Zero Energy & Passive House Certifications

Charting the path for projects seeking a dual rating

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Partnering to deliver energy efficient buildings

This document addresses the International Living Future Institute's (ILFI) **Zero Energy** (ZE) certification and the **Passive House** certification of the Passive House Institute (PHI). ILFI and PHI consider these certification programs to be highly complementary. The energy efficiency requirements of Passive House provide a targeted pathway focused on high energy efficiency for pursuing Zero Energy. The 12-month performance requirements of Zero Energy certification, in turn, provide a mechanism to validate the outcome of anticipated energy savings from Passive House.

The following pages offer guidance for buildings seeking to benefit from both certification schemes by choosing the high energy efficiency of a Passive House complemented with renewables as a compliance pathway to reach Zero Energy. In general, the Passive House and EnerPHit standards provide key thermal and envelope targets for new and retrofitted buildings that lead to substantial reductions in overall building energy consumption. In order to meet the ZE requirements, this remaining energy consumption must be met with measured renewable energy generation. This document provides clarification on how to navigate the different metrics included in each standard.

All guidance in this document is in reference to Passive House Standard version 9f and International Living Future Institute Zero Energy Certification.

Enervillas, Anaptiksi Kataskevastiki SA, photo © Dimitrios Dimopoulos

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About ILFI Zero Energy Certification

The International Living Future Institute's (ILFI) Zero Energy (ZE) certification was created to recognize projects that demonstrate the highest level of energy performance and spur the creation of renewable energy resources. The program is building an advanced cohort of industry-leading building projects with third-party performance verification.

To achieve ZE certification, one hundred percent of the building's energy needs on a net annual basis must be supplied by on-site renewable energy. Certification is based on actual performance, and achievement is validated after a 12-month performance period. With the aim of contributing to an energy future that is free of fossil fuels, ZE certification does not allow the use of combustion in building operations except in very limited circumstances.

ZE certification evolved out of the Living Building Challenge (LBC), which was first released in 2006, and set a new benchmark for green building by requiring wholistic and proven performance. The LBC Standard is divided into seven issue areas, or Petals, which are subsequently divided into twenty total Imperatives, each of which has a specific focus and set of requirements. Projects achieving LBC Living Certification meet the requirements of all twenty Imperatives, and in so doing generate all of their own energy with renewable resources, capture and treat all water onsite without the use of chemicals, promote health and address inequity, operate efficiently, invoke beauty, and are toxin-free. Through the Energy Petal, the LBC addresses energy performance by requiring net positive performance and energy storage for resiliency. The ZE certification program was developed in 2011 to follow a similar structure as the Energy Petal while setting a streamlined target of a net zero annual balance of energy consumed and generated. In 2017, the ZE certification program was revised to omit all non-energy requirements, focusing exclusively on the energy balance.

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About the Passive House and EnerPHit Standards

The international Passive House standard was launched in 1996 by the Passive House Institute (PHI) in Germany, following the construction and monitoring of the first Passive House pilot project in 1991. It delivers high performance buildings in all climates of the world, taking into account the respective context. Thanks to an approach that focuses on the envelope and efficient mechanical systems, Passive House buildings consume up to 90% less heating and up to 80% less cooling energy than typical existing buildings, depending on climate. At the same time, they provide healthy, high quality living and working conditions (comfortable temperatures all year round, no drafts or mold, good indoor air quality). With very low operating costs and high temperature stability, these buildings also provide resilience against rising energy prices and changing climate conditions.

The Passive House standard is based on the laws of physics and its methodology is applicable worldwide, both for new and existing buildings. Thousands of built examples prove that Passive House delivers its objectives for various building typologies, shapes, materials, and scales. Whether it is a climate neutral settlement, an office in China or a high-rise in New York, various inspiring examples can be found on the Passive House Database.

