream hydraulic heater coils (Passive House supply air heating) the apparatus must have an emergency shutdown if the supply air temperature falls below +5°C (e.g. malfunction of exhaust air fan). For the user a clearly perceptible corresponding error message should be issued at the control unit.

The testing involves the closing of the extract air duct and parallel decrease in the outdoor air temperature. The temperature profile of the air flows, the development of the flow rates and the electrical power consumption of the apparatus are to be described in the test report.

8. Checking of the frost protection for the heat exchanger

Switching threshold of the factory setting

The frost protection of the apparatus must guarantee regular operation, that is, with mass flow balance on the outdoor air/ exhaust air side and undiminished mass flow, at all times. For this a suitable preheater is necessary (cf. 1).
This should be operated in the factory setting as delivered by the manufacturer. The outdoor air temperature at which the pre-heating is activated should be ascertained by measurement, with a standardised extract air condition of 21°C /50 % rH. The switching threshold for the frost protection must be –3°C or less. The temperature profile of the air flows, air humidity and the development of the flow rates as well as the electrical power consumption of the apparatus are to be described in the test report.

The effectiveness of the freeze-protection

The effectiveness of the freeze-protection is to be proved in a twelve-hour long-term test with an external air temperature of –15°C and standardised extract air condition of 21°C /50% rH. A visual inspection of the heat exchanger for ice deposits ends this part of the examination. The test is to be carried out using the flow rate of the upper limit of the operational range. The temperature profile of the air flows, air humidity and the development of the flow rates as well as the electrical power consumption of the apparatus are to be described in the test report.

Measurement of the critical temperature

The temperature at which the exhaust air temperature reaches the frost limit should be determined with deactivated pre-heating. This critical temperature for the inside positioning of the apparatus should be documented. The test is carried out using the mid flow rate of the operational range. The temperature profiles of the air flows, air humidity and the development of the flow rates as well as the electrical power consumption of the apparatus are to be described in the test report.
For a minimised frost protection energy demand it should be possible to set the limit temperature so that no frost can occur in the heat exchanger.

The approach for the manual readjustment of the frost protection limit temperature must be clearly described in the assembly instructions supplied with the apparatus. The factory setting must, however, guarantee the maximum temperature of –3°C.

9. Comfort criterion

The observation of a minimal supply air temperature of 16.5 °C at –10 °C outdoor air temperature is to be proved by measurement. A frost protection unit for the heat exchanger is active with its factory setting in this test. The temperature profile of the air flows, air humidity and the development of the flow rates as well as the electrical power consumption of the apparatus are to be described in the test report.

10. Ascertainment of the standby loss

The electrical power consumption of the ventilation unit (including controls, also any essential external systems) is to be ascertained for the purely stand-by operation of the apparatus. In the stand-by mode a consumption of 1 W should not be exceeded, otherwise the manufacturer should provide the possibility of a complete disconnection from the electrical supply as a standard.

11. Restart after a power failure

It must be ensured that the apparatus automatically starts regular operation after a power failure without any user intervention. The operation must be continued at the same setting as before the power failure. The test is to be carried out by pulling out the mains plug and waiting for ten minutes.

12. Hygiene

Inspection and cleaning of the central apparatus including the heat exchanger should be easy. It must be possible for the user to change the filters himself (no expert should be required for this), a description for this procedure and suppliers for the spare filters should be documented in the handbook.
The service life of the outdoor air filter should be limited to one year (to avoid endotoxins). The manufacturer must ensure that the proliferation of microorganisms and the entry of endotoxins is prevented permanently by providing either components or obligatory attachments for the apparatus.

13. Miscellaneous

All specified test procedures apply for typical cases. For unusual construction types alternative or additional testing may be necessary. It is recommended that this is agreed at an early stage with the Passive House Institute.
If, due to the available facilities in a certain laboratory, individual air conditions cannot be achieved, after early agreement with the PHI an arrangement should be made which approximates the intentions of the requirements as much as possible.

