REPORT
DELIVERABLE 2.2

OutPHit WP2
Reliable Deep renovation Systems

An overview on qualities and requirements

Darmstadt, 10.10.2022,

D2.2_PRELIMINARY SURVEY REPORT ON SUITABLE RENOVATION SYSTEMS FOR VARIOUS CLIMATES (TASK 2.2)

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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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SUITABLE RENOVATION SYSTEMS FOR VARIOUS CLIMATES

REQUIREMENTS FOR A REFURBISHMENT CONSTRUCTION SYSTEM

Building envelope and building services

Also in the case of serial refurbishment, each element has to be made to fit exactly to the existing building. This applies to element sizes, element geometries, window sizes and spacing, parapet heights, etc. In contrast to a modular new built construction or prefab building system, which is based on a fixed given grid, a system provider for refurbishment must be able to flexibly adapt its production. In order to achieve high volumes and speeds, the process must be automated as far as possible. For widespread implementation, these two basic conditions (flexibility and automation) must be met by an increasing number of suppliers. Up to now, only few of them are able to fulfill these requirements. For further information beyond the scope of this document, see [Database and Criteria for PH suitable components]

In the area of building services, a broad scalability of the components is already given by the fact that both heat generators and ventilation units have a wide range of application (consistently high efficiency). Certainly, a precisely fitting design is required for energy-efficient operation.

Systems have a very wide range of use through modulability and/or by the option of cascading.

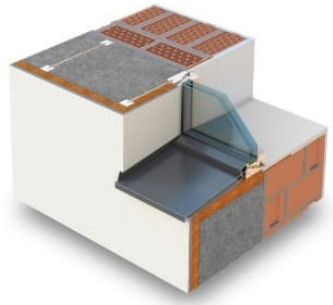
Increasingly, elements of the building envelope and building services are being combined. For example, prefabricated wall or roof elements are equipped with PV. Other initial products of facade-integrated cooling and heating with heat pumps and/or ventilation with heat recovery are available on the market.

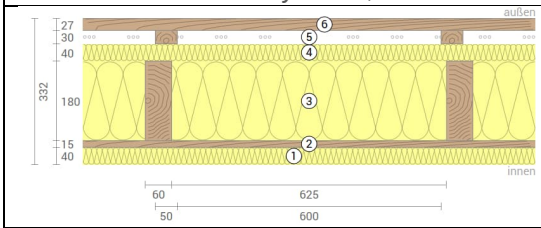
SYSTEMS FOR SERIAL REFURBISHMENT – AN OVERVIEW

Lightweight wooden construction

Advantages: High insulation thicknesses, lightweight construction, use of plate-like materials allows high stability, renewable raw material (gray energy). Easy workability. Disadvantages: Fire protection, current: resource availability (there is no wood at the moment). General: airtightness must usually be ensured by foils or special boards (tested OSB boards or fiber cement boards).

Examples available on the market:

<table>
<tr><td colspan="2">Some systems are already yet evaluated and fulfill the ambitios criteria described below.</td></tr>
<tr><td> 
 
</td><td>A certified and highly efficient building system for renovation is the Ecococon system. It is a modular timber frame system with 40 cm thick straw insulation and can be used both as a load-bearing roof element and as a curtain wall insulation panel for renovation.</td></tr>
<tr><td> 
 
</td><td>Another system is the Smartshell reno. A slim line load-bearing system with insulation thicknesses suitable for passive houses and thermal-bridge-optimized window installation enable highly efficient renovations. Source www.smartshell.de.</td></tr>
</table>

Further construction systems, to be evaluated later to fulfill the criteria	
	Wall structure of a prefabricated facade element made of lightweight wood construction with cellulose insulation and ventilated exterior cladding. Source: Steigmann, SSR
	Another product is not based on a lightweight wood construction but on a lightweight metal construction. The system was developed for insulating existing buildings. Insulation is blown into the air gap between the load-bearing wall and the outer shell of the existing structure. Steel frame elements are installed in front of the wall, the inner layer of which is insulated with mineral wool, the outer layer with EPS as a thermal insulation composite system. The roof elements are also made of a steel frame construction, but the outer insulation layer is made of Resol foam. The roofing is applied to battens, which are screwed to the steel frame through the Resol foam. Source: Renolution
Saint Gobain, ISOVER	Wooden construction system with mineral wool, including windows and ventilation unit
ecoworks	Wooden construction system, including windows and ventilation unit
B&O	Wooden construction system, including ventilation unit, roof elements by PU and metal sheet (Kingspan)
BAM	Prefab masonry wall elements
Fischbach	ETICS system wall elements

BUILDING CERTIFICATION CRITERIA FOR ENERPHIT

The EnerPHit proof for a successful refurbishment can either be provided by compliance with the criteria for the individual components or for the entire building by means of an energy balance (PHPP) and compliance with a maximum heating requirement of 25 kWh/(m²a).

The following overview shows the required efficiency standards of the components of the building envelope and the building service components, namely ventilation with heat recovery and heat pumps for different climate zones.

REQUIREMENTS FOR COMPONENTS FOR DEEP RENOVATIONS

The following criteria must be met for a building system to be considered suitable for serial refurbishment.

- The EnerPHit standard is a key to a climate-neutral building stock see the comments in D2.1
- To achieve the EnerPHit standard, compliance with minimum energy efficiency requirements for components is required. Within the framework of an energy balance, the individual components of the building envelope and building services can be varied in a meaningful way and adapted to the actual boundary conditions of the specific building.
- U-values of the building envelope correspond to the PH standard but a "bonus" is included for the WB, i.e. for the cold basement, foundation thermal bridges, and balconies.
- The corresponding minimum requirements result either from building physics necessities such as minimum surface temperatures to prevent condensation and mold, or they ensure a high level of living and working comfort such as draught-free conditions and radiation temperature asymmetry.
- Transferred to prefabrication, this means that the characteristic values of the individual components, such as facades or roof elements, must be achieved in accordance with the PH requirements.
- This is not trivial because prefabricated elements require higher proportions of supporting structures (usually wood) to provide the necessary stability for transportation and installation, in contrast to on-site renovation measures. In addition, prefabricated systems are placed on individual brackets so that dead weight and wind loads are directed into the building at specific points. This requires stabilizing and load-distributing components within the element.
- This means that proof of compliance with the U-values, including all the necessary load-bearing elements, is absolutely essential. A standard section is not sufficient to evaluate a building system for serial refurbishment!

