Criteria

for the Passive House, EnerPHit and PHI Low Energy Building Standards

Version 10b I May 2022

Passive House Institute

Certified Passive House
Passive House Institute
classic | plus | premium

EnerPHit
Certified Retrofit
Passive House Institute
classic | plus | premium

PHI Low Energy Building

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1 Introduction

1.1 Objectives, applicability and validity

1.1.1 Objectives

The "**Passive House**" and "**EnerPHit**" energy standards for buildings as defined by the Passive House Institute in this document have the objective of ensuring the following building characteristics in particular:

- year-round comfortable and healthy indoor conditions
- an extremely high level of energy efficiency (as a prerequisite for cost-effective operation and climate protection)
- a high level of user satisfaction

These criteria describe requirements that are precisely defined for achieving these objectives.

The "**PHI Low Energy Building**" standard is an alternative standard for buildings which do not completely meet the energy-efficiency and comfort objectives.

1.1.2 Applicability

Buildings which comply with the requirements described in Section “2 Criteria” will attain the Passive House, EnerPHit or PHI Low Energy Building standard.

For the purpose of quality assurance, the building can be certified by the PHI or a Passive House building certifiers accredited by the PHI (hereafter referred to as "Certifier"). If the thorough review shows that the building meets all criteria, then the Certifier may award one of the applicable seals as described in Section 3.1.1 "Certified Passive House", "EnerPHit Certified Retrofit" or "PHI Low Energy Building".

The PHI's building seals or the addition "certified" may not be used for buildings which meet the criteria but have not been certified as described above.

1.1.3 Validity

This update of the criteria takes effect when **version 10 of the Passive House Planning Package** (PHPP) is released. The PHPP 10 in English was released on 24 May 2022. As PHPP 10 is released in other languages, these criteria take effect for persons using those versions.

1.2 Structure of criteria

This document contains the criteria for the energy standards for buildings defined by the Passive House Institute. Subsections **2.1**, **2.2** and **2.3** list specific **criteria** for the three standards. The requirements in Subsection 2.4 "General minimum criteria for all Standards" apply to all three standards.

Evidence of compliance with the criteria will be provided with the Passive House Planning Package (PHPP) using the conditions given in Subsection **2.5 "Conditions for the PHPP calculation"**.

If a building is to be certified by the PHI or one of its accredited Certifiers, then a review will take place in accordance with Section **3 "Technical Rules for Building Certification"**. Subsection 3.2 lists the documents to be submitted for certification.

The **Appendix (Section 4)** contains additional rules on detailed questions relating to certification. Where necessary, these will be referred to in the preceding sections.

The separate document "Building Certification Guide" serves as a supplement to the "Criteria for the Passive House, EnerPHit and PHI Low Energy Building Standards" published by the Passive House Institute. The guide is intended to facilitate an understanding of the requirements presented in this document, in a concise and precise form and to provide additional explanations. In case of uncertainty, the requirements described in the criteria shall take precedence over the explanations in the guide.

1.3 Relevant modifications compared to the previous version

The changes mentioned below are automatically taken into account in PHPP version 10:

1.3.1 Version 10b

Energy

- Cooling period: the **cooling load criterion** is no longer used. For climates with a high cooling demand, the **cooling demand requirement** has been slightly relaxed on the basis of previous experiences.
- Heating period: the requirements for the **heating demand** now also apply in hot climates.
- For residential or office buildings with high occupancy densities, an alternative **project-specific primary energy requirement** (PER and PE) may be used. This is automatically calculated in the PHPP.
- New EnerPHit component criterion for the **building envelope to ground**: the average heat loss per square metre of component area (under consideration of the insulating effect of the ground) may not be higher than for a component of the building envelope against ambient air which complies with the EnerPHit component requirements.

General minimum requirements

- A more precise **comfort criterion** (minimum U-value) based on the window size (smaller windows have a less stringent requirement). The previous exception for the comfort criterion for windows under 1 m² therefore no longer applies.

- A more precise **hygiene criterion** (temperature factor f_{Rsi}, avoidance of mould). This is now calculated in the PHPP on the basis of project-specific conditions and replaces the previous criterion that depended on the climate zone.
- Profiles for **door thresholds** so far were often not able to meet the hygiene criterion due to technical reasons. There is now a less stringent limit value for these profiles.
- The requirements for comfort and hygiene now also apply for **hot climate zones**.
- Ventilation system: clearer requirements relating to **prevention of draughts**
- Ventilation requirements for **stairwells**

Conditions for the PHPP calculation

- Calculations for PV and solar thermal energy as well as shading may only be performed with the PHPP. The use of **external software** is no longer allowed for this purpose (except for shading with designPH from Version 2 onwards).
- If a significant **difference in the actual usage** and the standard conditions in the PHPP is anticipated, then a second PHPP variant must be calculated with the deviating conditions (e.g. anticipated consumptions). This applies especially for countries shown to have higher electricity or hot water consumption.
- For calculation of the **cooling demand requirement** in the PHPP for the EnerPHit and PHI Low Energy Building standards, airtightness is assumed to be n_{50}=1.0 1/h (instead of 0.6 1/h as used previously).
- More exact rules for determining the primary energy factor for **district heating**
- Standard values for internal heat gains: for **schools**, a distinction is now made between half-day schools and full-time schools; the value for **nursing homes / student dorms** is no longer included.
- Specification of the **minimum volume flow rates** for the building ventilation; the upper limit for volume flow no longer applies.
- **Setpoint temperature of rooms** in the heating period: the reference to EN 12831 has been replaced with a separate provision

Documents to be submitted

- The documentation of the **ventilation commissioning** (flow rate adjustment) must contain the signature of the person performing the adjustment.
- A **pressure loss calculation** for the ventilation ductwork must be submitted for non-residential buildings; for residential buildings this must be submitted only for ventilation units with a volume flow greater than 600 m³/h (standard operation).
- For measurement of the **building airtightness** the criteria now refer to ISO 9972 (not to EN13829 anymore). Additionally, the criteria include supplementary provisions for calculating the volume.
- For buildings without active cooling, the documentation of the **summer comfort strategy** must be signed by the building owner.
- Clarification that the **average** value obtained from the **negative and excess pressures** will apply for achieving the n_{50} limit value
- Verification is necessary that the **heating and hot water pipes** have been insulated in a thermal bridge minimised manner if this is specified in the PHPP.

Miscellaneous

- New section on **exemptions** and **pilot projects**
- New regulation in the event of **inadequate durability** of efficiency measures (e.g. unsuitable adhesive tapes for sealing/airtightness)
- **Additional provisions** related to the criteria have been integrated into the **Appendix** of the present document which were previously published on Passipedia.

2 Criteria

2.1 Passive House Standard

Passive House buildings combine superior thermal comfort with minimum energy consumption. In general, the Passive House Standard is cost-effective particularly in new buildings. Passive Houses are classified as Classic, Plus or Premium depending on their renewable primary energy (PER) demand and renewable energy generation.

Table 1: Passive House criteria

			Criteria[1]			Alternative Criteria[2]
Heating						
Heating demand	[kWh/(m²a)]	≤	15			-
Heating load[3]	[W/m²]	≤	-			10
Cooling						
Cooling + dehumidification demand	[kWh/(m²a)]	≤	15 + variable allowance[4]			
Airtightness						
Pressurization test result n_{50}	[1/h]	≤	0.6			
Renewable Primary Energy (PER)[5]			Classic	Plus	Premium	
PER demand[6]	[kWh/(m²a)]	≤	60	45	30	±15 kWh/(m²a) deviation from criteria...
Renewable energy generation[7] (with reference to projected building footprint)	[kWh/(m²a)]	≥	-	60	120	...with compensation of the above deviation by different amount of generation[8]

[1] The criteria and alternative criteria apply for all climates worldwide. The reference area for all limit values is the treated floor area (TFA) calculated according to the latest version of the PHPP Manual (exceptions: generation of renewable energy with respect to the projected building footprint and airtightness with respect to the net air volume).

[2] Two alternative criteria together (enclosed by double lines) may replace both criteria on the left (also enclosed by a double line).

[3] The steady-state heating load calculated in the PHPP. Loads for heating up after temperature setbacks are not taken into account.

[4] Variable allowance for the cooling + dehumidification demand subject to climate data, necessary air change rate and internal heat and moisture loads (calculation in the PHPP).

[5] Evidence for the Passive House Classic, EnerPHit Classic and PHI Low Energy Building Standards can alternatively continue to be provided by proving compliance with the requirement for the non-renewable primary energy demand (PE). The desired verification method can be selected in the PHPP worksheet "Verification". In the PHPP the PHI has specified the country-specific PE limit values based on national primary energy factors. If no values exist for a country in the empty PHPP, then Qp ≤ 120 kWh/(m²a) will apply (with a PE factor for electricity mix: 2.6). The primary energy factor profile 1 must be used for PE verification in the PHPP (selection in the "PER" worksheet).

[6] All energy uses in the building are included (see also Subsection 2.5.10). The limit value applies for typical residential, educational and office/administrative buildings. In case of uses deviating from these, if a very high electricity demand arises then the limit value may also be exceeded after consultation with the Passive House Institute. Evidence of efficient use of electrical energy for all significant devices and systems is necessary for this, with the exception of existing devices which were already owned by the user before the construction measures if retrofitting or replacement for improving the electrical efficiency can be shown to be uneconomical over the lifecycle. For residential and office/administrative buildings with a high occupancy density the automatically calculated "project-specific" criterion in the PHPP can be used alternatively (selection in the "Verification" worksheet).