14. Symbols and abbreviations

AU	Outdoor air	[-]
FO	Exhaust air	[-]
ZU	Supply air	[-]
AB	Extract air	[-]

ϑ_{AU}	Outdoor air temperature	[°C]
ϑ_{FO}	Exhaust air temperature	[°C]
$\vartheta_{FO,korr}$	Corrected exhaust air temperature	[°C]
ϑ_{ZU}	Supply air temperature	[°C]
ϑ_{AB}	Extract air temperature	[°C]
$\dot{m}$	Mass flow	[kg/h]
$\dot{m}_{Dis}$	Mass flow difference/imbalance	[kg/h]
$\dot{m}_{AU}$	Mass flow outdoor air	[kg/h]
$\dot{m}_{FO}$	Mass flow exhaust air	[kg/h]
c_p	Specific thermal capacity of air	[Wh/(kg K)]
P_{el}	Real electrical power	[W]
$\eta_{WRG,t,eff}$	Effective heat recovery	[%]

Passive Houses have high requirements for the quality of the applied components because they can dispense with a separate heating system. A highly efficient heat recovery apparatus is an essential component of the comfort ventilation in a Passive House.
The following requirements have been stipulated by the PHI for the certification as "Passive House suitable component – heat recovery device" (details and explanations can be found in the appendix of the certificate):

Passive House - comfort criterion	Minimum supply air temperature of 16.5°C
Efficiency criterion (Heat)	The effective dry heat recovery efficiency must be higher than 75 % with balanced mass flows at external temperatures of between – 15 and + 10 °C and dry extract air (ca. 20 °C). $$\eta_{WRG,t,eff} = \frac{(\vartheta_{Ab} - \vartheta_{Fo}) + \frac{P_{el}}{\dot{m} \cdot c_p}}{(\vartheta_{Ab} - \vartheta_{Au})}$$
Electrical efficiency criterion	At the designed mass flow rate the total electrical power consumption of the ventilation device may not exceed 0.45 W per (m³/h) of transported supply air flow.
Balancing and controllability	Outdoor air and exhaust air mass flows must be balanceable for the rated air flow rate, with controllability of at least 3 levels (basic ventilation (70-80%), standard ventilation (100%), increased ventilation (130%)).
Sound absorption	Noise level in installation room < 35 dB(A), in living areas < 25 dB(A), in functional areas < 30 dB(A).
Room air hygiene	Outdoor air filter at least ISO ePM1 50%, extract air filter at least ISO Coarse 60%
Frost protection	Frost protection for heat exchanger without supply air interruption, frost protection for an air heater in case of failure of the extract air fan or frost protection heater coil

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Requirements and testing procedures for energetic and acoustical assessment of Passive House ventilation systems < 600 m³/h for Certification as “Passive House suitable component”

Supplementary test of frost protection - Preliminary

Preface

The existent document complements the requirements and testing procedures for passive house ventilation systems < 600 m³/h [1]. This document replaces the testing of the frost protection according to [1] point 8 as well as the testing of the comfort criterion according to [1] point 9.
Within the next revision of the requirements and testing procedure [1], the existent document will be considered, and supplementary sheet and testing procedure will be combined to one document.

Requirements concerning the frost protection strategy for the heat exchanger

In order to utilize heat recovery ventilation units in passive houses with optional supply air heating, an operation of the heat recovery unit without interruption of the supply air flow rate is mandatory. The mass flows must remain in balance even at low outdoor air temperatures. The maximum imbalance allowed is 10%.

The automatic threshold for activating the frost protection strategy can vary depending on the heat recovery rate and the frost protection strategy. In order to achieve an efficient operation of the device during low outdoor air temperatures, the automatic threshold should be ≤ -3°C. The efficiency of the frost protection strategy mainly depends on the control strategy. Controlling the frost protection energy only based on the outdoor air temperature (before the heater coil) without controlling the power output can’t be an acceptable frost protection strategy.
Furthermore the average exhaust air temperature mustn’t exceed 5°C.