- Another point is to ensure air and wind tightness. As a rule, existing buildings do not have an airtightness concept based on a continuous airtightness layer. This must therefore be created in a suitable manner as part of the refurbishment. As a rule, either the existing interior plaster or the existing exterior plaster is used. Criteria for the selection of the airtight level are therefore: quality of the plaster level (cracks, adhesion to the substrate...), transitions to adjacent building components (e.g. exterior wall - top floor ceiling). This decision must be made individually for each building!
- According to the airtightness concept, it may be necessary that the serially prefabricated new element represents the new airtight level of the building. This gives special importance to the quality of the joints between the elements, because this level is located on the inside of the element for reasons of building physics. In the case of facades, this usually means that this level cannot be subsequently accessed and checked after installation and therefore cannot be reworked. In the case of roof elements, depending on the supporting system of the roof truss, a certain degree of accessibility to the inner airtight layer is still possible. The wind tightness is on the outside and can (if necessary) be reworked from the outside.

Permissible U-value of building envelope components according to the German building code (GEG). Source: Act on the Saving of Energy and the Use of Renewable Energies for Heating and Cooling in Buildings (Building Energy Act - GEG), Annex 7 (to § 48).

• Insulation of exterior walls	U = 0.24 W/(m2-K)
• Windows and French windows	Uw = 1.30 W/(m2-K)
• Roof windows	Uw = 1,40 W/(m2-K)
• Replacement window glazing	Ug = 1,10 W/(m2-K)
• French windows with hinged, folding, sliding or lifting mechanism	Uw = 1.60 W/(m2-K)
• Windows, French windows and skylights with special glazing	Uw/Ug = 2.0 W/(m2-K) or Ug = 1.6 W/(m2-K) if only glazing or window frames are replaced
• Exterior doors	U = 1.8 W/(m2-K) for door area
• Roof / pitched roof (new roof covering, insulation of top floor ceiling)	U = 0.24 W/(m2-K)
• flat roof	U = 0,24 W/(m2-K)
• Walls and ceilings against unheated basement, floor slab	U = 0.24 W/(m2-K) U = 0.50 W/(m2-K) if renovation/construction of floor is from heated side

The typical refurbishment depths in Germany are largely determined by the present building code 'GEG'. The German KfW funding program "Efficiency House 85" does not require improved U-values. On the other hand, anyone wishing to take advantage of the "EH 70" federal program must demonstrate better U-values. For the exterior wall and roofs, for example, U = 0.20 W/(m²K).

The majority of renovation measures do not take the form of a complete renovation, but rather individual measures.

Typical renovations of the building envelope have U-values between 0.24 and 0.20 W/(m²K). For prefabricated elements, this U-value must be verified with a standard construction. An EnerPHit or PH suitable system must have a significantly improved U-value (0.15 W/m²K) and this must also be proven for the entire element including all supporting elements (e.g. wooden frame). This results in the requirements:

1) Improved insulation with insulation layers between 22 and 24cm (thermal conductivity 0.035 W/m²K) and

2) A U-value calculation including all wood components. Typically, lightweight wood constructions have a wood content of about 12%. For the curtain walls and the described increased wood portions for bracing and transport, this is more like 20%.

3) An optimization of the joints in relation to the locally higher wood proportions, i.e. reduction of thermal bridges.

The improvement of the total U-value can be achieved once by a thicker insulation core. With the help of insulation layers that cover the supporting structure on the outside, continuous supporting elements from the inside to the outside are avoided or their thermal bridge effect is sufficiently reduced. In addition, load-bearing structures made of materials with low thermal conductivity (wood instead of steel) help.

High concentrations of load-bearing elements at the joints should be avoided by providing insulation layers between the beams. A frictional and airtight connection at the joints must be provided everywhere.

As part of the building system certification as a component suitable for passive houses, the concepts developed by manufacturers are examined with regard to the efficiency criteria described above, calculated and certified for different areas of application (climate zones).

EFFICIENCY FIRST – WHY THE NEED FOR CERTIFICATION?

Worldwide, the market for highly energy efficient buildings is growing rapidly, and with it the need for reliable, performing components. But often, the requirements as well as the options to reach them are unclear and some producers might claim energy performance data that cannot be achieved in operation. The Passive House Institute certifies highly energy efficient components according to international criteria for respective thermal performance, comfort and indoor air quality. PHI provides component certification for the following categories:

- Building services
- Transparent building envelope
- Opaque building envelope

All minimum criteria refers to the climate zone where the project is located. See below the various climatic regions:

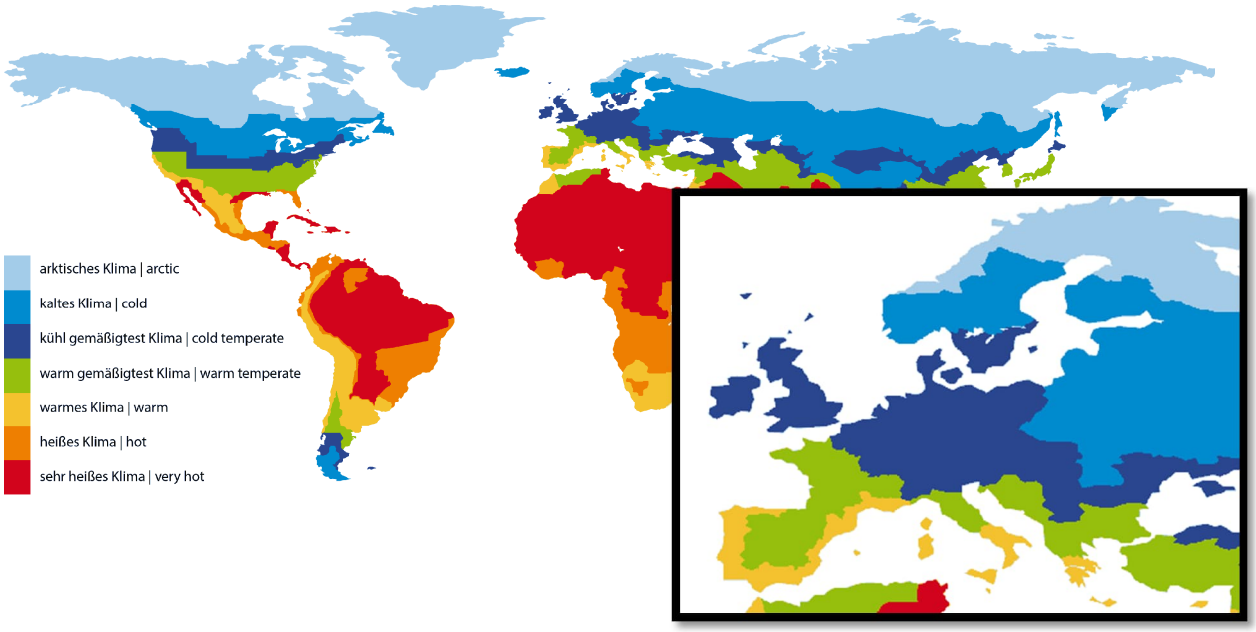


Figure 1: Assignment of regions with identical requirements, based on studies by the PHI

Component quality requirements is crucial as it provides reliable energy performance data for energy balance calculation of the building with PHPP. The Passive House Planning Package (PHPP) is an affordable energy balance tool ideal for high performance building standards with extremely accurate results.

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 that 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
- Entrance into a growing market
- 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

CRITERIA & REQUIREMENTS FOR OPAQUE AND TRANSPARENT COMPONENTS

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-value of the building envelope. However, the values mentioned for the various climatic zones are everywhere significantly more ambitious than the legal minimum standards currently in force in the respective regions. And the actual qualities of the existing buildings are usually significantly worse. In this respect, the EnerPHit standard represents a significant improvement in the energy efficiency of buildings worldwide.

Table 1: Certification criteria (excerpt – complete requirements see appendix)

Climate zone	Comfort criterion	Efficiency criteria			
	U-value of the installed window[1] ≤	U-value of the exterior building component $U_{opaque} * f_{R\ PHI}$[2] ≤	Absence of thermal bridges Ψ_a ≤[4]	Component U-value[2] glazing	U-value glazing installed
	[W/(m²K)]	[W/(m²K)]	[W/(mK)]	[W/(m²K)]	[W/(m²K)]
1 Arctic	0.45 (0.35)	0.09		0.40	0.45
2 Cold	0.65 (0.52)	0.12		0.60	0.65
3 Cool, temperate	0.85 (0.70)	0.15		0.80	0.85
4 Warm, temperate	1.05 (0.90)	0.25	0.010[5]	1.00	1.05
5 Warm	1.25 (1.10)	0.50		1.20	1.25
6 Hot	1.25 (1.10)	0.50		1.20	1.25
7 Very hot	1.05 (0.90)	0.25		1.00	1.05

AIRTIGHTNESS SYSTEMS CRITERIA

A good air tightness minimizes the likelihood and the risk of critical leaks and thus avoids structural damage due to convection of moist air through the structure and subsequent condensation. In addition, good air tightness reduces uncontrolled heat loss during the heating season.

A concept for a continuous airtight layer without gaps is required as early as the planning phase. In new buildings, this is usually easy to implement, whereas in existing buildings it presents a significant challenge (see above). Not all building components and component connections can be subsequently connected to the airtight level with reasonable effort, and there may also be surface leaks such as porous concrete ceilings. For this reason, the limit value for the airtightness of the entire building is increased to an n_{50} value of 1.0 /h. Nevertheless, all components of the renovation must be airtight in themselves and connected to the existing structure in the best possible way. Here, too, there are limit values within the scope

of the certification of components suitable for passive houses, which the products must comply with. See appendix: Limiting values for certification classes)

REQUIREMENTS FOR BUILDING SERVICE COMPONENTS

High energy efficiency requirements are also placed on building service technology. On the one hand, these ensure that the energy used for electrical energy, for example for the ventilation system with heat recovery, requires significantly less electric energy than it ultimately saves in heat over an entire heating period.

On the other hand, the high efficiency criteria for all other building services equipment have put the focus on their unnecessary energy losses and have contributed to the fact that a large number of products are now available on the market that achieve a high level of energy efficiency.

The requirements are based on PHI building service certification, which provides reliable energy performance data based on independent third-party laboratory measurements for:

- ventilation devices with heat recovery
- heat pumps, compact heat pump- and mini split units
- drain water heat recovery

Ventilation devices with heat recovery

There are three main concepts of mechanical ventilation systems with heat recovery which are treated differently both in terms of their range of application and with regard to the efficiency criteria. The detailed certification criteria for ventilation units can be found in the appendix.

Large ventilation units are used both for non-residential buildings (office buildings, schools, administrative buildings) and in multi-family residential buildings when a central ventilation system is implemented there. Central ventilation systems have a more complex air distribution system, but have the advantage during operation that only one unit needs to be serviced and maintained.

In multi-story residential buildings, decentralized residential ventilation systems are often used, which are easier to handle in terms of fire protection and odor transmission. In the context of serial renovation, the implementation of air distribution in serially prefabricated elements is therefore of particular interest.

Within the framework of two demonstration projects (outPHit CS35 and CS36), the installation of the ventilation unit in apartment-wise decentralized building services elements is implemented. A so-called building services backpack is attached to the outside of the façade, which contains heating and hot water connections and the ventilation unit for each apartment.

In the context of renovation, decentralized room-by-room ventilation units are also popular, as they do not require a duct network and can be installed quickly. For energy efficiency reasons and also with regard to sound insulation, these systems must be viewed critically if they do not have a second room connection.