[7] Renewable energy generation which is not adjacent to or attached to the building may also be taken into account (except for biomass use, waste-to-energy plants, and geothermal energy): only new systems may be included (i.e. systems which did not start operation before the beginning of construction of the building) which are owned by the building owner or the (long-term) users (first-time acquisition).

[8] If the PER demand exceeds the standard criterion, the limit value for the PER demand is increased as much as necessary, but by no more than 15 kWh/(m²a). A prerequisite for this is that the difference between the standard PER limit value and the calculated PER demand is offset to the same extent through additional generation of renewable energy (beyond the standard limit value for renewable energy generation). On account of the different area references (treated floor area/ projected building footprint), the calculation of the offset takes place in absolute numbers i.e. in kWh/a. In the same way, too little renewable energy generation can be compensated to the same extent through a reduced PER demand but by no more than 15 kWh/(m²a).

2.2 EnerPHit Standard

A retrofit to the Passive House Standard may not be cost-effective due to various difficulties, but a retrofit to the EnerPHit Standard using Passive House components improves thermal comfort, durability, cost-effectiveness and energy efficiency.

Only those buildings for which modernisation to the Passive House Standard (for new builds) would be uneconomical or structurally impossible on account of the existing building characteristics or building substance can be certified according to the EnerPHit Standard. An EnerPHit certificate generally cannot be issued for entirely newly constructed buildings.

For an EnerPHit retrofit, if more than 25 % of the opaque exterior wall area is insulated on the inside, then **EnerPHit^{+i}** (with a superscript "+i") will be used for that building. This does not apply for the warm, hot and very hot climate zones.

The EnerPHit Standard can be attained by complying with the criteria in the **component criteria method** (Table 2) or alternatively by complying with the criteria in the **energy demand method** (Table 3). Compliance with the criteria of only one of these methods is necessary. The climate zone to be used for the building location will be determined automatically in the PHPP on the basis of the selected climate data set.

The criteria in Table 2 generally conform to the thermal performance criteria for certified Passive House components[1]. The criteria must be complied with for the entire building at least as an average value[2]. Exceeding these values is acceptable in some areas if this is compensated through accordingly better thermal protection in other areas.

In addition to the criteria in either Table 2 or Table 3, the EnerPHit building must always meet the **general criteria** in Table 4. The EnerPHit building achieves the classification of Classic, Plus or Premium depending on the renewable primary energy (PER) demand and renewable energy generation.

Partial renovations may be pre-certified if these are implemented within the framework of an EnerPHit Retrofit Plan (see Section 3.3)

[1] Certified Passive House component criteria and data sheets are available at www.passivehouse.com.
[2] Note: When calculating average U-values for insulated components, the area-weighted mean U-value, and not the U-value calculated with the average insulation thickness, applies. Thermal bridges must be included in the calculation of the average U-value only if they are part of the standard structure of the component (e.g. studs in a wall). With multiple ventilation systems, use volumetric-flow-weighted average values.

2.2.1 EnerPHit criteria for the building component method

Table 2: 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]		
	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 ≤ 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 U_g 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.

2.2.2 EnerPHit criteria for the energy demand method

Table 3: EnerPHit energy demand criteria (as an alternative to Table 2)

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[1]
Cold	30	
Cool-temperate	25	
Warm-temperate	20	
Warm	15	
Hot	15	
Very hot	15	

[1] In deviation from the Passive House requirement, airtightness is assumed to be n_{50}=1.0 1/h (instead of 0.6 1/h) for the calculation of the building-specific limit value for the cooling and dehumidification demand.

2.2.3 General EnerPHit criteria (irrespective of the method)

Table 4: General EnerPHit criteria (always applicable irrespective of the chosen method)

			Criteria[1]			Alternative Criteria[2]
Airtightness						
Pressurization test result n_{50}	[1/h]	≤	1.0			
Renewable Primary Energy (PER)[3]			Classic	Plus	Premium	
PER demand[4]	[kWh/(m²a)]	≤	60 + allowance for larger heating/cooling demand (compared to Passive House)	45 + allowance for larger heating/cooling demand (compared to Passive House)	30 + allowance for larger heating/cooling demand (compared to Passive House)	±15 kWh/(m²a) deviation from criteria...
Renewable energy generation[5] (with reference to projected building footprint)	[kWh/(m²a)]	≥	-	60	120	...with compensation of the above deviation by different amount of generation[6]

[1] See footnote 1 of the Passive House criteria on page 9.

[2] See footnote 2 of the Passive House criteria on page 9.

[3] Alternatively, evidence for the EnerPHit Classic Standard can continue to be provided by proving compliance with the requirement for the non-renewable primary energy demand (PE). This will be calculated automatically in the PHPP with the following formula:

$Q_P \leq Q_{P,\ \text{Passive House criterion}} + (Q_H - 15\ \text{kWh/(m²a)}) \cdot 1.2 + Q_C - Q_{C,\ \text{Passive House criterion}}$

In the formula mentioned above, if the terms "$(Q_H - 15\ \text{kWh/(m²a)})$" and "$Q_C - Q_{C,\ \text{Passive House criterion}}$" are smaller than zero, then zero will be adopted as the value.

The desired verification method can be selected in the PHPP worksheet "Verification". The primary energy factor profile 1 in the PHPP must be used for PE verification (selection in the "PER" worksheet).

[4] See footnote 5 of the Passive House criteria on page 9.

Calculation of the allowance (calculated automatically in the PHPP):

Classic: $(Q_H - Q_{H,PH}) \cdot f_{\varnothing PER,H} + (Q_C - Q_{C,PH}) \cdot ½$

Plus and Premium: $(Q_H - Q_{H,PH}) + (Q_C - Q_{C,PH}) \cdot ½$

Q_H: heating demand

$Q_{H,PH}$: Passive House criterion for the heating demand

$f_{\varnothing PER,\ H}$: weighted mean of the PER factors of the heating system of the building

Q_C: cooling demand (incl. dehumidification)

$Q_{C,PH}$: Passive House criterion for the cooling demand

If the terms "$(Q_H - Q_{H,PH})$" and "$(Q_C - Q_{C,\ PH})$" are smaller than zero, zero will adopted as the value.

[5] See footnote 7 of the Passive House criteria on page 9.

[6] See footnote 8 of the Passive House criteria on page 9.

2.2.4 EnerPHit exceptions

If necessary, the heat transfer coefficient limits for the exterior envelope shown in Table 2 may be exceeded for one or more of the following reasons:

- Legal requirements
- If required by the historical building preservation authorities
- A required measure is not cost-effective due to exceptional circumstances or additional requirements (see Subsection 3.2.13).
- The required insulation level unacceptably restricts the use of the building or surrounding area.
- No components are available which comply with both the EnerPHit criteria and special, additional requirements (e.g. fire safety).
- The heat transfer coefficient ($U_{w,installed}$) of windows is increased due to a high thermal bridge loss coefficient (psi value) when windows are installed with an offset to the insulation layer in a wall that has interior insulation.
- In the case of interior insulation, thinner insulation is required to avoid damage due to moisture accumulation
- For other compelling reasons related to construction

If any of these restricts the insulation thickness, then the insulation thickness that is still possible must be installed using a **low-conductivity** $\lambda \leq 0.025$ W/(mK) insulation which is cost-effective and, in the case of interior insulation, safe regarding moisture accumulation. If this is the case with floor slabs or basement ceilings, additionally install an **insulation skirt** around the perimeter of the building if cost-effective.

Certification may be refused in the case of very extensive use of exemptions (see Subsection 3.1.6). We therefore recommend early coordination with the Certifier.

2.3 PHI Low Energy Building Standard

Buildings which do not comply with one or more of the Passive House or EnerPHit criteria may still satisfy the PHI Low Energy Building Standard.

Table 5: PHI Low Energy Building criteria

			Criteria[1]	Alternative Criteria[2]
Heating				
Heating demand	[kWh/(m²a)]	≤	30	
Cooling				
Cooling + dehumidification demand	[kWh/(m²a)]	≤	Passive House requirement[3] + 15	
Airtightness				
Pressurization test result n_{50}	[1/h]	≤	1.0	
Renewable Primary Energy (PER)[4]				
PER demand[5]	[kWh/(m²a)]	≤	75	Exceeding the criteria up to +15 kWh/(m²a) is permitted...
Renewable energy generation[6] (with reference to projected building footprint)	[kWh/(m²a)]	≥	-	...with compensation of the above deviation by additional generation[7]

[1] See footnote 1 of the Passive House criteria on page 9.

[2] See footnote 2 of the Passive House criteria on page 9.

[3] See footnote 1 of the EnerPHit energy demand criteria on page 14.

[4] See footnote 5 of the Passive House criteria on page 9.

[5] See footnote 6 of the Passive House criteria on page 9.

[6] See footnote 7 of the Passive House criteria on page 9.

[7] See footnote 8 of the Passive House criteria on page 9.

2.4 General minimum criteria for all Standards

Besides a high level of energy efficiency, Passive House and EnerPHit buildings provide optimal thermal comfort, user satisfaction, and low risk of damage from moisture accumulation. In order to guarantee these, Passive House and EnerPHit buildings must also comply with the following minimum criteria. With the exception of thermal comfort, these requirements also apply for PHI Low Energy Buildings.