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King Street office building, JW Architects, photo © Lara Swimmer, artwork © Liz Tran

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An essential aspect of achieving the Passive House performance targets is the design and quality assurance process. By means of modelling the predicted energy demand, the Passive House Planning Package (PHPP) is used as a design tool to optimize a building's design. Complemented with selected on-site quality assurance measures (e.g. airtightness measurement) the PHPP energy modelling forms the basis for Passive House verification and certification.

In renovations of existing buildings, achieving the Passive House energy targets is not always possible due to variability in initial conditions. Complete all-at-once or phased step-by-step renovations according to Passive House principles are therefore awarded the EnerPHit standard. This standard can be attained either through modeled energy performance (slightly higher energy demand than Passive House) or a component quality-based approach according to climate zones.

In addition to the Passive House and EnerPHit Classic standards, buildings that incorporate renewable energy generation and higher overall efficiency can aim for the Plus or Premium classes of Passive House or EnerPHit (see appendix "Primary Energy Renewables" for details).

King Street office building, JW Architects, photo © Lara Swimmer, artwork © Liz Tran

How to read this document

This document outlines each requirement in the Passive House standard that is relevant to a net zero energy target, and then states how each will contribute towards the performance verification process of the ZE standard.

Note that this document tracks the alignment of standards with the understanding that most project teams will first pursue Passive House certification, as it can be challenging to successfully pursue Passive House after achieving ZE, unless both standards were targeted from the outset.

The guidance provided in this document is of a summary nature; complete details on the requirements are stated in the respective standards. It is also noted that the Passive House standard includes other requirements not directly related to energy (e.g. comfort and acoustics) that are not stated in this document. Links to the complete requirements for both standards are provided in the References.

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Passive House Standard to Zero Energy Certification

This table provides an overview of the alignment between Passive House / EnerPHit requirements and Zero Energy Certification requirements.

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	Passive House/EnerPHit Plus and Premium Requirements	Zero Energy Certification Requirements	Alignment
PROJECT SCOPE			
Project Scope	Only entire buildings (with very limited exemptions for phased retrofits or pilot projects)	New buildings may limit certification to a part of the building, where the ownership, funding, and operation are all distinct from the rest of the building, and the area to be certified is physically and visually distinguishable	Whole-building compliance for Passive House is compatible with ZE
Combustion	Permitted	Not permitted; exceptions in very limited circumstances, with restrictions	To be eligible for ZE, Passive House projects must not include combustion (with limited exceptions)
Energy Uses Included in the Energy Balance	All energy uses within the thermal envelope	All equipment and energy-using systems related to any part of the building program (including process energy), with the exception of electrical vehicle charging, which is excluded	The scope of energy uses in Passive House and ZE is mainly compatible. Compatibility for specific projects should be verified

Passive House Standard to Zero Energy Certification

	Passive House/EnerPHit Plus and Premium Requirements	Zero Energy Certification Requirements	Alignment
PERFORMANCE REQUIREMENTS			
Energy Demand Limits by End Use	(a) Useful heating demand and heating load (b) Useful cooling and dehumidification demand, cooling load	No limits are specified for heating and cooling demand. Total site energy use measured from a utility or private meter is reported over 12-month period	The low energy limits of Passive House are advantageous to reaching the measured ZE balance
Building Envelope	(c) Airtightness Supplementary criteria regarding minimum thermal properties to ensure high comfort and hygiene	Building envelope performance requirements are not specified	Meeting the airtightness requirements in Passive House is expected to reduce the overall energy use measured for ZE through the 12-month performance period
Total Energy Demand	Requirement set for (d) total renewable Primary Energy (PER) demand Includes conversion factors from site energy to renewable Primary Energy to account for grid sourcing of energy (transmission, conversion and storage losses)	No limits are specified for overall energy demand Projects must demonstrate that site energy use is equal to, or less than, site energy generation over a 12-month period	The two standards take different approaches to compliance metrics. Note that the annual site energy demand reported in PHPP can be used to predict potential achievement of ZE when compared to estimates of onsite energy generation. (PHPP v9.6, PER worksheet, cell S84)