Detailed description of certification criteria for ventilation with heat recovery

In following section, the detailed measurement/certification criteria for different building services products are being presented. In many instances, the large parts of criteria for similar components e.g. small ventilation units, large ventilation units, ventilation units combined with heat pump, compact units etc. are very similar/the same. The following categories of ventilation units are considered in detail below:

- Large - airflow rate > 600 m³/h (350 cfm)
- Small – airflow rate < 600 m³/h (350 cfm)
- Single-room devices

The main characteristics of high efficiency ventilation with heat recovery is the degree of heat recovery, and the electric power requirements of the ventilation unit. These criteria are summarized below. The assessment based on laboratory measurements includes:

- Heat recovery rate
- Electric power consumption
- Comfort criterion
- Internal and external leakage
- Acoustic performance
- Room air hygiene (filter)
- Frost protection

Passive Houses and EnerPHit refurbishments 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”:

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 rooms < 25 dB(A), in functional areas < 30 dB(A).
Room air hygiene	Outdoor air filter at least F7, extract air filter at least G4
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

Combined systems: Ventilation unit equipped with heat pump for space heating and domestic hot water preparation

There are special low power heat pump combi-systems or so called 'compact units' available combining classical ventilation unit with heat recovery and an air-to-air heat pump. The idea is to have all the building service systems needed in one unit: ventilation, air-heating & cooling, and DHW preparation. The test conditions compose of combining the testing of ventilation units with heat recovery and those of heat pumps. The assessment is based on laboratory measurements and includes the following qualities:

- comfort criterion (no draught risk)
- seasonal efficiency for heating and cooling
- Acoustic performance
- Control
- Room air hygiene (filter)
- Defrosting of evaporator during heating season
- Dehumidification ability
- Determination of efficiency for heating of domestic hot water (COP values for heating-up and re-heating of the DHW in the storage tank)
- Stand-by consumption

Exterior wall ventilation sealing systems

In the framework of ventilation systems the simple air-outlets have to be mentioned shortly here. Outlets for air through the exterior wall are needed for example for cooking hoods with direct exhaust air to outside. The outlets must be air tightly closed, when the cooking hood is off. The air-tightness requirements are: Residual leakage at 50 Pa ql ≤ 1 m³/h/ for each Exterior wall air outlet. On the other hand, the pressure losses when open have to be as small as possible: Pressure loss at 300 m³/h should be Δp ≤ 100 Pa. The residual leakage is determined by measurement. At a differential pressure of ± 50 Pa, the leakage volume flow ql50 must not exceed a value of 1 m³/h per external wall air outlet. For details see the appendix.

LIST OF SOURCES

[IWU 2015]	https://www.iwu.de/fileadmin/publikationen/gebaeudebestand/episcope/2015_IWU_LogaEtAl_Deutsche-Wohngeb%C3%A4udetypologie.pdf
[OutPHit-Key Points]	https://univention.passiv.de/nextcloud/s/9iqEDR5zmXr2gsW
[Passipedia 2019]	Economic analysis for the retrofit of a detached single family house to the EnerPHit standard. https://passipedia.org/planning/refurbishment_with_passive_house_components/economic_analysis_for_the_retrofit_of_a_detached_single_family_house_to_the_enerphit_standard
[Data base of 2010]	https://www.destatis.de/DE/Themen/Branchen-Unternehmen/Bauen/Publikationen/Downloads-Bautaetigkeit/baugenehmigungen-baustoff-pdf-5311107.pdf?__blob=publicationFile
[Database and Criteria for PH suitable components]	https://database.passivehouse.com/en/components/ https://passivehouse.com/03_certification/01_certification_components/01_information-regarding-certification.htm https://passivehouse.com/03_certification/01_certification_components/01_information-regarding-certification.htm https://passivehouse.com/03_certification/01_certification_components/02_certification_criteria/02_certification_criteria.htm especially for wall construction systems: https://passiv.de/downloads/03_certification_criteria_construction_systems_en.pdf especially for windows https://passiv.de/downloads/03_certification_criteria_transparent_components_en.pdf

APPENDIX

EFFICIENCY CRITERION PH / ENERPHIT STANDARD

Table 1: Certification criteria

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

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 $f_{Rsi=0.25\ m^2K/W} \geq$ see detailed description of criteria [Database and Criteria for PH suitable components].
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 accordingly, see [Database and Criteria for PH suitable components]

Source:
https://passiv.de/downloads/03_certification_criteria_construction_systems_en.pdf

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 accordingly
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. [Database and Criteria for PH suitable components]

Table 1: 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

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

Source:
https://passiv.de/downloads/03_certification_criteria_transparent_components_en.pdf

Limiting values for certification classes:

Airtight window connection
Products for airtight and thermal bridge minimised installation of PH windows in wall openings.
Airtightness testing of the window to wall joint sealing in solid and lightweight wall constructions will be carried out. Window frames made of PVC as well as wood will be tested in the process.

Surface sealing
Systems for surface sealing of walls, roof, floors in lightweight or solid constructions.

Testing of the airtightness of the sealing systems will take place in accordance with DIN 12114. System-specific butt joints and connections are included:

0 Material on its own without a connectio
1 Force fitting of similar adjacent surfaces
2 Adjacent surfaces consisting of ai composite wood board
3 Adjacent concrete bui component/plastered surface

The required values for PH certification for a "*window connection*" can be taken from the following table:

Class	Air permeability per unit length @ 50 Pa [m³/(hm)]
phA+	≤ 0.05
phA	≤ 0.30
phB	≤ 0.50
phC	≤ 0.80

The required values for PH certification for "*surface sealing*" can be taken from the following table:

Class	Air permeability per unit area @ 50 Pa [m³/(hm²)]
phA	≤ 0.10
phB	≤ 0.18
phC	≤ 0.25

Source:
https://passiv.de/downloads/03_certification_of_airtightness_systems_en.pdf

Table 1: EnerPHit component criteria

Climate zone according to PHPP	Opaque envelope[1] against...				Windows (including exterior doors)					Ventilation	
	...ground	...ambient air			Overall[4]			Glazing[5]	Solar load[6]		
	Insu-lation	Exterior insulation	Interior in-sulation[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 reco-very rate[7]	Min. hu-midity re covery rate[8]
	Max. heat transfer coefficient (U-value)			Cool colours							
	[W/(m²K)]			-	[W/(m²K)]			-	[kWh/m²a]	%	
Arctic	Deter-mined 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 ≤ 0	100	80%	-
Cold		0.12	0.30	-	0.65	0.70	0.80	U_g - g*1.0 ≤ 0		80%	-
Cool-temperate		0.15	0.35	-	0.85	1.00	1.10	U_g - g*1.6 ≤ 0		75%	-
Warm-temperate		0.30	0.50	-	1.05	1.10	1.20	Ug - g*3.2 ≤ -0.6		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)

1 Opaque building envelope

If the heat transfer resistance (R-value) of the layers in an assembly before renovation is taken into account for the improvement of the heat transfer coefficients (U-value) of the modernised components, demonstrate the R-value according to accepted technical standards or enter a conservative value from accepted reference charts. If the precise nature of those materials is unknown, estimate from catalogues of comparable assemblies of a similar age.

