1 The new Passive House standard

The new PHI Low Energy Building Standard no longer distinguishes between residential and non-residential buildings and is not limited to the cool-temperate climate zone [1].

A new, more sustainability oriented evaluation procedure based on Primary Energy Renewable (PER) has been integrated, which will be explained in subsection 1.1. Depending on the PER demand and renewable energy (RE) generation, one of the three new PH classes can be achieved as described in subsection 1.2. [1]

The new criteria for a Passive House are now more robust and verifiable and so –called "soft criteria" are no longer applied [1].

1.1 The Primary Energy Renewable sustainability assessment

The energy balance and Passive House Planning Tool (PHPP) was based on the primary energy (PE) assessment. In this evaluation, a distinction between renewably generated electricity and fossil fuel based generation was not made. The energy demand is multiplied by the primary energy factor of 2.6 in both cases. This primary energy factor is primarily a factor used to calculate how much energy is needed to generate the amount of energy reaching the consumer, but is also a political factor to control the composition of the energy mix. The primary energy factor of 2.6 is a significant disadvantage for renewably generated electricity, especially bearing in mind that renewables generate electricity most of the time. [2]

A suitable indicator for the sustainability of buildings is needed, and so the new PHPP 9 now uses the Primary Energy Renewable to calculate the specific energy losses of an energy application, as described as the respective PER factor, similar to the primary energy factor before. [3]

The methodology of the PER factor is based on an industry that is running fully on RE supply. RE provides primary electricity that can be partly used directly, which results in a low PER factor. Storage capacity is necessary to store excessive energy at times with high gains for used in periods with lower energy gains. This storage is associated with losses and results in a higher PER factor. The demand for domestic energy is quite constant throughout the year and only short-term storage is needed, which results in an average PER factor. Only the heating demand causes more energy consumption in the winter. In order to provide enough energy in winter, electricity must be produced in summer and stored with very high losses for the winter, which results in a high PER factor. [4]

Today we are still far away from this type of industry, but many countries, like the members of the European Union and Iceland, are focusing on this aim of a renewable based industry. An RE based industry will most likely be a reality in Europe in 2060. [4]

The individual calculations of the PER factors are based on climate data, and the resulting PER factors describe how much more renewable energy must be supplied in order to cover the final energy consumed in the building, including all losses incurred along the way. The PER factor is the result of energy demand and the renewable source [3]:

$$PER = \frac{Energy\ supply\ from\ renewable\ sources}{Final\ energy\ demand\ at\ the\ building}$$

A possible energy flow from the RE supply to the energy consumed in the building, including facilities for short-term and seasonal storage, are shown in Figure 1-1. Using methane for seasonal storage has the advantage that the existing infrastructure of the natural gas can be used, and the storage losses are minimal. The disadvantage of methane produced by Power-to-Gas is the losses in the process; the efficiency for the end-user would be about 30 percent. [4]