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Passive House Standard to Zero Energy Certification

	Passive House/EnerPHit Plus and Premium Requirements	Zero Energy Certification Requirements	Alignment
PERFORMANCE REQUIREMENTS			
Total Energy Generation	(e) Renewable energy generation with reference to the projected footprint area of the building (only Plus and Premium classes) Both onsite and offsite renewable generation are accepted Renewable energy generation must be additional, not already existing “Renewable energy” is defined as photovoltaics, solar thermal, wind turbines and water- powered micro-turbine	Minimum not specified Must be equivalent or greater than the total site energy use over a 12-month period All renewables must be onsite. Offsite renewables are only permitted in limited circumstances Renewable energy generation must be additional, not existing “Renewable energy” is defined as passive solar, photovoltaics, solar thermal, wind turbines, water-powered micro-turbines, direct geothermal or fuel cells powered by hydrogen generated from renewably powered electrolysis. Nuclear energy is not considered renewable, nor are combustion- based sources	The two standards take different approaches to compliance metrics. But note that the annual site energy generation reported in PHPP can be used to predict potential achievement of ZE when compared to estimates of annual energy demand. (PHPP v9.6, PER worksheet, cell S85) The definition of acceptable “renewable energy” is slightly different between the two standards
Zero Energy Balance	Not specified Energy demand and energy generation have independent targets	Net energy balance of site energy use and energy generation over 12 consecutive months, must be zero or better	The two standards take different approaches to compliance metrics Note that in PHPP v9.6, cell S86 in PER* worksheet, a zero or negative number indicates predicted achievement of ZE

Passive House Standard to Zero Energy Certification

	Passive House/EnerPHit Plus and Premium Requirements	ILFI Zero Energy Requirements	Alignment
COMPLIANCE + DOCUMENTATION			
Predictive Modeling	Modelled with the Passive House Planning Package (PHPP) Submission for pre-certification is highly recommended	Narrative of design methodology is required, but energy modelling not reviewed as part of required certification documentation	ZE compliance is based on measured performance, so modelling data do not need to be submitted for ZE certification. As noted above, the PHPP modelling process may yield early indication that building has capability to achieve zero energy[1]
Metering	Not required	Either utility or private meters must be installed to directly measure or permit calculation of total annual energy generation separately from energy consumption. Net meters alone are not sufficient	Meter data showing one-time annual energy generation and consumption is required for ZE; it is not required for Passive House
Final Verification	PHPP calculation and respective project documentation Pressurization test Ventilation commissioning (flow rate adjustment) Building site documentation	Building site documentation (photographs) Design drawings, system schematics and narratives Total energy use data for 12-month performance period	Passive House projects need to be equipped with utility or private meters and submit 12 consecutive months of data to verify ZE compliance No site visit from a certification auditor is required

[1] Note that use-related variables such as different thermostat settings, ventilation habits, occupancy schedules and numbers, and year-to-year weather variations, can all affect actual energy use. These will be observed no matter what model or building standard is applied, and should be accounted for in sizing renewable systems to achieve Zero Energy. The better the energy standard, the lower the absolute fluctuation margins. In the case of the Passive House standard, the Passive House Institute has data showing that for the heating demand, the average consumption of a range of identical certified buildings is close to the predicted energy use (see Appendix).

Zero Energy Certification as a path to PHI Passive House / EnerPHit compliance

It is noted that Passive House and EnerPHit certifications have rigorous requirements for airtightness and modelled energy efficiency to ensure buildings that are future-proof, comfortable, and provide good air quality at a low energy expense. While these strategies are appropriate for achieving the level of efficiency needed to achieve a ZE target, the ZE certification program does not set specific requirements for these metrics. Thus, it cannot be assumed that ZE buildings will automatically qualify for Passive House / EnerPHit certification.