Requirements concerning a comfortable supply air temperature at low outdoor air temperatures

A minimum supply air temperature of 16,5°C should be maintained at outdoor air temperatures of -10°C and extract air temperatures of 21°C [1)] (under standard frost protection settings).

1) The requirement doesn’t comply with the measurement. Proving the requirements is generated with calculations based on the measurement.

With some frost protection strategies the comfort criterion might not be full filled (e.g. outdoor – supply air bypass, rotor heat exchanger). In this case the manufacturer should provide measures for compensation (e.g. supply air heater).

Required data/ documentation to be provided by the manufacturer

In order to evaluate the frost protection strategy as well as to check possible deviation from the testing requirements, a detailed description of the frost protection strategy with recommendations respecting the nominal values of the control variable as well as the capacity of pre heater or supply air heater (if installed in the device) is mandatory.

In case that the frost protection strategy is based on an external heat exchanger, a data sheet of the pre heater is required with technical data and installation instruction.

In order to check possible deviation from the testing requirements, the manufacturer documentation of the frost protection strategy should be handed in preferentially before the measurement starts.

Description of the measurements

a) <u>Settings of ventilation device</u>

The settings of the ventilation device especially the settings respecting the frost protection strategy should remain as default/ should be set according to manufacturer information. If changes of the default settings should be required in order to fulfill the requirements, the documentation of the changes in the measurement report is mandatory.

If the frost protection strategy is based on an external heating device, it must be installed according to manufacturer recommendations. The documentation of the installation situation as well as optional minimum distance between heater and ventilation device (if required) in the measurement report is required.

b) <u>Measurement condition</u>

The measurement of the frost protection strategy should be conducted under following conditions, in accordance with DIN EN 13141-7:

- Air flow rate at the upper limit of the certified air flow range (in accordance to [1]) or, alternatively, at a higher air flow rate
- Outdoor air temperature: -15°C
- Extract air temperature: 20°C/ relative humidity: 25% – 40%
- Duration of measurement from steady state of the air flow rates at -15°C outdoor air temperature on: minimum 6 h

The air flow rates must be adjusted to a balanced operation mode before the measurement or in the beginning of the measurement.

From 0°C on the outdoor air temperature should decrease gradually until reaching the test temperature of -15°C. The activation of the frost protection strategy should be documented with time, outdoor air temperature and exhaust air temperature.

The air condition should remain constant temporary at an outdoor air temperature of -10°C. When reaching a steady state (e.g. after 30 minutes), the supply air temperature is to be documented in the measurement report.

Afterwards the outdoor air temperature decreases until the testing temperature of -15°C.

Alternatively to the before described procedure the test for determining the supply air temperature at an outdoor air temperature of -10°C could also be conducted separately (lowering the outdoor air temperature during the test of the frost protection strategy should occur without interruption, then).

During the whole measurement the following parameter must be logged:

- Air flow rates (SUP, ODA, ETA, EHA)
- Temperatures (ODA, SUP, ETA, EHA)
- Electric power input of frost protection strategy or optional of the whole ventilation device (including frost protection)

In order to evaluate the frost protection efficiency in future, recording the power consumption of the frost protection strategy (alternatively of the whole device) in a defined time frame (recommendation: 6h) is required.
The power consumption should be logged as soon as the outdoor air temperature reaches -15°C until the end of the test.
At an outdoor air temperature of -10°C the power consumption should be logged additionally for a defined time frame (30 min).

Required data/ documentation to be provided from the laboratory
The test and documentation of the frost protection strategy should follow the existent description. The laboratory should provide the measured values in a form that allows examination (e.g. ms excel file).