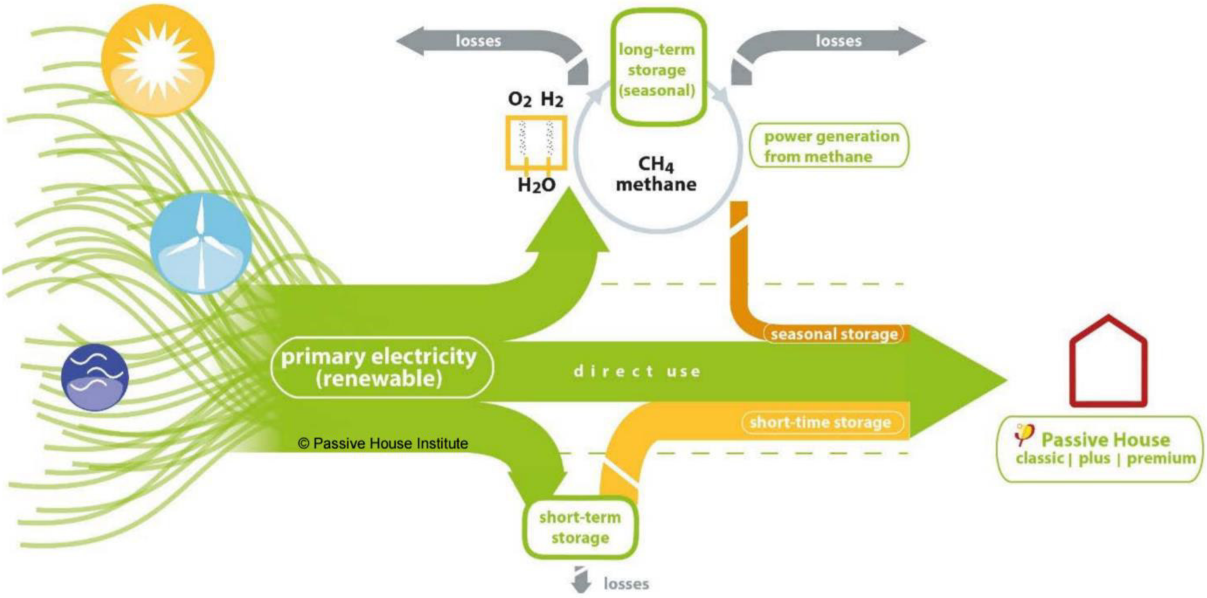

Figure 1-1 Energy flowchart from the RE supply to the energy consumed at the building, including facilities for short-term and seasonal storage. [3]

1.2 The new Passive House classes: Classic, Plus, Premium

The new Passive House classes are making the Passive House modern. In the modern world, we can choose between different qualities or sizes, for example, a cup of coffee. The old Passive House standard nowadays is not far off upcoming regulations in various countries like the members of the European Union. However, in other parts of the world, like Canada or Australia, the old PH standard is still a difficult task.

The PHI is becoming more and more international and so a new graded evaluation, similar to the Leadership in Energy and Environmental Design (LEED) evaluation, is needed. The three new classes, as presented in Figure 1-2, are suitable gradings based on lots of experience and research. [4] [5] [6]

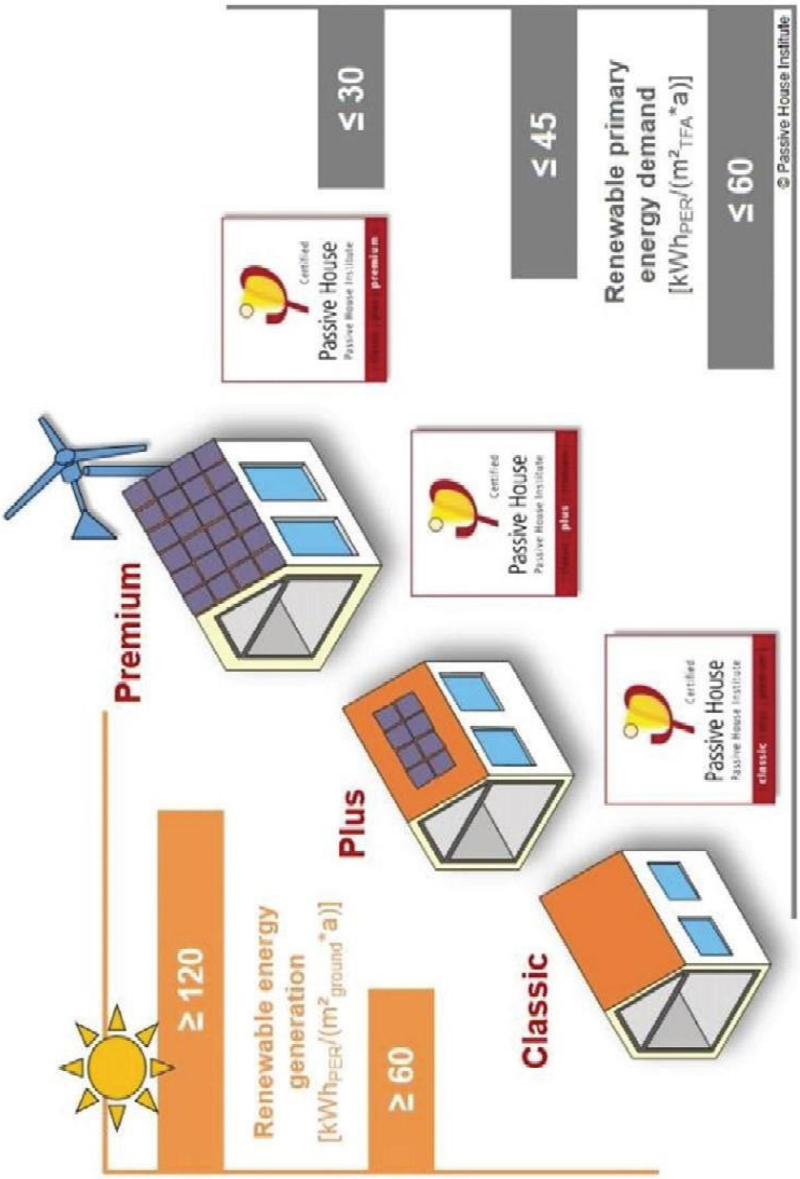

Figure 1-2 The new Passive House classes: Classic, Plus, Premium. [6]