However, it is possible to apply for Passive House / EnerPHit certification after completion of a ZE building. It would require completing and submitting the PHPP model with all supplementary drawings and documentation, as well as the results of a specifically prescribed airtightness test. To learn more about the required documentation for Passive House / EnerPHit certification, please refer to the certification guidelines. Certification can be carried out by accredited certifiers.

References

- **International Living Future Institute**
  Zero Energy Certification
  Complete description of the certification program and links to supporting documents.
  https://living-future.org/net-zero/certification/

- **Zero Energy Certification**
  Documentation Requirements
  Complete listing of documentation requirements.
  https://living-future.org/wp-content/uploads/2018/03/ZE-Documentation-Requirements.pdf

- **Passive House Criteria for Passive House Classic,**
  Plus, Premium and EnerPHit
  Detailed description of all requirements.
  https://passiv.de/downloads/03_building_criteria_en.pdf

- **Passive House Certification Guide**
  Explanation of the certification process and documentation requirements.
  https://passivehouse.com/03_certification/02_certification_buildings/09_guide/09_guide.html

- **Passive House projects monitoring**
  Research on PHPP modelled versus measured energy.
  https://passivehouse.com/05_service/03_literature/0305_alle.php

Appendix

Definitions

Explanation of important terminology used in the document in alphabetical order.

Passive House

Passive House is a performance-based standard for highly energy efficient buildings. The internationally applicable numeric criteria are listed in the table below.

		Criteria	OR Alternative Criteria	
Heating				
Heating demand	≤	15	-	kWh/(m²$_{TFA}$a)
Heating load	≤	-	10	W/m²$_{TFA}$
Cooling				
Cooling and dehumidification demand	≤	15 + dehumidification contribution	Variable limit value	kWh/(m²$_{TFA}$a)
Cooling load	≤	-	10	W/m²$_{TFA}$
Airtightness				
Pressurization test result n_{50}	≤	0.6 h^{-1}		

Renewable Primary Energy (PER)		Classic	Plus	Premium		
PER demand	≤	60	45	30	± 15 deviation from criteria...	kWh/(m²$_{TFA}$a)
Renewable energy generation	≥	-	60	120	... with compensation of the above deviation by different amount of generation	kWh/(m²$_{projected}$a)

PHPP

Passive House Planning Package - The energy balance and planning tool for efficient new buildings and refurbishments accepted by the Passive House Institute for Passive House certification.

Site Energy

Also referred to as final energy, site energy is essentially the energy reflected in utility bills. It is the energy used to operate the building, reflecting efficiencies of energy-using equipment and fixtures. For example, the electricity needed to operate a heat pump to heat and cool a building, to provide lighting, and run appliances.

Useful Energy

Useful energy is the energy that actually powers the end use. It's distinct from energy that is lost for example in the delivery process, as exhaust, or due to equipment inefficiency. An example of useful energy is the thermal energy that needs to be added or removed from a building to heat or cool it to a desired temperature.