2.4.1 Frequency of overheating

Percentage of hours in a calendar year with indoor temperatures above 25 °C

- Buildings without active cooling systems: ≤ 10 %
- with active cooling: cooling system must be adequately dimensioned

2.4.2 Frequency of excessively high humidity

Percentage of hours in a calendar year with absolute indoor air humidity levels above 12 g/kg

- without active cooling: ≤ 20 %
- with active cooling: ≤ 10 %

2.4.3 Ventilation

- **Ventilate all rooms**
  All rooms within the thermal building envelope must be ventilated either directly or indirectly (transferred air) with a sufficient volume flow rate. This also applies for rooms which are infrequently occupied by persons, provided that the mechanical ventilation of these rooms does not involve a disproportionately high investment. Access areas (stairwells, corridors etc., except if these are used only rarely, e.g. for maintenance purposes or solely as emergency exits, see also Subsection 2.5.7) must be ventilated without exception. In case of use exclusively for the purpose of access, mechanical ventilation may be dispensed with if window ventilation is possible.
- **Controllable**
  The ventilation volume flow rate must be adjustable for the actual demand. In residential buildings the volume flow rate must be individually and permanently adjustable by the user (not just for a temporary boost) for each accommodation unit (three settings are recommended: standard volume flow / standard volume flow +30 % / standard volume flow -30 %).
- **Prevent excessively low relative indoor air humidity**
  If the PHPP (“Ventilation” sheet) predicts a relative indoor air humidity lower than 30 % for at least one month, then effective countermeasures must be undertaken (e.g. moisture recovery, air humidifiers, automatic demand-based (zone) control, extended cascade ventilation). Alternatively, provisionally dispensing with countermeasures is accepted under the following conditions: regular measurement during operation and a rough concept for subsequent measures which will increase the relative humidity if necessary (see Subsection 3.2.14).

- **Quiet**
  The ventilation system must not generate noise in rooms typically occupied at a standard flow rate. Guidance values for the noise level are as follows:
  - ≤ 25 db(A): supply air rooms in residential buildings, as well as bedrooms and recreational rooms in non-residential buildings
  - ≤ 30 db(A): rooms in non-residential buildings (except for bedrooms and recreational rooms) and extract air rooms in residential buildings
- **Draughts**
  The ventilation system must not cause unpleasant draughts. This requirement is considered to have been fulfilled under the following conditions:
  - supply air rooms with less than a two-fold air change rate during normal operation: supply air is not blown in directly into the area occupied by persons (e.g. along the ceiling or wall instead)
  - supply air rooms with at least a two-fold air change rate during normal operation (e.g. classrooms, meeting rooms): submission of a plausible description of how draughts are to be avoided)

2.4.4 Minimum thermal protection

The minimum level of thermal protection is in most cases already covered by complying with the more stringent criteria on the previous sections. Therefore, the limits described below apply in only exceptional cases.

The criteria for the minimum level of thermal protection apply to all Standards (exception: the thermal comfort criteria do not apply to PHI Low Energy Buildings). They apply even when EnerPHit exemptions are granted. They apply for each individual assembly (wall assembly, window, connection detail). Averaging several different building components to prove compliance is not permitted.

Thermal comfort

The **interior surface temperatures** of standard cross-sections of walls and ceilings may not be more than 4.2 K below the operative indoor temperature. In the case of windows, this requirement must be complied with for the radiation temperature at a point located centrally at 0.5 m in front of the window. Less stringent requirements result from this in the case of smaller windows. The floor surface temperature must not fall below 19 °C (this also applies for walk-on glazing). The requirements will be checked in the PHPP for a room temperature of 22 °C and a minimum outdoor temperature taken from the climate data set of the building's location. For components in contact with the basement or ground, the requirement for the U-value will be divided by the reduction factor f_T ("ground reduction factor" in the PHPP sheet "Ground").

In the **warm to very hot climate zones** the U-values of ceiling components may not be higher than the EnerPHit component requirements for windows of the same inclination.

The following exemptions apply to the thermal comfort requirements:

- The requirements do not apply for areas which are not adjacent to **rooms with prolonged occupancy**.
- For windows and doors, **exceeding the limit value** is acceptable if low temperatures arising on the inside are compensated by means of heating surfaces under or directly next to the window or through air heating directed at the window (see 4.1.4), or if for other reasons, there are no concerns relating to thermal comfort.
- The requirements for the U-values of **ceilings** in warm to very hot climates will not apply if the component is largely shaded on the outside.
- Alternatively, the thermal comfort criteria will be deemed to have been complied with if evidence of the comfort conditions is provided according to DIN EN ISO 7730.

Moisture protection

- **Moisture accumulation within components**
  - All standard cross-sections and connection details must be planned and executed so that excessive moisture build-up in the component can be ruled out with the intended building use.
- **Interior surface temperature**
  - In the PHPP a specific limit value based on the climate and building is determined for the **minimum temperature factor** $f_{Rsi=0.25\ m^2K/W}$ ("Verification" worksheet, section "Minimum Thermal Protection"). The temperature factor must not fall below the limit at any cross-section or connection detail. The same minimum temperature factor applies for components in contact with the ground/basements. For this reason, the outdoor air temperature (not the ground temperature) must be used as a reference for fRsi in the thermal bridge calculation also for components against the ground.
  - Exception: A separate limit value for the minimum temperature factor $f_{Rsi=0.25\ m^2K/W}$ applies for special **threshold profiles of exterior doors** (e.g. entrance doors). This is indicated in the PHPP (however, the normal limit value will apply for doors (French windows) with normal lower frame profiles similar to parapet windows).

2.4.5 Occupant satisfaction

Exemptions to the requirements below are possible in justified cases as long as there is no significant likelihood of occupant satisfaction being impaired.

- All rooms with prolonged occupancy must have at least one **operable window**.
- It must be possible for the **user to operate** the lighting and temporary shading elements. Priority must be given to user-operated controls over any automatic control.
- In case of buildings with active heating and/or cooling systems, it must be possible for users to control those systems to **regulate** the **indoor temperature** separately for each utilisation unit.
- The heating or air-conditioning system must be **capable of ensuring the specified temperatures** for heating or cooling under design conditions.

2.5 Conditions for the PHPP calculation

The conditions to be used when verifying the criteria using the PHPP are described below.

In case of anticipated differences between the standard conditions and operation:

In individual cases the actual values during operation may deviate from the standard conditions. For example, the occupancy rate (2.5.4), the electricity demand (2.5.11) or the hot water demand (2.5.8) might differ.

If a significant deviation is expected (e.g. based on the typical user behaviour in a country or measured values from comparable buildings), then a second **PHPP variant** (PHPP worksheet "Variants") must be calculated with the deviating conditions. In case of uncertainty, the Certifier will decide whether a variant must be calculated. Based on the available information, values for the conditions of the variant which are as plausible as possible should be determined at one's own discretion. The variant **does not have to comply with the criteria**.

The **building owner** must be **informed in writing** (as early as possible) when the variant shows a higher energy demand, a higher frequency of overheating or a higher frequency of excessively high humidity than with the standard conditions. If the frequency of overheating or the frequency of excessively high humidity exceeds the limit values, this written notice must include an express warning that without any countermeasures, summer comfort and protection against moisture cannot be guaranteed.

2.5.1 Zoning[3]

- The **entire, closed building envelope (i.e. insulated and airtight)** must be taken into account for the calculation of the specific values of a building, which includes all permanently heated or cooled rooms, e.g. a row of terrace houses, an apartment block or an office building with multiple suites. Generally, the PHPP user may perform a single PHPP calculation for the entire building TFA. If all zones have the same set temperature, then weighted average values based on the treated floor area (TFA) from individual PHPP calculations of several sub-zones may also be used for verification of compliance with the criteria.
- A building may not be divided into **zones that are to be certified with different energy standards for buildings**.
- **Combination of thermally separate buildings** is not allowed. Exception: thermal separation between two conditioned zones, e.g. due to different setpoint temperatures. Buildings which are adjacent to other buildings (e.g. continuous perimeter block development, terrace houses, extensions of existing buildings, buildings which are connected only through conditioned connecting passages) must include at least one exterior wall, a roof area and a floor slab to the ground and/or basement ceiling in order to be eligible for separate certification.
- It is not permitted **to exclude single parts** of a building (e.g. one or several storeys, or parts of storeys) from the energy balance (exceptions from this are described in the supplementary provisions mentioned in the following paragraph).

[3] In this section, "building" refers to a structure or parts of a construction which are built within a limited time span by the same owner.

- **Additional rules** for certification of terrace or semi-detached houses (see 4.1.2) and for residential and office buildings with non-standard use on the base floors (see 4.1.3) are in the Appendix.

2.5.2 Internal heat gains (IHG)

- The PHPP contains **standard values** for internal heat gains for a range of types of building use. Normally these are to be used. In deviation from this, the values calculated in the PHPP must be used for the summer case or the cooling period if they exceed the chosen standard value.
- The use of the internal heat gains **individually calculated** in PHPP is only permitted if it can be shown that the actual use will and must differ considerably from the use on which the standard values are based.

2.5.3 Internal moisture gains

Average value based on the whole year (including periods of time when the building is not in use):

- **residential buildings**: 100 g/(person*h)
- **non-residential building**s without significant moisture sources beyond the moisture emitted by persons (e.g. office, educational buildings etc.): 10 g/(person*h)
- **non-residential building**s with significant moisture sources beyond the moisture emitted by persons: plausible substantiated estimation, based on the expected use

2.5.4 Occupancy rates

- **Residential buildings**: the standard occupancy density in the PHPP must be used. Exception: if the occupancy rate is exactly known due to a specific building use (e.g. student dorm) then the actual occupancy rate must be used (e.g. number of beds multiplied by a reduction factor for partial occupancy).
- **Non-residential buildings**: occupancy rates and periods of occupancy must be determined on a project-specific basis and coordinated with the use profile.