Source

[1] Requirements and testing procedures for energetic and acoustical assessment of Passive House ventilation systems < 600 m³/h for Certification as „Passive House suitable component, Passivhaus Institut, 2009

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Requirements and testing procedures for the energetic and acoustic assessment of Passive House ventilation systems for certification as “Passive House suitable component”

Supplementary Sheet Moisture Recovery for ventilation units < 600 m³/h

In order to determine the energy-relevant influence of ventilation units with moisture recovery in Passive Houses, the following additional regulations have been set up on the basis of comprehensive investigations. The general requirements and testing methods for the energetic and acoustic assessment of Passive House ventilation units for certification as "Passive House Suitable Components" are not affected by this supplement. The experimental set-up described in the main document applies for all tests, unless otherwise specified. For devices with a regenerative operation (rotors) the respective supplementary sheet is also to be considered.

In accordance with the general requirements and testing methods for the energetic and acoustic assessment of Passive House ventilation units for certification as "Passive House Suitable Components", the effective dry heat recovery efficiency is calculated when determining the thermodynamic characteristics.

The moisture recovery is determined for the standardised extract air conditions of 21°C/50% rH and for outdoor air conditions of 4°C/80% rH.

$$\eta_x = \frac{x_{AB} - x_{FO}}{x_{AB} - x_{AU}} \qquad [5]$$

For the energy-relevant assessment of moisture recovery with $\eta_x \leq 0{,}6$ the following rule applies:

$$\eta_{WRG,eff} = \eta_{WRG,t,eff} + 0{,}08 \cdot \eta_x \qquad [6]$$

For moisture recovery $\eta_x > 0{,}6$ the bonus is limited to a maximum of 4,8 %.

The heat recovery efficiency including the applicable allowance can be stated on the unit's certificate. The moisture recovery will be listed in the appendix to the certificate.

In order to prevent damage from occasional excessive humidity, units with a moisture recovery of $\eta_x > 0{,}6$ must have a regulated air flow rate, which is controlled by the indoor air humidity. For certification, the method of regulation should be explained.

Furthermore, the increased air change rate required to limit the indoor air humidity must be taken into account in energy balance calculations: Without reliable information, it can be presumed to be

$$\dot{V}_{eff} = \dot{V}_{hyg} \cdot \frac{0{,}4}{1-\eta_x} \qquad [7]$$

for residential use (35 m²/person, moisture generated ca. 2 g/(m²h)).

For devices with a high moisture recovery and special boundary conditions, particularly for adjustable moisture recovery, more favourable values can be calculated with an annual energy balance based on a dynamic hygrothermal building simulation in contrast to the more simplified method according to [6]. The Passive House Institute carries out such assessments on request.

Symbols and abbreviations

η_x	Moisture recovery	[-]
x_{AB}	Absolute humidity extract air	[g/kg]
x_{FO}	Absolute humidity exhaust air	[g/kg]
x_{AU}	Absolute humidity outdoor air	[g/kg]
$\dot{V}_{eff}$	Effective air flow rate	[m³/h]
$\dot{V}_{hyg}$	Air flow rate required for hygienic reasons	[m³/h]
$\eta_{WRG,eff}$	Certifiable effective heat recovery efficiency	[-]
$\eta_{WRG,t,eff}$	Effective dry heat recovery efficiency	[-]

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Reuqirements and testing procedure for the energetic and acoustic assessment of Passive House ventilation units for certification as "components suitable for Passive Houses"

Supplementary sheet for regenerative HR < 600 m³/h - Preliminary

For determining the characteristics of home ventilation units with regenerative heat recovery, particular consideration needs to be given to some special features which sometimes make it necessary to modify and amend the procedure for the requirements and the testing procedures for the energetic and acoustic assessment of Passive House ventilation units for certification as "components suitable for Passive Houses". The rules for the general testing procedures apply as long as any special features are not specified.

Prevention of ice build-up in the heat exchanger

For units that ensure the prevention of ice build-up in the heat exchanger without any auxiliary devices, the experiments given in the testing regulations are carried out without these devices, and their effectiveness is verified by means of measurements.