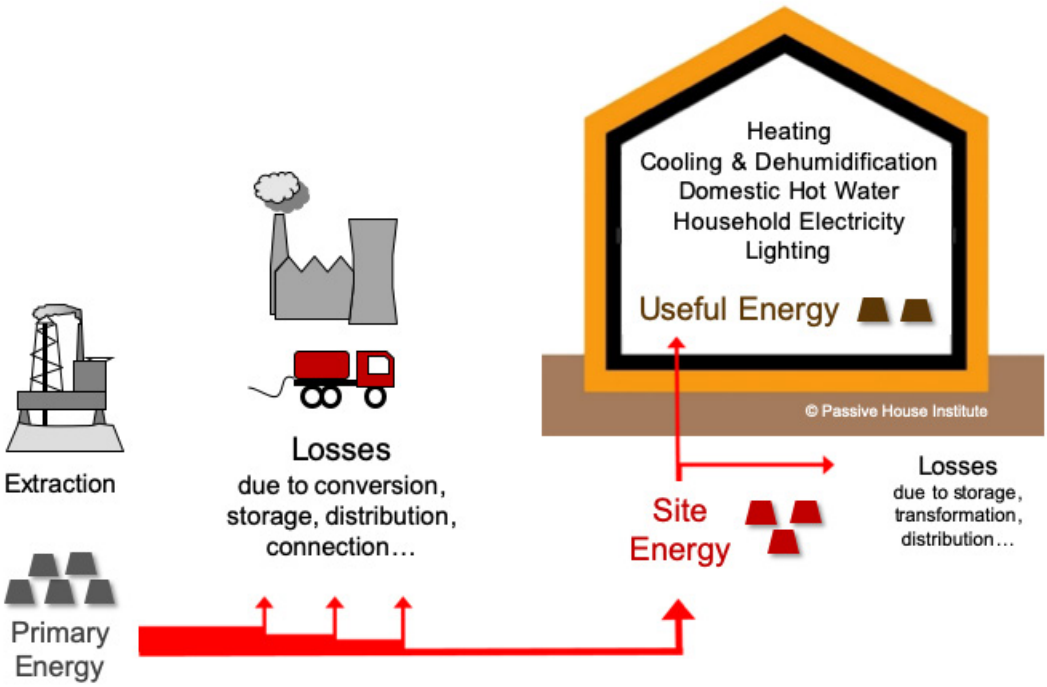
Zero Energy

ILFI defines zero energy as 100% of the building's energy needs being supplied by onsite renewable energy on a net annual basis. At the end of a 12-month performance period, as demonstrated by a utility meter, or where not available a private meter, the total energy generated must be equal to or greater than the total energy consumed.

The ILFI zero energy standard is based on Site Energy.

Primary Energy

Also referred to as Source Energy Use, Primary Energy (PE) is the total amount of raw fuel that is required to operate a building. In addition to the energy consumed on-site as the building is used, Primary, or Source Energy includes losses that take place during generation, transmission, and distribution of the energy. PE conversion factors differ for different energy carriers (e.g. electricity or natural gas) and countries. Calculating the PE demand enables an assessment of raw fuel resource needs resulting from building operations based on the energy supply structure.



Primary Energy Renewable

Primary Energy Renewable (PER) demand is equivalent to Source/Primary Energy above, but in the context of a future in which 100% of energy is renewable. The PER demand thus reflects the total amount of renewable energy required to operate a building, including all losses in the process of transmitting the energy from the renewable generation site to the use at the building.

PER Conversion Factor

To calculate the PER demand of a building, PER conversion factors are applied as multipliers to the Site Energy. These factors differ depending on the end use (e.g. heating, cooling, hot water), the energy carrier (e.g. electricity or natural gas from renewables), and the region. They take into account storage losses caused by the variability in alignment between regional renewable generation capacity and energy demand for a specific use over the seasons of a year. For generated renewable energy, one kWh is defined as equivalent to one kWh of PER (i.e. PER factor = 1 for renewable energy supply.)