For components for which a user-defined temperature weighting factor is used in the PHPP worksheet "Areas" the U-value requirement is divided by the factor. In the hot and very hot climate zones, the factor for the cooling demand is used for this, for all other zones the factor for the heating energy demand is used. For negative factors, the requirement for the respective component does not apply. The respective correct requirement will be automatically calculated in the PHPP.

Unlike new Passive Houses, it is not always possible to eliminate thermal bridges with reasonable expense. Nevertheless, minimise thermal bridges as much as it is reasonable based on long-term cost-effectiveness. Thermal bridges in the construction system, e.g. wall ties, must be included in the assembly's heat transfer coefficient.

2 Interior insulation

These requirements apply only for exterior walls with interior insulation. For roofs, basement ceilings and floor slabs that are insulated on the inside the requirements for exterior insulation apply.

3 Exterior colour

Cool colours have a low absorption coefficient in the infrared part of the solar spectrum.

This criterion is defined by the solar reflectance index (SRI) which is calculated from the absorptivity and emissivity in the PHPP in accordance with the international standard ASTM E1980-11.

Flat roofs (inclination ≤ 10°): SRI ≥ 90

Sloped roofs and walls (inclination > 10° and < 120°): SRI ≥ 50

Use measured values of areas exposed to weathering for at least 3 years. If measured values are only available for the new surface then the absorptivity must be converted using the auxiliary calculation in the PHPP "Areas" sheet. For simplification, the emissivity can be kept as it is.

This criterion does not apply to:

"greened" surfaces; areas which are covered with rear ventilated solar collectors or photovoltaic panels (including the areas required between the panels); penetrations in components and the associated equipment; accessible (roof) terraces or paths; areas that are strongly shaded or do not face the sun.

Alternative measures (e.g. increasing the insulation thickness beyond the applicable criterion) are allowed as long as the cooling demand is not greater than the cooling demand of the building with cool colours.

4 Windows, overall

The small graphics in the table above show the inclination of the installed window. Apply the criterion nearest to the window's inclination; do not interpolate from the criteria. However, note that since the U-value of the glazing changes with the inclination due to physical processes, the glazing U-value Ug corresponding to the actual inclination must be entered in PHPP.

In the case of small windows (windows above an average frame length to window area ratio of 3 m/m²) the limit is gradually increased. PHPP automatically calculates the limit and displays it in the "Verification" sheet according to the following formula:

Addition to the limit value [W/m²K]: (l/A-3)/20

l: length of window frame

A: window area

5 Glazing

The limit applies only to buildings with a heating demand above 15 kWh/(m²a) and active heating.

6 Solar load

The limit applies only to buildings with a sensible cooling demand above 15 kWh/(m²a) and active cooling. It refers to the solar radiation entering the building per m² of glazing area after taking into account all reduction factors due to shading etc., and must be complied with for the average values of all windows facing the same cardinal direction as well as the average of all horizontal glazing.

7 Ventilation, minimum heat recovery efficiency

The limit applies to the entire ventilation system as a whole (not simply the ventilation unit as in PH component certification), i.e. including the heat losses of the ventilation ducts between the thermal envelope and the ventilation unit.

8 Minimum humidity recovery efficiency

The climate conditions are classified as "humid" if the dry degree hours for dehumidification are ≥ 15 kKh (based on a dew-point temperature of 17 °C). This is automatically determined in the PHPP.

Source: https://passiv.de/downloads/03_building_criteria_en.pdf

SUMMARY OF SOURCES: LIST OF DOCUMENTS CONSULTED:

Opaque criteria:
https://passiv.de/downloads/03_certification_criteria_construction_systems_en.pdf

Transparent criteria:
https://passiv.de/downloads/03_certification_criteria_transparent_components_en.pdf

Airtightness criteria:
https://passiv.de/downloads/03_certification_of_airtightness_systems_en.pdf

Building certification criteria:
https://passiv.de/downloads/03_building_criteria_en.pdf

DETAILED DESCRIPTION OF VENTILATION SYSTEMS: REQUIREMENTS AND TESTING PROCEDURE

A) REQUIREMENTS AND TESTING PROCEDURES FOR ENERGETIC AND ACOUSTICAL ASSESSMENT OF PASSIVE HOUSE *SMALL VENTILATION SYSTEMS* 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. The inspecting authority must guarantee a testing procedure in accordance with these testing regulations.

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 Class F7 filter, on the extract air side a Class G4 filter is to be inserted.

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.

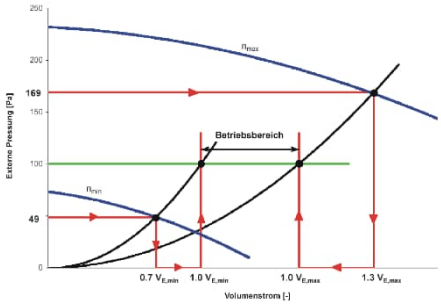
Emergency shutdown for frost protection

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).

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:

- The unit is operated at full speed with an external pressure of 100 Pa x $1{,}3^2$ = 169 Pa. The flow rate measured divided by 1.3 gives the upper limit of the operational range.
- The unit is operated with an external pressure of 100 Pa x $0{,}7^2$ = 49 Pa at the lowest fan speed. The measured flow rate divided by 0.7 gives the lower limit of the operational range.
- The flow rate for the test is computed from the average value of the upper and lower limits of the operational area.



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.

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 measurements should be made for at least four testing pressures at a time in the range between 50 Pa and 300 Pa.

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.

Thermo-dynamical testing

Winter case

Heat recovery. 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.

The measurements is to be made at outside temperature 4 °C and an extract air temperature of 21°C. There should be no condensation in the heat exchanger (dry measurements).