Electrical efficiency

In order to show the influence of auxiliary drives in regenerative devices (rotor drive, dampers), an additional measurement of the electrical power consumption at the lower limit of the operational range is necessary. The limit value of 0.45Wh/m³ must be complied with.

Internal leakages / transfer of exhaust air

The transfer of exhaust air should be determined by measuring. This is done using the tracer gas method based on EN 308. However, the following boundary conditions should be set differently from the standard: the volumetric flow should correspond with the upper limit of the operational range, balanced operation on the outdoor air/exhaust air side and external pressure as given in the testing regulations.

The leakage rate must not exeed 3 % of the mean air flow rate of the operational range. By designing of the unit accordingly (consideration of fan positioning use of a purging chamber) it is possible to achieve much better values (<0,5 %) which is recommended by PHI.

For devices with discontinuous operation, the effective average value should be ascertained over a sufficiently long measurement period.

Inherent to regenerative heat recovery systems is the possibility of water soluble odorous substances being transferred from extract air to supply air is given. These are mainly food odours that occur in the kitchen extract air

The applicability of regenerative heat recovery systems has to be assessed specifically for each project especially if one heat recovery ventilation unit supplies more than one (dwelling) unit.

External leakage

The external leakage is determined in accordance with the Nord Test Method as given in the testing regulations. In principle, the tracer gas method may also be used if this simplifies the measurements. However, pressure differences should be applied in a similar way.

Moisture transfer

Transfer of moisture is likely to occur in regenerative heat recovery systems due to the design of the device. The moisture recovery η_x should be determined in accordance with the regulations in the supplementary sheet for moisture recovery. The requirements for the control of moisture as given there and the procedures for taking into account the enthalpy transfer apply when determining the effective heat recovery rate.

For devices with discontinuous operation, the effective average value of moisture transfer should be determined over a sufficiently long measurement period.

Purging air and heat recovery rate

In order to prevent the transmission of extract air towards the supply air, the regenerator is usually flushed with outdoor air. The mass flows of outdoor and exhaust air differ from the mass flows of the supply air and extract air by the amount of purging air even with ideal air tightness of the device.

$$\dot{m}_{Spül} = \dot{m}_{AU} - \dot{m}_{ZU} \qquad [8]$$

The determination of the operational range is not affected by this; here the reference value is the volumetric supply air flow.

However, the determination of the effective heat recovery rate requires the taking into account of the quantity of purging air.

The following applies for balanced the mass flows:

$$\eta_{WRG,t,eff} = \frac{\dot{m}_{ZU} \cdot \vartheta_{AB} + \dot{m}_{Spül} \cdot \vartheta_{AU} - \dot{m}_{AU} \cdot \vartheta_{FO} + \frac{P_{el}}{c_p}}{\dot{m}_{ZU} \cdot (\vartheta_{AB} - \vartheta_{AU})}$$

$$\eta_{HR,d,eff} = \frac{\dot{m}_{SUP} \cdot \vartheta_{ETA} + \dot{m}_{Cl} \cdot \vartheta_{ODA} - \dot{m}_{ODA} \cdot \vartheta_{EHA} + \frac{P_{el}}{c_p}}{\dot{m}_{SUP} \cdot (\vartheta_{ETA} - \vartheta_{ODA})} \qquad [9]$$

The taking into account of a measured disbalance for constant-controlled fans takes place through the consideration of the exhaust air mixing temperature $\vartheta_{FO,korr}$ depending on the disbalance $\dot{m}_{Dis}$.

$$\dot{m}_{Dis} = \dot{m}_{AU} - \dot{m}_{FO} \qquad [10]$$

$$\vartheta_{'FO,korr} = \frac{\vartheta_{FO} \cdot \dot{m}_{FO} + (\dot{m}_{Dis}) \cdot \vartheta_{AB}}{\dot{m}_{FO} + (\dot{m}_{Dis})} \qquad [11]$$