2.5.5 Design indoor conditions

- **Heating**
  Residential buildings: 20 °C without night setback
  Non-residential buildings: Use 20 °C for typical building uses in the sectors administration, education, retail, services, gastronomy and entertainment. Use 18°C for gyms. For other uses, the indoor temperature is to be determined on a project-specific basis. For intermittent heating operation (night setback), the design room temperature may be decreased upon verification (method according to the PHPP User Manual).
- **Cooling and dehumidification**: 25 °C and 12 g/kg absolute indoor air humidity

2.5.6 Climate data

Use **PHI-approved climate data sets** (with a seven-digit ID number). The selected data set must be representative of the climate where the building is located. If an approved data set is not yet available for the location, then request a new data set from a Certifier.

2.5.7 Average ventilation volumetric flow

- **Residential buildings**: at least 20 m³/h per person in the household and at least 0.30-fold air change rate with reference to the treated floor area multiplied by 2.5 m room height.
- **Non-residential buildings**: the average ventilation volumetric flow must be determined for the specific project based on a fresh air demand of:
  - at least 20 m³/h per adult
  - at least 17 m³/h per child from age 12 to 18 years
  - at least 15 m³/h per child up to age of 12 years

  The different operation settings and times of the ventilation system must be considered. Operating times for pre-ventilation and post-ventilation must be taken into account when switching off the ventilation system.
- The air mass flows used in the PHPP must correspond with the actual **flow rates commissioned** for standard operation in the case of both residential and non-residential buildings.
- For **circulation areas** outside of residential/utilisation units used solely for access (stairwells, corridors etc.), at least a 0.1-fold air change rate must be used (also in case of window ventilation, with 0% heat recovery efficiency in that case)

2.5.8 Domestic hot water demand

- **Residential buildings**: 25 litres of water with a temperature of 60 °C per person per day unless the Passive House Institute has specified other national values.
- **Non-residential buildings**: in the PHPP the hot water demand must be determined on a project-specific basis. For office/administrative buildings, 3 litres of hot water at 60 °C per person per day may be assumed without the need of further verification (for typical facilities, e.g. small kitchen, hand washbasin, but not showers).

2.5.9 Quality of insulation of fittings, pipe suspension etc.

Use the option "1 - none" for heating and DHW pipes in the PHPP worksheet "DHW+Distribution". Alternatively: select a better quality of insulation with the corresponding evidence in accordance with the explanation in the PHPP User Manual).

2.5.10 Balance boundary for electrical and non-electrical energy uses

All energy uses that are within the thermal building envelope are taken into account in the energy balance. Energy uses that are outside of the thermal envelope, on the building or on the premises, are generally not taken into account. In deviation from this, the following energy uses are taken into account even if they are outside of the thermal envelope:

- Energy and **auxiliary electricity** for providing and distributing space heating, domestic hot water and cooling, as well as ventilation for any area within the thermal envelope.
- **Pumps and trace heating for pipes**, as long as the medium (usually water) is transported mostly inside the thermal envelope (e.g. water pressure booster pumps, sprinkler systems).
- **Elevators and escalators** which are situated outside, provided that these overcome the height difference caused by the building and are used to access the building.
- **Computers and communication technology** (server including UPS, telephone system etc.) including the room conditioning necessary for these, as long as they are used by the building's occupants.
- **Household appliances** such as washing machines, dryers, refrigerators, freezers if used by the building's occupants themselves.

2.5.11 Electricity demand for appliances and lighting (residential buildings)

Standard verification: full use of all values pre-entered in the worksheet "Electricity" in the empty PHPP (regardless of the actual appliances, or also if there no information available yet regarding the appliances).
Alternatively: separate evidence, only if planning or concept for efficient electricity use exists.

2.5.12 Primary energy factor for district heating

Utilisation factor of a **district heating transfer station**: the tabular values given in the PHPP User Manual may be used if more exact data is not available.

- **PER method**
  - In general, the "**Reference district heating**" in the PHPP may be used.
  - "**Detailed calculation**" is also acceptable if all necessary information is available.
- **PE method**
  - PE factors of **less than 0.3** from (PHPP) calculations or certificates must be replaced by a factor of 0.3.
  - If the actual system corresponds to one of the **standard heat generators** in the PHPP, then this must be used. Alternatively the "detailed calculation" in the PHPP is acceptable, if all necessary information is available.
  - If the heat generator is not included in the PHPP, then the PE factor from a **certificate** issued by an independent third party may be used.
  - If **no information** is available regarding the district heating network, a PE factor of 1.5 must be used.

3 Technical regulations for building certification

3.1 Verification procedure

Passive House and EnerPHit buildings achieve year-round comfort with extremely little energy. Their superior energy-efficiency requires care in all steps of creating the building: design, planning and construction.

The Certifier assists the designer by means of a careful, independent, external examination and offers the building owner the certainty that the agreed energy standard will actually be achieved. In order to avoid conflicts of interest, the Certifier may not carry out the Passive House project planning (Passive House designer role) for the same building.

3.1.1 Seal

When the Certifier has established the technical accuracy of the necessary evidence for the examined building in accordance with Subsection 3.2 (or Subsection 3.3 in the case of pre-certification for a staged retrofit), and if the building meets the criteria in Section 2, the Certifier will issue the applicable seal:

Passive House seal

EnerPHit seal

EnerPHit^{+i} seal (for buildings with mostly interior insulation)

PHI Low Energy Building seal

Pre-certification seal for staged retrofits

These seals may only be used in connection with the certified building.

3.1.2 Validity

The certificate is valid for the implemented construction and building use as documented in the booklet accompanying the certificate. The energy-relevant characteristic values of the building may change due to extensive conversions, change of use, or altered shading situations that may occur in the future, in which case the certificate will become invalid.

3.1.3 Criteria

The certification criteria and requirements are always available in the current version of this document (at www.passivehouse.com). They take precedence over the calculation method in the PHPP software and User Manual, which apply subordinately.

PHI reserves the right to adapt the criteria and calculation procedures to reflect technical advances.

3.1.4 Procedure

An informal **application** for the certificate can be made with the chosen Certifier. The required documents according to Section 3.2 must be submitted in full to the Certifier. For certification, the documents must be checked at least once. Depending on the procedure, further reviews may also be arranged.

For the best building performance and the best value from the certification process, provide relevant documents to the Certifier early on, so that they can be checked during the planning stage. Then, the designer may make any corrections or improvements before construction begins. If the designer or builder lacks experience with Passive House construction, they should consult with the Certifier at least once prior to planning and again prior to or at the beginning of construction.

After the assessment, the client will receive the results and corrected calculations and suggestions for improvement where appropriate. The on-site inspection of construction work is not included in the certification. But additional quality assurance through the inspection of the construction work by the Certifier is particularly useful if the construction manager has not constructed a Passive House building or EnerPHit retrofit.

3.1.5 Scope of the review

The Certifier’s assessment determines only that the documentary proof related to the Standards in Section 2 meets the requirements on Subsection 3.2. It includes neither supervision of the construction work, nor monitoring the building user’s behaviour. All liability for the planning remains with the responsible planners and liability for the implementation lies with the construction management.

Documents submitted for certification may be used by the Passive House Institute for anonymised scientific study and statistics.

3.1.6 Withholding of the certificate due to serious deficiencies in the building

If any of the reasons mentioned below are present, the Certifier may refuse to issue the certificate even though all requirements for attaining the chosen energy standard have been formally fulfilled:

- The Certifier becomes aware of serious **defects** related to the building but outside the scope of the criteria (e.g. in relation to fire safety, structural stability) which would greatly limit usability, safety or user satisfaction
- The Certifier finds out that products with inadequate **durability** have been used (e.g. unsuitable adhesive tape used for airtight sealing) for building components which are relevant for compliance with the criteria. Due to this the building will probably prematurely fail to meet all criteria. However, certification does not include any systematic examination with regard to durability.
- On account of special circumstances not foreseen during development of the criteria, the building diverges obviously and to a great extent from the **primary objectives** of the criteria mentioned in the introduction (Section 1.1), although formally the criteria have been fulfilled.
- A significant reduction in the energy demand of the building has not been achieved due to an extensive use of the **exceptions in the EnerPHit component method**.

If the reasons mentioned above are not rectified within a reasonable time period, the Certifier shall only issue confirmation of the achieved energy values instead of a certificate.

3.1.7 Exemptions from the criteria / pilot projects

The PHI reserve the right to permit **exemptions** from the criteria in special cases if the primary objectives mentioned in Subsection 1.1 can still be achieved.

Furthermore, buildings in which the PHI's energy standards for buildings are applied to new areas may be certified as "**pilot projects**" if the criteria cannot be met with justifiable effort for this reason. For example, this may apply for the first certified building in a country with poor availability of Passive House components or for new types of building uses. Deviations from the criteria and to a small extent also from the primary objectives mentioned in Subsection 1.1 are acceptable for pilot projects.

For exemptions from the criteria, as well for categorisation as a pilot project and the associated deviations from the criteria, **written confirmation** by the PHI is necessary which invariably pertains exclusively to the building mentioned in it and is not transferable to other buildings.

3.2 Documents to be submitted

The use of PHI-certified components[4] is advised because all necessary parameters have been reliably tested, are available, and can be used for building certification without the need for any further verification. The applicant must provide plausible evidence for the performance values of components which are not PHI-certified.