- 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).
- All flow rates (outdoor air /exhaust air and supply air/extract air) are measured and logged.
- The air temperature and humidity is measured and logged for all flows (outdoor air /exhaust air and supply air/extract air).
- 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.

Moisture recovery

The moisture recovery (provided tested unit is equipped with one) is determined for the standardised extract air conditions of 21°C/50% rH and for outdoor air conditions of 4°C/80% rH.

Summer case

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

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 should be 35 °C with a relative humidity ≤ 50%. Extract air temperature is to be set to 25 °C. For certification as a Passive House component, the calculated heat recovery on cooling must be 70 % or more.

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 the entry of moisture into the home from outside.

The moisture recovery rate should be determined by measurements under the following boundary conditions: Outdoor air at 30 °C with a relative humidity = 70%, Extract air at 25 °C with a relative humidity ≤ 50%

The moisture recovery rate should be better than 60%.

Heat recovery bypass

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

Extract air at 25 °C

Outdoor air at 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.

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).

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. 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.

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.

Checking of the frost protection for the heat exchanger

Switching threshold of the factory setting

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 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.

Measurement of the critical temperature

The temperature at which the exhaust air temperature reaches the frost limit should be determined with deactivated pre-heating.

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..

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.

B) TESTING PROCEDURE FOR THE ENERGY-RELEVANT AND ACOUSTIC ASSESSMENT OF LARGE PASSIVE HOUSE VENTILATION UNITS FOR CERTIFICATION AS 'COMPONENTS SUITABLE FOR PASSIVE HOUSES'

The principal idea of evaluation of large ventilation unit is the same as for small ventilation units presented in part A). However some particularities need to be take into account for units being used in non-residential buildings. Especially the boundary conditions for the measurements differ. In the text below, things which differe to small units are described.

Applicability

The testing criteria apply for central ventilation units with volumetric air flow rates from 600 m³/h. The criteria will only apply for recuperative heat exchangers initially. The classification of the central ventilation units into categories will take place in accordance with those for small units, see above.

Table 2: Required differential pressure subject to the category of volumetric flow.

Volumetric fresh air flow [m³/h]	External pressure [Pa]	
	Requirement for non-residential buildings	Requirement for residential buildings
upto 600m³/h	190	155
upto 650m³/h	195	160
upto 700m³/h	200	165
upto 750m³/h	204	169
upto 800m³/h	208	173
upto 900m³/h	215	180
upto 1000m³/h	222	187
upto 1100m³/h	228	193
upto 1200m³/h	233	198
upto 1300m³/h	238	203
upto 1400m³/h	243	208
upto 1500m³/h	247	212
upto 1600m³/h	251	216
upto 1700m³/h	255	220
upto 1800m³/h	259	224
upto 2000m³/h	265	230
upto 2200m³/h	271	236
upto 2400m³/h	276	241
upto 2600m³/h	281	246

Volumetric fresh air flow [m³/h]	External pressure [Pa]
	Requirement for non-residential buildings
upto 2800m³/h	286
upto 3000m³/h	290
upto 3200m³/h	294
upto 3400m³/h	298
upto 3600m³/h	302
upto 4000m³/h	308
upto 4500m³/h	316
upto 5000m³/h	322
upto 5500m³/h	328
upto 6000m³/h	333
upto 6500m³/h	338
upto 7000m³/h	343
upto 7500m³/h	347
upto 8000m³/h	351
upto 8500m³/h	355
upto 9000m³/h	359
upto 10000m³/h	365
upto 11000m³/h	371
upto 12000m³/h	376
upto 13000m³/h	381
upto 14000m³/h	386
upto 15000m³/h	390

Thermodynamic testing

The application area of the volumetric flows is specified by the manufacturer. Before starting the thermodynamic test it must be checked whether the requirements for electrical efficiency even with maximum mass flows are complied with. The test facility measurement must be carried out for the following fresh air mass flows:

- if qmin/qmax > 0.77, then the test facility measurement must be carried out for qmax at least.
- if $0.77 \geq$ qmin/qmax > 0.62 , then the test facility measurement must be carried out for qmax and qmin at least.
- if qmin/qmax $\leq$ 0.62, then the test facility measurements must be carried out for three fresh air mass flows: qmax, (qmax + qmin)/2 and qmin

Measuring the power consumption for adjustment control

In contrast with small home ventilation units, large ventilation units do not always have an adjustment control mechanism integrated into or supplied with them.

If a regulating mechanism is not supplied with the device, an overall general value is allowed for the specific power consumption.

C) REQUIREMENTS AND TESTING PROCEDURES FOR ENERGETIC AND ACOUSTICAL ASSESSMENT OF PASSIVE HOUSE (FAÇADE INTEGRATED) VENTILATION SYSTEMS

The items (part of text) deviating from preivous ventilation units or additional measurements needed for decentralized units is described below.

Certified Airflow range

In deviating from the centralized ventilation units, the certified airflow range of decentralized ventilation devices is determined according to the achievable sound level. Within the certificate two operation levels will be documented: one for continuous operation and another one for demand operation. The certified airflow range depends on the achievable sound pressure level in the respective room category.

Airtightness

External Leakage: Reference is made to EN 13141-8. The measurement is performed at a pressure difference of +/- 20 Pa (according to EN 13141-8), and at +/- 50 Pa (additional measurements in step with actual practice).

Internal Leakage: The measurement should be performed according to the tracer gas method described in [EN 13141-8]. Alternatively the measurement could be performed

based on the pressure testing method according to [EN 13141-8] with an additional measurement point at +/- 50 Pa (obligatory measurement at +/- 20 Pa).

Ventilation effectiveness

Ventilation devices ventilating only one room with an air inlet and an air outlet close to each other have a higher risk of mixing exhaust air with fresh outdoor air (or fresh supply air with the extract air) due to short-circuit flow.

EN 13141-8 appendix C describes a suitable measurement procedure in order to quantify the amount of air transfer through the heat exchanger that can't be used for ventilation purpose.

Sound reduction index

The measurement of the sound insulation of the ventilation device integrated in the façade is to be performed according to ISO 10140-2, which describes a measurement of airborne sound insulation.