The effective dry heat recovery rate is finally determined by applying the mixing temperature thus ascertained:

$$\eta_{WRG,t,eff} = \frac{\dot{m}_{ZU} \cdot \vartheta_{AB} + \dot{m}_{Spül} \cdot \vartheta_{AU} - \dot{m}_{AU} \cdot \vartheta_{FO,korr} + \frac{P_{el}}{c_p}}{\dot{m}_{ZU} \cdot (\vartheta_{AB} - \vartheta_{AU})} \qquad [12]$$

The present additional information regarding ventilation units with regenerative functioning for the purpose of certification as Passive House suitable components are preliminary. In case of doubt or uncertainties, the PHI should be consulted before carrying out measurements.

Symbols and abbreviations

η_x	Humidity conditions	[-]
$\dot{m}_{ZU}$	Supply air mass flow	[kg/h]
$\dot{m}_{Spül}$	Scavenging air mass flow	[kg/h]
$\dot{m}_{AU}$	Outdoor air mass flow	[kg/h]
$\dot{m}_{Dis}$	Disbalance mass flow	[kg/h]
$\dot{m}_{FO}$	Exhaust air mass flow	[kg/h]
ϑ_{AB}	Extract air temperature	[°C]
ϑ_{AU}	Outdoor air temperature	[°C]
ϑ_{FO}	Exhaust air temperatur	[°C]
$\vartheta_{FO,korr}$	Exhaust air mixing temperature	[°C]
P_{el}	Electric power consumption	[W]
c_p	Specific heat capacity of air	[W·h/(kg·K)]
$\eta_{WRG,t,eff}$	Effective heat recovery rate	[-]

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Requirements and test procedures for energy relevant and acoustic assessment of Passive House ventilation units for certification as Passive House Components

Supplementary sheet for the efficiency ratio - provisional

The efficiency ratio is used for the overall energy relevant assessment of a ventilation unit. It specifies the amount by which the energy demand caused by ventilation can be reduced through the use of a ventilation unit with heat recovery.

The efficiency ratio takes into account the final energy demand for covering the ventilation heat losses and the necessary auxiliary energy for the ventilation unit and the frost protection strategy. Because heat supply takes place with a heat pump, only electrical energy is incurred (different approaches for primary energy factors therefore do not play any role). The efficiency ratio is determined using a representative data set for the relevant climate zone.

The efficiency ratio is calculated in accordance with the following formula:

$$\boldsymbol{\varepsilon} = \frac{\boldsymbol{Q_{V,end,ref} - Q_{V,end,HR} - Q_{rv,aux} - Q_{rv,defrost}}}{\boldsymbol{Q_{V,end,ref}}}$$

$Q_{V,end,ref}$	Final energy demand for covering the ventilation heat losses of a reference system without heat recovery [kWh/a]
$Q_{V,end,HR}$	Final energy demand for covering the ventilation heat losses of the ventilation system with heat recovery [kWh/a]
$Q_{rv,aux}$	Energy demand of the ventilation unit in the heating period [kWh/a]
$Q_{rv,defrost}$	Energy demand of the frost protection strategy for the heat exchanger [kWh/a]

With the following calculation approaches:

$$Q_{V,end,HR} = V \cdot n \cdot c \cdot (1 - \eta_{HR}) \cdot G_t \cdot e_H$$
$$Q_{V,end,ref} = V \cdot n \cdot c \cdot G_t \cdot e_H$$

$V \cdot n = 1\, m^3/h$
$c = 0.33\, Wh/(m^3K)$

η_{HR}	measured heat recovery efficiency (according to the PHI test regulations) [-]
G_t	heating degree hours in accordance with the climate zone [kKh/a]
$e_H = 0.44$	performance ratio of the electric heat pump heating system [-]

$$Q_{rv,aux} = 0.001 \cdot V \cdot n \cdot P_{el} \cdot t_H$$

P_{el}	measured specific electrical power consumption of the ventilation unit (according to the PHI test regulations) [W/(m³/h)]
t_H	duration of the heating period (for ventilation system operation) according to the climate zone [h]

$Q_{rv,defrost}$ energy demand for the frost protection strategy [kWh/a]. Calculation algorithm according to [PHPP]

Frost protection strategy: the following switch-on points are used depending on the foreseen frost protection strategy.