1.3 The new Passive House criteria

The definition of the Passive House standard, as described in section 3, is still valid. Only the Passive House criteria have been changed and extended as shown in Table 1-1 [1].

1.4 General minimum criteria

In addition to the high level of energy efficiency, that is resolution of the criteria of Table 1-1, PH buildings offer an optimum standard of thermal comfort according to ISO 7730 and high degree of user satisfaction as well as protection against condensation related damage. [1]

Table 1-1 Passive House criteria. [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 + dehumidification contribution[4]			variable limit value[5]
cooling load[6]	[W/m²]	≤	-			10
Airthightness						
pressurization test resultl n_{50}	[1/h]	≤	0.6			
Renewable Primary Energy (PER)[7,8]			Classic	Plus	Premium	
PER demand	[kWh/(m²a)]	≤	60	45	30	±15 kWh/(m²a) deviation from criteria...
renewable energy generation (with reference to ground area)	[kWh/(m²a)]	≥	-	60	120	...with compensation of the above deviation by different amount of generation

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 reference to ground area and airtightness with reference to the net air volume).
2 Two alternative criteria which are enclosed by a double line together may replace both of the adjacent criteria on the left which are also enclosed by a double line.
3 The steadyAstate heating load calculated in the PHPP is applicable. Loads for heating up after temperature setbacks are not taken into account.
4 Variable limit value subject to climate data, necessary air change rate and internal moisture loads (calculation in the PHPP).
5 Variable limit value subject to climate data, necessary air change rate and internal heat and moisture loads (calculation in the PHPP).
6 The steadyAstate cooling load calculated in the PHPP is applicable. In the case of internal heat gains greater than 2.1 W/m² the limit value will increase by the difference between the actual internal heat gains and 2.1 W/m².
7 Energy for heating, cooling, dehumidification, DHW, lighting, auxiliary electricity and electrical appliances is included. The limit value applies for residential buildings and typical educational and administrative buildings. In case of uses deviating from these, if an extremely high electricity demand occurs then the limit value can also be exceeded after consultation with the Passive House Institute. Evidence of efficient use of electrical energy is necessary for this.
8 The requirements for the PER demand and generation of renewable energy were first introduced in 2015. As an alternative to these two criteria, evidence for the Passive House Classic Standard can continue to be provided in the transitional phase by proving compliance with the previous requirement for the nonArenewable primary energy demand (PE) of QP ≤ 120 kWh/(m²a). The desired verification method can be selected in the PHPP worksheet "Verification". The primary energy factor profile 1 in the PHPP should be used by default unless PHI has specified other national values.

The following minimum criteria are the "Criteria for the Passive House, EnerPHit and PHI Low Energy Building Standard" in an unchanged form and written in italic letters. [55]

1.4.1 Frequency of overheating

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

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

1.4.2 Frequency of excessively high humidity

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

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

1.4.3 Minimum thermal protection

The criteria for the minimum level of thermal protection according to…Table 1-2… They apply for each individual building component on its own (e.g. wall build-up, window, connection detail). Averaging of several different building components as evidence of compliance with the criteria is not permissible.
As a rule, the minimum level of thermal protection is already covered by the much more stringent criteria mentioned in…subsection 1.3…The following minimum criteria are therefore effective only in exceptional cases.