[4] Data sheets for certified components can be found at https://database.passivehouse.com/en/components/

3.2.1 Passive House Planning Package (PHPP)

Compliance with the criteria must be verified using the **latest version of the PHPP**. However, transfer of data to a newer version of the PHPP published when the project is already in planning or construction is not necessary.

A second PHPP variant must be calculated and submitted in the case of expected **deviating conditions** (see Section 2.5).

External simulations are not admissible for "SolarDHW", "PV" and "Shading" (exception: shading factors determined using designPH from Version 2 onwards).

Please submit the PHPP calculation as an Excel file with at least the following calculations:

Worksheet name	Function	Submit for certification?
Verification	Building data; summary of results	yes
Check	Data entry assistance	yes
Climate	Climate region selection or definition of user data	yes
U-Values	Calculation of standard building assembly U-Values	yes
Areas	Areas and thermal bridge summary	yes
Ground	Calculation of reduction factors against ground	optional
Components	Component database	yes
Windows	Determination of U-values for windows and entry doors	yes
Shading	Determination of shading coefficients	yes
Ventilation	Air flow rates, Exhaust/Supply air balancing for heating period, Pressurisation test results	yes
Addl vent	Design and planning of ventilation systems with diverse ventilation units	if used
Addl vent 2	Design and planning of ventilation systems with diverse ventilation units	if used
Heating	Space heating demand calculation Monthly method according to ISO 52016	yes
Heating Load	Building heating load calculation[5]	yes
SummVent	Determination of summer ventilation	yes
Summer	Assessment of summer climate[5]	if no active cooling
Cooling	Monthly method for cooling demand	in case of active cooling
Cooling units	Latent cooling energy and cooling method selection	
Cooling load	Building cooling load calculation[5]	
DHW+Distribution	Distribution losses; DHW demand and losses	yes
SolarDHW	Solar DHW heating	if present
PV	Electricity generation by photovoltaic	if present
Electricity	Electricity demand in residential buildings	for residential
Use non-res	Patterns of non-residential use	for non-residential
Electricity non-res	Electricity demand for non-residential use	for non-residential
Aux Electricity	Auxiliary electricity demand	yes
IHG	Internal heat gains in residential buildings	for residential, if no Standard-IHG
IHG non-res	Internal heat gains for non-residential use	for non-residential, if no Standard-IHG
PER	Primary energy and CO_2 figures	yes
Compact	Performance ratio of heat generator Compact heat pump unit	if present
HP	Performance ratio of heat generation of the heat pump	if present
HP Ground	Ground probe or ground collector in combination with a heat pump	if present
Boiler	Performance ratio of heat generator Boiler	if present
District Heating	District heat transfer station	if present

[5] The PHPP calculations for the heating load, summer overheating and cooling load have been developed for buildings with a single use (e.g., residential or office use but not both uses). For buildings with multiple uses, intermittent ventilation or heating/cooling operation, or with greatly fluctuating internal loads, please provide more detailed studies possibly using other calculation methods where appropriate.

3.2.2 Design and planning documents

- **Site plan** including the building's orientation, the position and height of relevant shading elements (neighbouring buildings, prominent trees, elevated terrain, etc.); photographs of the site where the building will be constructed and its surroundings; and other data sufficient to clearly and fully document the shading situation so that the Certifier will understand it.
- **Construction drawings** (floor plans, sections, elevations) with comprehensible dimensions for all area calculations (room dimensions, envelope areas, rough window opening sizes).
- Clear calculation of the **treated floor area**.
- **Reference drawings of envelope areas** which allow easy and clear identification and allocation of the areas and U-values in the PHPP to the planning drawings. Alternatively, submit a DesignPH file which includes this information.

3.2.3 Standard and connection details

- **Reference drawing of thermal bridges** (if present) for clear allocation of the entries in the PHPP
- **Detail drawings** of all building envelope connections, e.g. the exterior and interior walls at the basement ceiling or floor slab, exterior wall at the roof and ceiling, roof ridge, verge, attachment of balconies etc. The details must be given with dimensions and information about the materials used and their conductivities. The airtight layer must be indicated and its execution at connection points must be described.
- Evidence supporting the **thermal-bridge loss coefficients** based on EN ISO 10211 as used in the PHPP. Alternatively, comparable documented thermal bridges can be used (e.g. in certified Passive House/EnerPHit construction systems, PHI publications, thermal bridge catalogues).
- Manufacturer, type and technical data sheets for **insulation materials**. Rated values of the thermal conductivity according to national standards or building authority approvals are acceptable.
- In hot and very hot climates, evidence regarding **radiation properties** of the building's exterior surface. For roof products: measured values for absorptivity or reflectance and emissivity determined in accordance with ANSI/CRRC-1 (or comparable methods). For wall products: on account of the lack of data available, no requirements currently apply for the source of the specific values. All values must be determined after a period of exposure to weathering of at least 3 years (or conversion from new condition values in the PHPP).
- In cases where there is concern, proof of **protection against excessive moisture build-up**.

3.2.4 Windows and doors

- **Reference drawings for windows and doors** for clear allocation of the entries in the PHPP.
- Information about the **window and door frames** to be installed: manufacturer, type, U_f value, $\Psi_{Installation}$, $\Psi_{Glazing\ Edge}$, graphical representations of all planned installation situations in the exterior wall. The calculated values must be computed in accordance with EN ISO 10077-2.
- Information about the **glazing** fitted: manufacturer, type, build-up, type of edge spacer, U_g value according to EN 673, g-value in accordance with EN 410, or U_g and g-value in accordance with ISO 15099, mathematically computed
- U_f, U_g and g-value to **two decimal places** for values below 1.0

3.2.5 Shading

- **Movable shading elements**: product data sheet showing the type and geometry of the element. Evidence of the shading factor can be provided by means of the standard values in the PHPP User Manual, the manufacturer's data (U_g value in the manufacturer's calculation must not be significantly poorer than the U_g value of the installed glazing), or calculation in accordance with EN13363.
- **Fixed shading elements**: detail section which shows the relevant shading characteristics. Alternatively, evidence of the shading factor can also be provided by means of an existing designPH file (from Version 2.0 onwards). The computational accuracy of the analysis must be adjusted depending on the complexity of the shading situation (see designPH manual).

3.2.6 Ventilation

- **Ventilation drawings** and specifications: identification and dimensioning of ventilation units, volumetric flows (Final Protocol Worksheet for Ventilation Systems: "Design", see PHPP Download Package), sound protection, filters, supply and extract air valves, openings for transferred air, outdoor air intake and exhaust air outlet, dimensioning and insulation of ducts, subsoil heat exchanger (if used), regulation, etc.
- Evidence of the **heat recovery** efficiency of the ventilation system for the heating period and/or the cooling period. If only the heat recovery efficiency for the heating period is known, then the input cell for the cooling period in the PHPP worksheet "Components" must remain empty. The PHPP will then apply an overall deduction of 10 % to the heat recovery efficiency for the cooling period in cooling climates.
  If necessary, evidence of the **humidity recovery** efficiency; values for the heating period and cooling period; if a value is available only for one of the two periods, this may be used also for the other period.
  Evidence regarding the **electricity demand** of the ventilation system.
  Different **operation settings** and **operating times** must be taken into account.
  Verification takes place in accordance with the PHI method (see criteria for certification of Passive House components for ventilation units).
  Exhaust air systems without heat recovery (also fume hoods and fume cabinets etc.) must be included.
- Manufacturer, type, technical data sheets and verification of the electricity demand of all **components of the ventilation system** such as the heating coils, frost protection etc.
- Information about the **subsoil heat exchanger** (if used): length, depth and type of installation, soil quality, size and material of the tubes, verification of the heat recovery efficiency. For subsoil brine heat exchangers: regulation, temperature limits for winter/summer and verification of the heat recovery efficiency.
- **Pressure loss calculation** for the duct network for non-residential buildings and for ventilation units with an air flow greater than 600 m³/h, in order to verify the electrical efficiency of the ventilation unit.
- **HRV commissioning report** including: description of the property, location/address of the building, name and address as well as signature of the tester, time of adjustment, manufacturer of the ventilation system and type of device, adjusted volume flow rates for standard operation, mass flow/volumetric flow balance for outdoor air and exhaust air (maximum imbalance of 10 %). A report must be provided regarding the adjustment of all supply and extract air valves. If this is not possible in individual non-residential buildings for technical reasons, then at least the volume flow rates in the ventilation unit (outdoor air/exhaust air) and in the main ducts of the ventilation system must be

measured. Recommended template: "Final Protocol Worksheet for Ventilation Systems": “Initial start-up”, source PHPP Download Package.