Frost protection strategy	**Switch-on point outside air temperature [°C]**
Rotor/regenerative heat exchanger	< -15 °C
Recuperative heat exchanger with moisture recovery	Ca. -8 °C
Recuperative heat exchanger without moisture recovery	-3 °C
Recuperative heat exchanger without moisture recovery	-1.5 °C
Recuperative heat exchanger without moisture recovery	-1 °C

For recuperative heat exchangers without moisture recovery a general switch-on temperature of -1.5°C is assumed initially; lower switch-on temperatures can be taken into account later on after verification. Please contact us for this.

Climate data:

Climate zone cool, temperate (representative location: Frankfurt am Main):

G_t = 79 kKh/a, t_H= 5136 h

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Requirements and test procedures for energy relevant and acoustic assessment of Passive House ventilation units for certification as Passive House Components

Supplementary sheet for hot and very hot climates - provisional

25.05.2016

The following and to some extent different requirements and test procedures result for hot and very hot climates with reference to:

- Thermodynamic testing
- Moisture recovery
- Heat recovery bypass
- Electrical efficiency
- Hygiene

We recommend that proof of testing and verification as described in this supplementary sheet for certification in hot or very hot climates is provided in addition to certification for cool, temperate climates as both requirements may exist in many regions.

1. Thermodynamic testing

The external pressure difference to be applied for the measurements is generally 100 Pa. The applied external pressure drop should be uniformly distributed (i.e. about 50 % each) between the suction and discharge sides.

- All volumetric flows (ODA/EHA + SUP/ETA) should be measured and recorded.
- Air temperature and humidity should be measured and recorded for all volumetric flows (ODA/EHA + SUP/ETA).
- The total electrical power consumption of the device (including the control unit, possible also any necessary external systems etc.) should be determined and recorded.

The following (dry) temperature and moisture conditions should be set:

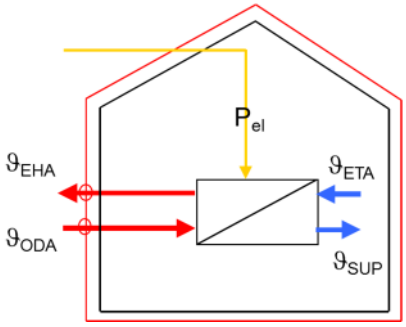
a) Measurement under indoor conditions

The outdoor air and exhaust air mass flows should be adjusted according to the device settings within the limits of measurement accuracy.

Outdoor air conditions ϑ_{ODA} = 35 °C with a relative humidity ≤ 50%

Extract air temperature ϑ_{ETA} = 25 °C with a relative humidity ≈ 50%

Ambient air = Extract air



Calculating the heat recovery on cooling

$$\eta_{\text{HR(hot climates)}} = \frac{(\vartheta_{\text{AB}} - \vartheta_{\text{FO}}) + \dfrac{P_{el}}{\dot{m} \cdot c_p}}{\vartheta_{\text{ETA}} - \vartheta_{\text{ODA}}} \qquad [1]$$

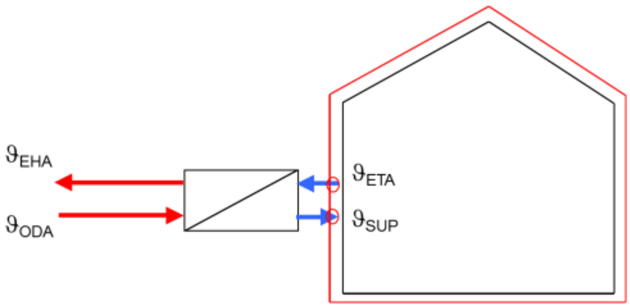
b) Alternatively, the measurement can also be performed under outdoor air conditions

The outdoor air and exhaust air mass flows should be adjusted according to the device settings within the limits of measurement accuracy.