1.4.4 Occupant satisfaction

- *All living areas must have at least one operable window. Exceptions are possible in justified cases as long as there is no significant likelihood of occupant satisfaction being affected.*
- *It must be possible for the user to operate the lighting and temporary shading elements. Priority must be given to user-operated control over any automatic regulation.*
- *In case of active heating and/or cooling, it must be possible for users to regulate the interior temperature for each utilisation unit.*
- *The heating or air-conditioning technology must be suitably dimensioned in order to ensure the specified temperatures for heating or cooling under all expected conditions.*

Table 1-2 Criteria for minimum thermal protection. [1]

Climate zone	Hygiene[1]	Comfort[2]			
	Min. temperature factor	Max. thermal transfer coefficient			
	$f_{Rsi=0.25\ m^2K/W}$	U-value			
	[]	[W/(m²K)]			
Arctic	0,80	0,45	0,50	0,60	0,35
Cold	0,75	0,65	0,70	0,80	0,50
Cool-temperate	0,70	0,85	1,00	1,10	0,65
Warm-temperate	0,60	1,10	1,15	1,25	0,85
Warm	0,55	-	1,30	1,40	-
Hot	-	-	1,30	1,40	-
Very hot	-	-	1,10	1,20	-

The criteria for the minimum level of thermal protection according to…Table 1-2… They apply for each individual building component on its own (e.g. wall build-up, window, connection detail). Averaging of several different building components as evidence of compliance with the criteria is not permissible.
As a rule, the minimum level of thermal protection is already covered by the much more stringent criteria mentioned in…subsection 1.3…The following minimum criteria are therefore effective only in exceptional cases.

1 Hygiene criterion
Besides the requirement for the temperature of the building component's interior surface (fRsi=0,25 m²K/W) mentioned in …Table 1-2…, all standard cross-sections and connection details must also be planned and executed so that excessive moisture in the building component build-up can be ruled out with the intended building use.
2 Thermal comfort
The limit values do not apply for areas which are not adjacent to rooms continuously used by persons and to separate areas smaller than $1\ m^2$. Exceeding the limit value is permissible in the case of windows and doors if low temperatures arising on the inside are compensated by means of heating surfaces. If there are doubts relating to thermal comfort. For building components in contact with the ground, the requirement for the U-value can be divided by the reduction factor f_T ("ground reduction factor" in the PHPP sheet "Ground").
For inclined building components the required value which most closely approximates the actual inclination of the window (according to the sketch "building component inclination" in…Table 1-2…) will apply. There will be no interpolation between two criteria.
Alternatively, the criteria for thermal comfort will be deemed to have been fulfilled if evidence of the comfort conditions is provided in accordance with DIN EN ISO 7730.
The thermal comfort criteria in Table 6 (last four columns) do not apply for PHI Low Energy Buildings.

- *Ventilation system:*
  - *Controllability:*
    The ventilation volume flow rate must be adjustable for the actual demand. In residential buildings the volume flow rate must be user-adjustable for each accommodation unit (three settings are recommended: standard volume flow / standard volume flow +30 % / standard volume flow - 30 %).
  - *Ventilation in all rooms:*
    All rooms within the thermal building envelope must be directly or indirectly (transferred air) ventilated with a sufficient volume flow rate. This also applies for rooms which are not continuously used by persons provided that the mechanical ventilation of these rooms does not involve disproportionately high expenditure.
  - *Excessively low relative indoor air humidity:*
    If a relative indoor air humidity lower than 30 % is shown in the PHPP for one or several months, effective countermeasures should be undertaken (e.g. moisture recovery, air humidifiers, automatic control based on the demand or zone, extended cascade ventilation, or monitoring of the actual relative air humidity with the option of subsequent measures).
  - *Sound level:*
    The ventilation system must not generate noise in living areas. Recommended values for the sound level are
    - *≤ 25 db(A): supply air rooms in residential buildings, and 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 uncomfortable draughts.

1.5 Verification of the new Passive House criteria

This new definition and concept needs to be actual project in the future. To now this new Passive House standard is based on the theoretical studies as described in the following section.

Sources

[1] Passiv Hause Institut, "Kriterien für den Passivhaus-, EnerPHit- und PHI-Energiesparhaus-Standard," Passiv Hause Institut, Darmstadt, 2015.

[2] W. Feist, "Passivhaus-Effizienz macht die Energiewende wirtschaftlich," in *Internationlae Passivhaustagung*, Frankfurt am Main, 2013.

[3] Passipedia, "The PER sustainability assessment," Passivhaus Institut, Darmstadt, 2015.

[4] W. Feist, "Passive House - the next decate," in *Internationale Passivhaustagung*, Achen, 2014.

[6] Passivhaus Institut, "passipedia.de," [Online]. Available: http://www.passipedia.de/planung/haustechnik/lueftung/ohne_lueftungsgeraet_geht_es_nicht. [Accessed 10 02 2015].