3.2.7 Space heating/cooling, DHW and waste water

- **Drawings and specifications for any space heating/cooling systems, DHW and waste water**: drawings showing heat generators, heat storage, heat distribution (pipes, heating coils, heating surfaces, pumps, regulation), hot water distribution (circulation, individual pipes, pumps, regulation), vented waste water pipes including their diameters and insulation thicknesses, representation and dimensioning of cooling and dehumidification systems.
- Evidence (e.g. photographs) of the quality of **insulation of fittings, pipe suspensions** etc. for the heating and hot water pipes (without evidence, only "1 - none" must be selected in the PHPP worksheet "DHW+Distribution")
- **Brief description** of any of these systems with schematic diagrams.
- Manufacturer, type, technical data sheets and verification of the electricity demand for **heat generators** for heating and hot water, heat storage, pumps, shower water heat recovery, cooling of the building (if used), booster pumps, lift pumps etc. (See also Section 2.5.12 for district heating).
- **Shower waste water heat recovery:** the following proof is admissible for devices that are not certified: efficiency calculated in accordance with NEN 7120 (the Dutch KIWA certificate), CAPE/RECADO-PQE (the French measurement in accordance with CSTB, measured value for hot and cold water connection) or CSA B55 (the Canadian test standard). PHPP input as a steady-state efficiency with an effective dead time of 10 seconds per litre of fresh water content.
- In buildings **without active cooling**:
    - Written documentation of the **strategy for thermal comfort in summer**, signed by the building owner
    - Evidence of **instructions given to the future building user** regarding the strategy for thermal comfort in summer, e.g. in a user handbook.
    - The PHPP method to determine overheating in summer only depicts an average value for the entire building - overheating of individual parts can still occur. If this is suspected, then an **in-depth examination** (e.g. with a dynamic simulation) must be carried out.

3.2.8 Electrical devices and lighting

- Residential buildings
    - Planning or **concept for efficient electricity use** (only if the standard verification is not used, see 2.5.112.5.11)
    - If applicable, electrical design for **common areas** including e.g. elevators, lighting etc.
- Non-residential buildings
    - Manufacturer, type, technical data sheets and evidence of the electricity demand for all significant **electrical uses** such as elevators, kitchen facilities, IT applications, telephone systems, security systems and all other electrical uses with a significant electricity demand that are specific to the building use, e.g. furnace.
    - Depiction and dimensioning of **lighting** (if applicable also concepts or simulations for the use of daylight)
    - Written confirmation by the building user (if known, otherwise building owner) that the **use profile** in the PHPP (worksheet "Use non-res") corresponds with the planned building use later on.

3.2.9 Renewable energy

Suitable **proof of ownership** for renewable energy generation systems (except for solar thermal systems) attached to the building, on the building plot, or off-site. Or if applicable, evidence relating to the percentage of ownership of the system as a whole. This evidence must show that it is a newly constructed system, i.e. systems that were not put into operation before the start of construction of the building and belong to the building owner or the (long-term) user (first time acquisition).

- **Solar thermal** systems attached to the building: data sheets related to the collectors and storage used, indicating the necessary input parameters.
- **PV** system: data sheets of the collectors and inverters used, indicating the necessary input parameters .
- **Other** renewable energy generation systems: suitable evidence of the predicted annual power generation of the system (simulation).

3.2.10 Airtightness of the building envelope

The airtightness measurement is to be carried out in accordance with ISO 9972 (method 1), with the following deviations:

- air volume Vn_{50} in accordance with Appendix 4.1.1 for calculation of the n_{50} value
- a series of measurements for both positive pressure AND negative pressure (compliance with the n_{50} limit value is necessary with the average value of both measurements)

The pressure test must only be carried out for the **heated/cooled volume** of the enclosing building envelope. Basements, porches, conservatories etc. that are not integrated into the thermal envelope of the building must not be included in the pressure test. It is recommended that the test is carried out when the airtight layer is still accessible so that needed repairs can be carried out. The pressure test report must also document the **calculation of the net air volume**.

The pressure test must be conducted by an institution or person **independent** of the building owner. A pressure test that has been carried out by the building owner will only be accepted if the test result is signed by someone taking personal responsibility for the accuracy of the information provided.

Only for EnerPHit and PHI Low Energy Buildings, for n_{50} values between 0.6 1/h and 1.0 1/h and for pre-certification: extensive **leak detection** must be carried out during the pressurisation test. Individual leakages which may cause structural damage or impair comfort must be identified and remedied. This must be confirmed in writing[6] and signed by the person conducting the leak detection.

3.2.11 Photographs

Evidence of the progress of construction must be supported with photographs, but it is not necessary to provide complete photographic documentation of all measures.

[6] Sample text for confirmation of air infiltration leak detection:
I hereby confirm that air infiltration leak detection was carried out at negative pressure. All rooms within the airtight building envelope were inspected during this process. All points known to be prone to leakage were checked for leaks (including locations that were difficult to access such as tall ceilings). Any large leakages with a significant share of the total leakages or affecting thermal comfort were sealed.
Note: in individual cases, leak detection at positive pressure may also be admissible, particularly in the case of an airtight layer situated on the outside. Leak detection can take place during a pressure test. Alternatively, the pressure difference can also be generated using simple fans or the ventilation system.

3.2.12 Exceptions (only for EnerPHit)

If applicable, provide necessary proof for the use of exceptions e.g. economic feasibility calculation (see 3.2.13), written confirmation by the historic building preservation authority, excerpts from laws and ordinances, drawings.

Generally, in the event that a specific value that is required as standard is exceeded on the basis of an exception, clear evidence must be provided that the prerequisites for the exception exist by presenting the appropriate documents with the signature of the person in charge.

3.2.13 Economic feasibility calculation (only for EnerPHit)

If applicable, required as evidence for the use of an exception (see Section 2.2.4).

Calculation of economic feasibility compared to a renovation without improvement of the energy efficiency, using the **PHPP worksheet "Comparison"**. Use the PHPP default parameters (interest rate, inflation, energy price) if different national conditions are not verified. Subsidised energy prices may not be applied.

Alternatively: in agreement with the Certifier, **separate calculation** using a dynamic valuation method (e.g. net present value method) over the lifecycle of the component, on the basis of all relevant costs minus the costs that are incurred anyway; a more exact description can be found e.g. in “Step by step retrofits with Passive House components" which can be downloaded from www.europhit.eu.

3.2.14 Verification of general minimum requirements (according to Subsection 2.4)

- **Ventilation**
  Excessively low relative indoor air humidity: Rough concept which shows how measures for increasing the monthly average relative humidity to more than 30 % (in all months) can be applied subsequently.
  Draughts: for supply air rooms with a 2-fold air change rate or more with normal operation (e.g. classroom, meeting room): plausible description of how draughts are to be avoided
- **Moisture protection**
  Excessively low interior surface temperatures: as a rule, no evidence for the temperature factor f_{Rsi} or input of this value in the PHPP are required for components with a typical Passive House quality. However, the Certifier may request such evidence in case of uncertainty.
  Moisture accumulation in a component: if the Certifier has concerns regarding structural damage caused by moisture, evidence of moisture protection in accordance with accepted technical standards may be requested. For example, this is the case for the following constructions:
    - components with interior insulation in climates requiring heating
    - certain flat roof constructions (e.g. with roof greening) in climates requiring heating
    - insulation in hot and humid climates
- For such critical constructions, proof of the moisture-related, technical suitability of components for the specific application must also be provided. In case of doubt, proof of suitability with regards to moisture protection must be provided by means of a corresponding expert's report (with legally effective acceptance of responsibility) based on accepted methods. This usually takes place through a hygrothermal simulation.
  In addition, for components with interior insulation, evidence must be provided regarding careful

detail planning, with which air flow behind the insulation layer can be safely and permanently prevented, if the execution of these details is carried out in accordance with the planning.

- **Thermal comfort**
  If the criteria for thermal comfort mentioned in Subsection 2.4.4 "Minimum thermal protection" are exceeded, then evidence of the comfort conditions in accordance with DIN EN ISO 7730 may be provided alternatively (not applicable for PHI Low Energy Buildings).
- **User satisfaction**
  If use is made of any of the exceptions mentioned in Subsection 2.4.5, then evidence of the prerequisites for these must be provided.

3.2.15 Construction manager's declaration

Construction according to the reviewed project drawings and specifications must be documented and confirmed with the construction manager's declaration. Where this is relevant for compliance with the criteria, any variations in the executed work must be mentioned, and if any of the products used deviate from those included in the original project planning, corresponding evidence must be provided.

In some circumstances it may be necessary to provide additional test reports or data sheets for the components used in the building. If values that are more favourable than those in the standard PHPP calculation procedure are to be used, these must be supported by plausible evidence.

3.3 Pre-certification for staged retrofits

If energy retrofits are carried out in several individual consecutive steps, then pre-certification of the building as an EnerPHit (or Passive House) project is possible. The preparation of a comprehensive **EnerPHit Retrofit Plan** (ERP) is a prerequisite for this. The pre-certificate provides building owners and planners with the security that the standard being aimed for will actually be achieved after the completion of all steps. The procedure is described below.

*The **EnerPHit Retrofit Plan** (ERP) is a document for building owners. It includes a well-thought-out overall concept for staged retrofits. This takes into account important interrelationships between different energy saving measures. Thus an optimal final result can securely be obtained over all steps with manageable effort. The ERP output file included on the PHPP CD creates the basic structure of the retrofit plan by import from a completed PHPP.*

3.3.1 Procedure for pre-certification

The pre-certification can take place as soon as the following prerequisites have been met:

- The ERP and all other necessary documents in accordance with Subsection 3.3.4 "**Documents to be submitted** for pre-certification " have been submitted to the Certifier.
- The **first modernisation step** has been completed and meets the specifications in the ERP
- The **energy demand** has been reduced significantly compared to the initial state. This can be substantiated according to cases a, b, c or d:
    a) at least a 20 % reduction of the renewable (**PER**) or non-renewable (**PE**) primary energy demand
    b) at least a 20 % or 40 kWh/(m²a) reduction of the **heating demand** or the sum of the **cooling and dehumidification demand**. Only a reduction for the type of space conditioning (heating or cooling + dehumidification) which had the higher useful energy demand in the initial state may be considered for this
    c) at least **one housing unit** has been almost entirely modernised in accordance with the ERP in a building with several owners
    d) a new **extension** has been built in accordance with the ERP
- Air infiltration **leak detection**[7] was carried out

Preferably, the required documents in Subsection 3.3.4 "Documents to be submitted for pre-certification " should already be submitted prior to the first modernisation measure so that any deviations from the criteria can be identified prior to implementation.