Outdoor air conditions ϑ_{ODA} = 35 °C with a relative humidity ≤ 50%

Extract air temperature ϑ_{ETA} = 25 °C with a relative humidity ≈ 50%

Ambient air = Outdoor air



Calculating the heat recovery on cooling

$$\eta_{\text{HR(hot climates)}} = \frac{\vartheta_{\text{SUP}} - \vartheta_{\text{ODA}}}{\vartheta_{\text{ETA}} - \vartheta_{\text{ODA}}} \qquad [2]$$

For all measurement series it should be ensured and verified through the recorded measured data that the overall test setup has reached a steady state.

For certification as a Passive House component, the calculated heat recovery on cooling must be 70 % or more.

2. Moisture recovery

For application in hot and humid climates, the use of heat exchangers with moisture recovery is necessary or at least strongly recommended in order to reduce to a minimum the entry of moisture into the home from outside.
The moisture recovery rate should be determined by measurements under the following boundary conditions (test setup and measurement similar to 1.).

Outdoor air ϑ_{ODA} = 35 °C with a relative humidity = 80%

Extract air ϑ_{ETA} = 25 °C with a relative humidity = 50%

Finally, the moisture recovery rate should be determined according to the following equation:

$$\eta_x = \frac{x_{ODA} - x_{SUP}}{x_{ODA} - x_{ETA}} \qquad [2]$$

The moisture recovery rate should be better than 60%.

3. Heat recovery bypass

Checking of the effectiveness of the heat recovery by pass for night-time cooling under the following conditions:

Extract air ϑ_{ETA} = 25 °C
Outdoor air ϑ_{ODA} = 16 °C
Volumetric flow at the upper operating limit
Bypass damper opened 100%

The supply temperature should be measured in order to determine the rise in temperature of the supply air temperature compared to the outdoor air temperature.

4. Elektroeffizienz

The total electrical power consumption of the ventilation unit (both fans, including the control unit, possibly also any necessary external systems) for the volumetric flow may not exceed the upper limit of the operating range of 0.45 W per (m³/h) of transferred supply air volume flow (recommendation for hot and very hot climates ≤ 0.35 Wh/m³). The test should be carried out at an external pressure of 100 Pa.

5. Hygiene

Filter

To protect the heat exchanger and the supply air duct network, a fine filter with Class F7 or better should be foreseen on the outdoor air side (corresponding with ASHRAE MERV 13 or better, or with EN779 E1 or better).
If the device itself does not provide the possibility of inserting a F7 filter then an external filter box should be recommended by the manufacturer. This must also be installed for the above-mentioned tests.

Condensate drain

For use in hot and humid climates or also in warm climates with moderate or only temporarily high air humidity levels, equipping the device with a condensate drain is strongly recommended.

a) The condensate drain should be implemented so that the condensate can drain away completely. The installation measures necessary for this should be clearly described in the instruction manual for the device.
b) The inner surfaces of the device housing, particularly on the supply air side should be smooth and easy to clean. Easy access to the device must be possible for maintenance and cleaning purposes (preferably without the need for tools).
c) The condensate drain should preferably be manufactured with a ball siphon or similar in order to prevent odour. The necessary accessories are either supplied by the manufacturer or a product will be recommended by the manufacturer.

Proof relating to a) and b) should be provided through corresponding device drawings and specifying of the materials of the device housing.

Symbols and abbreviations

$\eta_{HR(\text{hot climates})}$	Heat recovery on cooling	[%]
ϑ	Temperature	[°C]
ODA	Outdoor air	
SUP	Supply air	
ETA	Extract air	
EHA	Exhaust air	
η_x	Moisture recovery rate	[-]
x	Absolute humidity	[g/kg]