D) REQUIREMENTS AND TESTING CONDITIONS FOR ENERGY EFFICIENCY, COMFORT, ACOUSTIC AND HYGIENIC ASSESSMENT OF AIR-TO-AIR HEAT PUMPS FOR CERTIFICATION AS "PASSIVE HOUSE SUITABLE COMPONENT"

Acoustical testing

The methods described in the standards EN 12102 and ISO 3743-2 should be used to determine the sound power level of the tested unit. If the laboratory used is not equipped with a special reverberation test room, the ISO 3743-1 standard can be followed instead. The maximally accepted value of the sound pressure level of the inside unit is 25 dB (A) in order to consider room comfort (value is assuming room equipped with furniture). All measurements must therefore be done with the air flow of the inside unit generating a maximal sound pressure level of 25 dB (A). Only in this way can a user be informed about the performance of the unit at comfortable operation.

Energy Efficiency

The seasonal performance of tested unit is evaluated by the Passive House Institute for representative climates. This is based on the key characteristics determined for space heating, cooling and dehumidification operating modes at all test points specified in the testing regulations and stated in the certificate.

Verification is based on a model Passive House with a heating/cooling load of 10 W/m², a heating/cooling demand of 15 kWh/(m²a).

The Passive House Institute uses three reference climates, first for heating (cool,temperate), second for sensible cooling (hot and dry), and third for sensible cooling and dehumidification (hot and humid).

The following test points are to be measured in a laboratory:

Table 2: Testpoints to be measured for cooling operation

Cooling scenario[1)]				
Temperature [°C]		Operation (part-load)		
Outside	Inside	ON/OFF*	ON/OFF Limit**	Maximum***
35 (28)	25	optional	optional	required
30 (24)	25	required	required	required
25 (20)	25	optional	optional	required

1) All the mesurements are to be carried out at room relative humidity of 60%. Sensible heat ratio (SHR) should be documented for all the test points.

Table 3: Testpoints to be measured for heating operation

Heating scenario				
Temperature [°C]		Operation (part-load)		
Outside	Inside	ON/OFF*	ON/OFF Limit**	Maximum***
-7 (-8)	20	optional	optional	required
2 (1)	20	required	required	required
7 (6)	20	optional	optional	required

Explanation to tables above when using calorimetric method:

* approx. 30% of the power available at test point "ON/OFF Limit"

** the smallest power of tested unit available at continuous operation (if the power would be further decreased, the tested unit would start to switch on and off)

*** maximum power available for longtime operation at mode generating max. 25 dB(A) (as defined in section 1)

For multi-split and variable refrigerant flow systems, separate criteria are available, please ask Passive House Institute.

Hygienic requirements

Devices providing cooling below the dew point have to provide hygienic drainage for the condensate and must provide very good maintenance and cleaning options.

Mould growth in the cooling coil and drainage area must be avoided. The instructions for cleaning the units should be described by the manufacture.

The drainage of the condensate from the internal unit is to be evaluated and the test should be carried out according to EN 14511-4. The construction of the drainage system should allow immediate removal of condensate from the unit in order to avoid mould growth.

For packaged terminal air conditioners (in the field called often PTACs), the measurements described below must be done in addition to previously described measurements for heat pumps.

Sound reduction index

A measurement of the sound reduction of the tested unit as installed in the facade is to be performed according to ISO 10140-2, which describes a measurement of airborne sound insulation.

This measurement must be taken in order to provide adequate design values. The sound reduction index must be better than 30 dB. Reference is made to DIN 4109 for areas of category II (outside sound level 56 - 60 dB(A)).

Airtightness

The measurement is performed following the method described in EN 13141-8. The external airtightness of the tested unit is to be investigated. The airtightness test is to be carried out for a negative and a positive pressure difference. The measurements are to be made at ± 50 Pa pressure difference. The air flow rate which is necessary to maintain the static pressure difference between the apparatus interior and the surroundings is determined. Installation of unit should be done following producer`s instructions. The limit for airtightness is 3 m^3/h per tested unit.

Heat losses on facade

The heat loss of the tested unit to the outside environment in stand-by mode is to be measured (compressor and fans are turned off during measurements). The installation of the unit should follow the producer's instructions and must correspond exactly to the installation as in real operation (building installation). The limit for heat loss is 1 W/K per tested unit.

E) TESTING CONDITIONS FOR ENERGY EFFICIENCY, COMFORT, ACOUSTIC AND HYGIENIC ASSESSMENT OF VENTILATION UNIT EQUIPPED WITH HEAT PUMP INCLUDING DOMESTIC HOT WATER PREPARATION FOR CERTIFICATION AS "PASSIVE HOUSE SUITABLE COMPONENT"

As the text above suggests, this concerns unit combining classical ventilation unit with air-to-air heat pump. The test conditions compose of combining the text description in part A) and C). In addition, the preparation of domestic hot water is described below.

DHW- heating, reheating and standby

The measurements include determination of the heat pump's COP for hot water preparation mode and evaluation of storage heat losses from the storage tank. The preparation mode includes heating-up phase (case where tank has been filled with cold water) and re-heating phase (water amount has been partly used).

Evaluation for a stratified DHW tank

The test is a simplified version of the test in EN 255-3 [11] . The test is composed of different parts as described on picture below.

For details see [testing criteria]

Simplified method

The aim of the simplified measurement for determining the characteristics of the heat pump for hot water operation is to ascertain these without going through the relatively time-consuming process of the above described water withdrawal cycles. The simplified test described below provides sufficiently accurate results for mixed hot water tanks.

Test procedure for determining U*Atank

For the simplified method the tank's U*A is determined by heating the total hot water capacity with external electrical heater coils. The hot and cold water connections of the tank are short-circuited for this. An external circulating pump installed in front of the electric heater coils ensures that the water is thoroughly mixed. Due to this, the usage temperature is accurately known can be recorded using an external sensor, without any changes having to be made to the device itself. At this stage the internal temperature sensor of the compact unit and external measurements should be calibrated. The hat water tank is then heated from the cold state (<20°C) to the specified domestic water temperature (50 °C). During this process the temperature changes and corresponding electricty consumption of the heater coils must be recorded.