Also for all subsequent steps it is recommended to submit the documentation of the respective measures for review prior to implementation of the retrofit measures. The Certifier can then issue an updated version of the pre-certification after completion of the measure.

[7] Leak detection is only required after measures which could affect airtightness of the building envelope. Leakage detection must take place at a time in the construction process when the affected components are still easily accessible.

An application can be made for an EnerPHit (or Passive House) certificate after completion of the last retrofit step. The necessary documents as mentioned in Subsection 3.2 must be submitted if these have not already been handed over for the preceding retrofit steps.

3.3.2 Acceptable retrofit sequences

Pre-certification may be applied for any variant of a staged retrofit. This includes energy saving measures carried out at different points of time for:

- **components** (e.g. Step 1: wall insulation, Step 2: window replacement and ventilation system, Step 3: roof insulation and heating system etc.)
- **building sections** (e.g. single wings, apartments, new extensions or terrace houses)

3.3.3 Moisture protection: requirements for intermediate states

The risk of moisture-related structural damage must **not be higher** for any individual step, i.e. must not lead to a risk of damage, which did not exist or existed only to a lesser extent before the start of the retrofit measures.

3.3.4 Documents to be submitted for pre-certification

- PDF of the completed **EnerPHit Retrofit Plan** (ERP) with which the standard being aimed for (EnerPHit / Passive House) can be achieved, including the following documents:
- all relevant worksheets of the ERP Output File (Excel template is included in PHPP Download Package)
- attachment with
    - drawings of the existing building
    - drawings of the fully modernized building with the schematic representation of the position of the insulation and airtightness layers in all components of the building envelope (floor plans, sections and (if necessary) elevations, scale 1:50 to 1:100)
    - simplified drawings of regular details and connection details of the building envelope for future steps with representation of the position and connection of the insulation and airtightness layers (incl. representation of intermediate states)
- completed **PHPP** calculation as an Excel file. Each individual retrofit step must be entered as a variant in the worksheet "Variants".
- all documents in accordance with Subsection 3.2 that are necessary for the **energy efficiency measures** already completed at the time of submission.
- **leak detection report** at negative pressure (Subsection 3.2.10) in the area of the modernised component (only after the implementation of measures, which could affect airtightness of the building envelope).

4 Appendix

4.1 Additional regulations relating to the criteria

4.1.1 Calculation of the air volume Vn_{50} for the airtightness test

For the calculation of the air volume Vn_{50} to be applied for the n_{50} value, the **entire air volume** within the heated building envelope must be taken into account. The volume must be determined on a **room-by-room basis**. In doing so, **the base area of the room must be multiplied by the average clear height of the room**. Overall assumptions for determining the internal volume of the enclosed space (gross volume) by means of a reduction factor are not allowed.

The base area to be used for this calculation **differs** from the treated floor area which is normally used. The air volume Vn_{50} is not the same as the “volume of ventilated space” as used in the PHPP sheet "Heating" (standard room height 2.5 m).

Irrespective of the degree of completion of the building, **the dimensions used must always be those of the finished building** (e.g. when the screed hasn’t been installed yet). Air volumes above suspended ceilings do NOT count towards the total air volume. This is regardless of whether the ceiling already exists, is tightly connected with the wall, or has different types of perforations ("acoustic ceiling"). The reduction of the volume by layers of plaster does not have to be taken into account.

Visible rafters, beams, plasterboard encasings, wall-mounted installations (if these do not have the same height as the room) and the like are not taken into account; in the calculation they are *not* deducted for reasons of simplification. They are thus treated as if they do not exist (= air space).

The volume of **window reveals** (see illustration) is not taken into account (measurement only up to the inner wall surface). The same applies in the case of doorways.

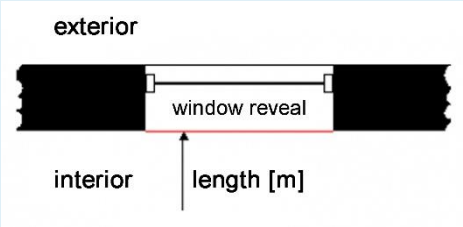


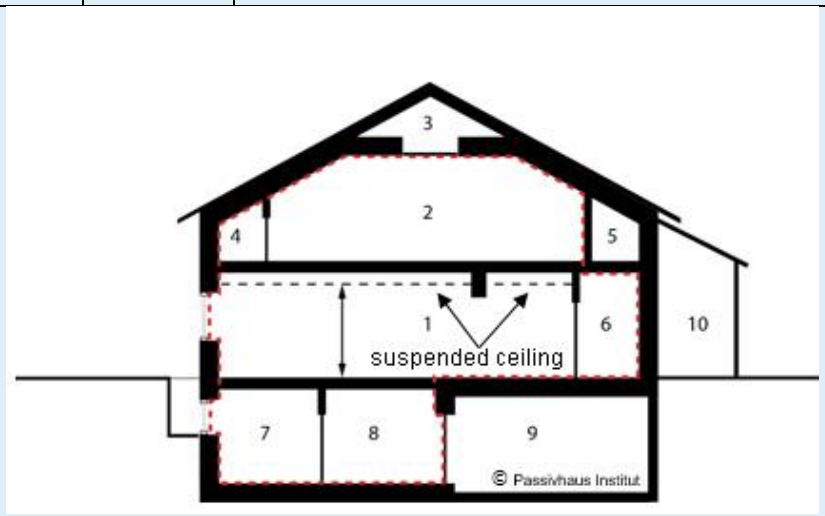
Fig 1: Omitting window reveals for calculating the air volume Vn_{50}

The air volume of a **stairwell** is part of the Vn_{50} and is fully taken into account. The volume of the steps of the staircase counts as part of the Vn_{50} in a simplified way and therefore is not deducted. The base area of the stairwell can thus be multiplied with the clear height.

The air volume of **elevator shafts** and of any **other kind of shafts** inside the thermal envelope is part of the Vn_{50} and is fully taken into account. The volume of the elevator cabin as well as of pipes, ducts etc. can be ignored and is not deducted. The base area of the shaft can thus be multiplied with the clear height.

Table 6: Calculation of the air volume Vn50 inside the airtight layer of a building. The red dashed line all around represents the airtight layer.

Room	Inside the airtight envelope?	Volume calculation
1	yes	Clear height up to (planned) suspended ceiling, the beam is not deducted from the volume
2	yes	Complete volume (roof inclinations are taken into account)
3	no	Volume is not taken into account (outside of the envelope)
4	yes	Complete volume (roof inclinations are taken into account)
5	no	Volume is not taken into account (outside of the envelope)
6	yes	Clear height up to the ceiling
7	yes	Basement: complete volume
8	yes	Basement: complete volume
9	no	Basement: volume is not taken into account (outside of the envelope)
10	no	Porch/conservatory: volume is not taken into account (outside of the envelope)



4.1.2 Certification of terrace houses and semi-detached/duplex houses

For terrace houses and semidetached/duplex houses there are two alternative ways of verifying compliance with the criteria (the term "terrace houses" as used below also includes semi-detached/duplex houses, i.e. houses that have two units side by side):

- **Method 1**: The criteria are met by the row of terrace housing as a whole, whereby individual houses (usually the end-of-terrace houses) can have an energy demand that is slightly higher than the requirements. A collective PHPP energy balance is prepared for the entire row of terrace houses. Alternatively, verification may take place through the area-weighted average values of the results of individual PHPP calculations ("Verification" worksheet) for each terrace house which are relevant for certification. Each homeowner may be given a copy of the certificate and the certification booklet for the entire row.
- **Method 2**: Each house in the row of terrace houses fulfils the criteria in itself. For this, a separate energy balance is prepared for each house using the PHPP. With this method, the end-of-terrace houses usually require a better standard of thermal protection on account of the larger envelope area, while the mid-terrace houses comply with the requirements with a slightly lower standard of thermal protection. After completion of the certification process, each house will receive its own certificate and the certification booklet with the energy balance calculation for the respective house.

Method 2 makes sense if it is important that each terrace house complies with the criteria individually or if the planning of the individual terrace houses on a row is carried out by different parties.

Method 1 is appropriate in all other cases. It reduces the expenditure for planning, implementation and certification because the same standard of thermal protection (insulation thickness etc.) can be implemented and only one PHPP calculation is necessary. Despite this, the energy demand for all terrace houses in total is not higher than with method 2. However, it is important to take into account that the heating load of the end-of-terrace houses is usually higher when dimensioning the heating system (supply air heating alone may not be sufficient).

End-of-terrace houses are part of a larger Passive House unit (row of terrace housing) and therefore comply with the Passive House criteria of the Passive House Institute. This case is comparable to an owner-occupied apartment in an apartment block that has been certified as a Passive House building. Here too, compliance with the criteria is achieved if the entire building meets the requirements – even though individual apartments might have a higher energy demand when calculated separately.

It is recommended that the chosen methodology is agreed at an early point in time with all relevant stakeholders and set out in writing.

It is possible to certify only one unit in a row of terrace houses. In that case the certification will be valid only for that specific unit and not for the entire row of terrace houses. Please see Subsection 2.5.1 for the detailed zoning regulations.