F) REQUIREMENTS AND TESTING CONDITIONS FOR EXTERIOR WALL VENTILATION SEALING SYSTEM FOR CERTIFICATION AS "PASSIVE HOUSE SUITABLE COMPONENT"

The requirements are:

Residual leakage at 50 Pa ql ≤ 1 m³/h/Exterior wall air outlet

Pressure loss at 300 m³/h Δp ≤ 100 Pa

Residual leakage

The residual leakage is determined by measurement. At a differential pressure of ± 50 Pa, the leakage volume flow ql50 must not exceed a value of 1 m³/h per external wall air outlet.

The specified certificate value refers to the measured leakage volume flow of the tested exterior wall air outlet at a differential pressure of ± 50 Pa. The leakage volume flow ql8 at a differential pressure of ± 8 Pa is relevant for determine the energy balance of the building. If ql8 ≥ is 0.3 m³/h, the additional heat loss due to infiltration must be taken into account in the building energy balance.

Pressure loss

High pressure losses of the exhaust air duct reduce the achievable exhaust air volume flow and also increase the power consumption of the kitchen exhaust system. High-quality exhaust systems under typical conditions ensure good capture of kitchen fumes already with exhaust air volume flows of < 300 m³/h. The exhaust air duct should therefore have only moderate pressure losses.

Recommendation: The pressure loss of the exterior wall outlet should not exceed 100 Pa at an exhaust air volume flow of 300 m³/h.

Thermal bridge coefficient

The punctual thermal bridge coefficient was determined for a reinforced concrete wall with a 25 cm thermal insulation system, suitable for cool moderate climate.

G) REQUIREMENTS AND TESTING CONDITIONS FOR DRAIN WATER HEAT RECOVERY FOR CERTIFICATION AS “PASSIVE HOUSE SUITABLE COMPONENT”

EFFICIENCY CRITERION

Under standardised boundary conditions (balanced flow, cold water temperature 10 °C, shower head temperature 40 °C, waste water temperature 35 °C, negligible pipe lengths, indoor temperature 20 °C, shower duration 6 minutes, volume flow rate 8 litres/minute), the system reduces the useful energy expenditure for shower water by at least 30 %*

* Note: Due to the temperature loss in the shower and to dynamic effects the useful energy savings typically amount to 75-80% of the nominal efficiency

VERIFICATION OF CERTIFIABILITY, CERTIFICATE

Evaluation of the HR systems will take place based on two parameters: steady-state nominal efficiency ηnom and effective dead time tdead.

BOUNDARY CONDITIONS

The parameters are determined under the following boundary conditions:

- Volume flow rate 8 l/min
- Temperature of cold water: 8 to 13 °C
- Ambient temperature: 18 to 25 °C
- Temperature of waste water: 35 to 39 °C

NOMINAL EFFICIENCY

The temperature ratio

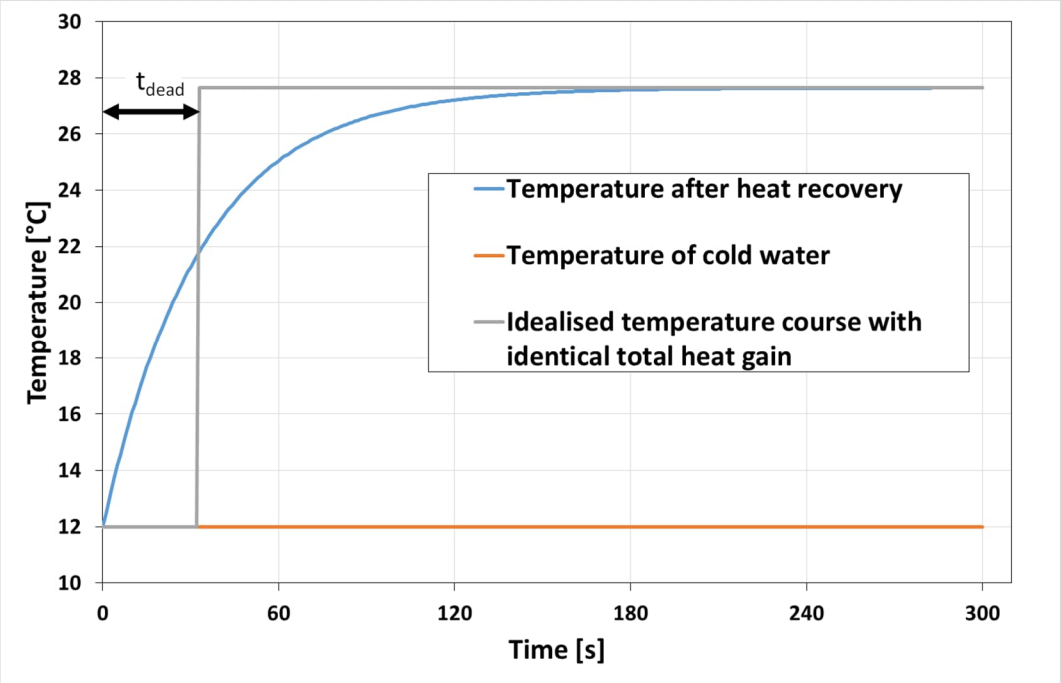
$\eta nom = (THR - T_{cold\ water})/(T_{waste\ water} - T_{cold\ water})$

characterises the degree of efficiency in steady-state continuous operation. Here, THR is the temperature of the cold water downstream of the heat exchanger. The value ηnom, measured under the above boundary conditions, is denoted as the nominal efficiency.

EFFECTIVE DEAD TIME

After the start of the shower process, temperatures will only gradually approach their values in steady state; an approximately exponential increase is typical. This is characterised as the “effective dead time” tdead.

The following chart illustrates the term effective dead time for a greatly simplified case.



PRESSURE DROP

For informational purposes only, pressure drop on the fresh water side will be stated with the nominal volume flow rate (typically 8 l/min).

CONNECTIONS

For informational purposes only, the sizes of the connecting pieces for waste water and fresh water will be stated.

HYGIENE

Hygienic requirements are not tested in the certification process. However, as a prerequisite for certification, the manufacturer has to testify comprehensibly that the unit fulfils the requirement of EN 1717 for a double-wall separation of waste water and fresh water.