4.1.3 Certification of buildings with non-standard use on the base floors

For the Passive House Institute's energy standards the entire heated volume of a building including all floors and usage areas is generally taken into account for certification. The expected types of use (residential, offices etc.) are considered in the energy balance with the PHPP.

A very common type of building is that with standard, homogeneous use of the upper floors (usually residential or office use), while the commercial areas on the base floors may be utilised in widely differing ways depending on the building user, e.g. as a supermarket, restaurant, bakery, medical practice, car workshop, shoe shop, day nursery etc. Often the user of the base floor areas is not known when the energy balance is set up. Options for the certification of such buildings are described in the following table. This table may not be used for base floor uses for which there are standard values in the PHPP (office, school, kindergarten).

Table 7: Possibilities for certification of buildings with commercially used base floors[8]. For all variants it is assumed that the upper floors have achieved the Passive House/EnerPHit Standard:

	New/ existing construction	User known at time of main check? [9]	Airtightness and thermal quality of building envelope on the base floors	PH suitable ventilation system on the base floors?	Part of building to be certified	Affixing of PH House Plaque	Further requirements
1	New construction	yes	PH	yes	entire building including base floors	outside	in case of special uses[10] on the base floors
2	New construction/ existing construction	no	PH / EnerPHit	yes	entire building including base floors	outside	assume standard use for base floors and note in certificate: IHG: 3.5 W/m²; electricity demand for all applications incl. hot water, (except for heating, cooling, auxiliary electricity): 3 W/m²; air change rate: 0.4-fold
3	New construction/ existing construction	no	PH/ EnerPHit	no	only upper floors	inside upper floors	see description under Table
4a	New construction/ existing construction	no	for the time being simple thermal protection standard; later reconstruction in accordance with user requirements	-	only upper floors	inside upper floors	see description under Table
4b	New construction	yes	Thermal protection poorer than PH standard based on user specifications	-	only upper floors	inside upper floors	see description under Table
5	existing construction	yes	non-renovated existing building in use	no	pre-certification for entire building	outside	EnerPHit Retrofit Plan necessary for pre-certification

[8] Also several base floors, but not more than 50 % of the treated floor area

[9] Main review of the PHPP calculation and planning documents by the Building Certifier – usually just before the start of construction

[10] For special uses such as a swimming pool, supermarket, hospital or the like, the requirements may differ from the normal criteria and must therefore be agreed directly between the Building Certifier and the Passive House Institute.

Case 3: Base floors with Passive House/EnerPHit envelope but without a ventilation system

- Certification will formally apply only for the upper floors (without the base floors). This will be stated on the certificate.
- The upper floors must meet the Passive House/EnerPHit criteria separately (verification with the PHPP). The ceiling between the base floors and the upper floors forms the system boundary in the downward direction and is assumed as adiabatic. In the stairwell area or similar the boundary can also be at the ceiling level even if there is a void here in part (in the stairwell the system boundary does not have to continue down to the ground).
- In addition, a separate PHPP calculation must be prepared for the base floors with overall values for internal heat sources (3.5 W/m²), air change rate (0.4 1/h) and heat recovery efficiency of the ventilation system (use average value of the upper floors). The area-weighted average of the base floors and the upper floors must also meet the Passive House/EnerPHit criteria for the space heating and cooling demand.
- The criteria for the airtightness of the building apply for the entire building envelope including the base floors.
- The heating on the adjacent upper floor must be adequately dimensioned in order to ensure comfortable temperatures even if the base floors are vacant and unheated. If it cannot be excluded that lower temperatures will prevail in the base floors over longer periods of time, the ceiling between the base floors and the adjacent upper floor must be so well-insulated that impairment of thermal comfort and structural damage are unlikely and the heating costs are not considerably higher than those of the other storeys. Alternatively, it can be ensured that a minimum temperature is maintained on the base floors if they are unoccupied.
- If the future building user on the base floors fulfils the Passive House criteria with regard to the ventilation technology and electrical equipment (verification with the PHPP for the building as a whole) then in consultation with the Certifier the certificate can later be extended to include the entire building.

Case 4 (a+b): the base floors only have a basic standard of thermal protection because later user requirements are still unknown, or due to non-negotiable requirements of a known building user

- The certification will apply only for the upper floors (without the base floors). This will be stated in the certificate.
- The upper floors must meet the Passive House/EnerPHit criteria (verification with PHPP). Between the two zones, there must be a clearly defined boundary which at the same time represents the airtight layer. With regard to the heat losses, ceilings and walls adjacent to the base floors may be entered in the PHPP as adiabatic.
- The requirements for the building airtightness apply for the upper floors (without the base floor zone).
- Rough (design) drawings must be prepared for the base floors with which the Passive House/ EnerPHit Standard can be achieved for the entire building. In principle, the position of the airtight layer and the insulation layer as well as the connection of these layers to the storey above must be evident from this. Detailed execution planning is not required. In addition, a separate PHPP calculation must be prepared for the base floors with overall values for the internal heat gains (3.5 W/m²), the air change rate (0.4-fold), heat recovery efficiency of the ventilation system (use average value of the upper floors), and airtightness (Passive House: n_{50}= 0.6 1/h; EnerPHit: n_{50}= 1.0 1/h). The area-weighted average of the base floors and the upper floors must also meet the Passive House/EnerPHit criteria for the space heating and cooling demand.
- The heating on the adjacent upper floor must be adequately dimensioned in order to ensure comfortable temperatures even if the base floors are vacant and unheated. If it cannot be excluded that lower temperatures prevail on the base floors over longer periods of time, the ceiling between the base floors and the adjacent upper floor must be so well-insulated that impairment of thermal comfort and structural damage are unlikely and the heating costs are not considerably higher than those of the other storeys. Alternatively, it can be ensured that a minimum temperature is maintained in the base floors if they are unoccupied.
- If the future building user on the base floors fulfils the Passive House criteria with regard to the ventilation technology and electrical equipment (verification with the PHPP for the building as a whole) then, in consultation with the Certifier, the certificate can later be extended to include the entire building.

4.1.4 Thermal comfort: compensating for excessively low interior surface temperatures

When using typical Passive House components, the minimum standard of thermal protection (see 2.4.4) and hence the level of thermal comfort is already complied with for windows and doors in most cases. As a less-than-ideal solution, low temperatures can be compensated for by means of heat emitters or air heating if windows with an adequate thermal quality are not available or their installation is not permitted due to reasons of historical building preservation.

Compensating for low temperatures by means of heat emitters

- If compensation for low temperatures takes place by means of heat emitters (e.g. radiators, wall heating/underfloor heating, baseboard heating), then these must be individually controllable and must always be available during the heating period e.g. also when heating in the rest of the building is not needed.
    - Heat emitters positioned to the side of the windows can only be taken into account if these are within 60 cm of either side of the window. Heat emitters underneath must be foreseen in the case of windows with a total rough opening width of more than 1.60 m.
- The **heating capacity of the heat emitters** must compensate the lower temperatures due to the window. Proof of this may be provided in two ways:
    - **Method 1**: without any other climate-dependent evidence, the heating capacities in the following table are sufficient.

Table 8: Capacities of the heat emitter to compensate low temperature of the window (linear interpolation may be used)

$U_{W,installed} - U_{criterion}$ [W/(m²K)]	Heating capacity per m² window area [W/m²]
0.1	5
0.2	10
0.5	25
1.0	50

    - **Method 2:** evidence must be provided for at least the following capacity:

$$(U_{W,installed} - U_{criterion}) * \Delta T * A_{window}$$

for which ΔT: 22 °C - Θ_e with Θ_e: outdoor temperature for the thermal comfort criterion ("Windows" worksheet)
$U_{Winstalled}$: U-value of the installed window
$U_{criterion}$: climate dependent U-value requirement for a window of any size (in PHPP worksheet "Verification", section “Minimum thermal insulation”)
A_{window}: window area (rough opening dimensions / wall cut-out)

- **Taking into account in the energy balance (PHPP)**: if the PE/PER factor of the compensating heat emitters is less efficient than that of the main heating system of the building, this must be taken into account in the "PER" worksheet in the contribution margin (useful energy) for the heating.
    - the useful energy [kWh/(m²a)] of the compensating heat emitters is calculated as follows: $(U_{W,installed} - U_{criterion}) * HDD * A_{window}$

      for which HDD (heating degree days) = $(\Theta_i - \Theta_a)* \Delta t$ in [kKh/a]
      Θ_i is the setpoint room temperature (usually 20°C, see PHPP "Verification" worksheet).
      Θ_a is the monthly average temperature of the outdoor air ("Climate" worksheet)
      Δt is the length of the month: the coldest month must always be taken into account, the remaining months must only be taken into account if $\Theta_a < 22\ °C – 4.2\ K / (0.13\ m²K/W * U_{W,installed})$

Thermal comfort: Compensating for low temperature by means of air heating

- Compensation of a higher U-value by means of air heating is possible if the air outlet is positioned at a distance of less than 1 m from the window and is directed at the window.
- In such a situation, the heat losses of the window will increase significantly because the inner pane is heated to above its normal temperature. This must be calculated into the efficiency of the heating system. If the simplified, pessimistic assumption is made that the air heating heats up the inner window surface without there being any change in the internal heat transmission resistance R_{si}, this will result in the factor with which the efficiency of the heating system must be multiplied in the "PER" worksheet as follows
    - $1 – R_{si} * U$

      for which $R_{si} = 0.13\ m²K/W$
      U is the average U-value of the window.