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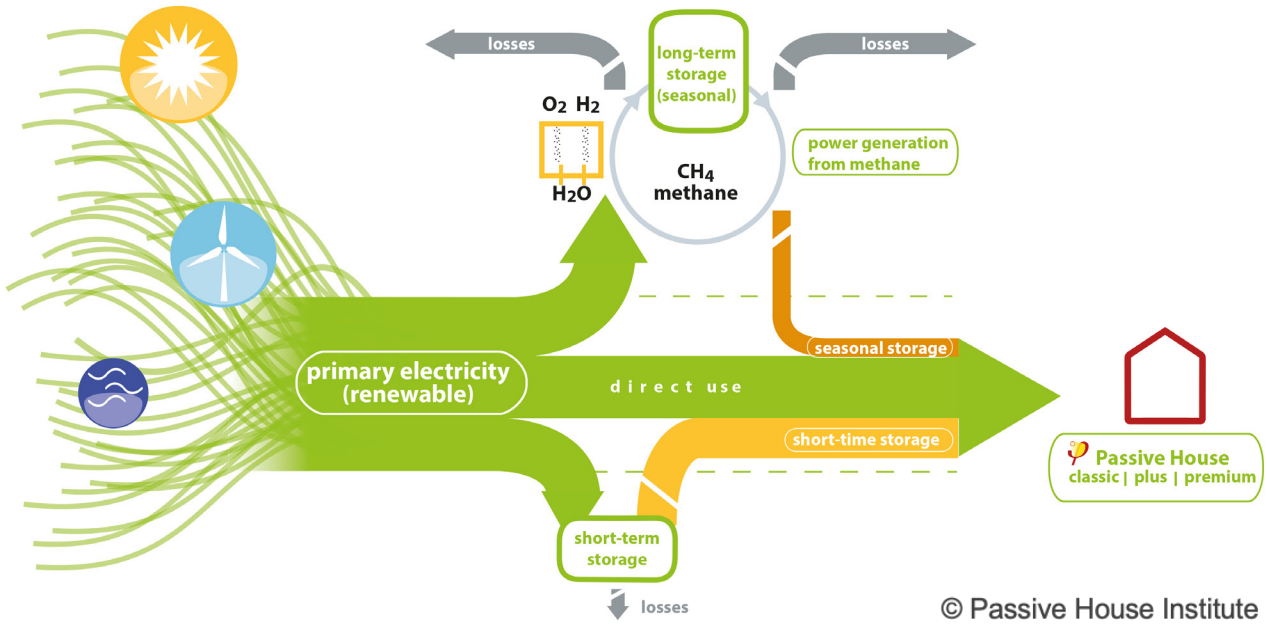
PER Energy Balance – Demand Versus Supply

PER demand and supply are rated independently of one another. The PER demand is based on the treated floor area of the project in order to reduce energy needs with respect to the useable space.

The renewable energy generation, (PER Supply) in turn, is based on the projected building footprint, in order to encourage maximized production with respect to the space occupied by the building. Thus, for single family houses, Passive House Plus is typically equivalent to net-zero site energy, while Passive House Premium is expected to achieve relevant amounts of surplus production. For mid- and high-rise buildings, the Plus and Premium classes require both very high efficiency and maximized onsite renewable energy production.

With this approach, buildings can benefit from the thermal and land use advantages of compact building shapes even if net zero energy cannot be achieved with rooftop renewables alone due to a relatively small available areas. For this reason, the Passive House Institute rates renewable energy generation base on the building footprint rather than via a total energy balance, providing a pathway to achieve the Passive House Plus / Premium certification and reward exceptional energy efficiency.



Comparing in-use energy consumption with calculated energy demand

The energy consumption of identical buildings or apartments will always be subject to use-related variations. These relatively large variations are caused by different interior temperatures, ventilation habits, occupancy, cooking habits, hot water use, electricity for appliances etc. and can be observed no matter the building standard. The better the energy standard, the lower the absolute fluctuation margins.

Over the years, the Passive House Institute has collected extensive monitoring data to verify in-use energy consumption of Passive House buildings. The image below depicts measured in-use heating energy data from four different row house developments (units identical within each development), where each orange bar represents a separate unit. Comparing the energy actually consumed for heating with the energy demand calculated based on PHPP energy modeling clearly shows that the average measured consumption is in very good agreement with the calculation results. This example analysis, and many more, provide evidence that the average expected heating energy demand can be reliably calculated with PHPP. Similarly for cooling energy, monitoring data of several projects confirm good agreement between calculated and measured values.

Looking at this spread in measured consumption for different living units also shows that it is difficult to draw general conclusions from the energy data of only one building. This can only ever provide information about the consumption of that specific building with the respective occupants' behavior and weather conditions during the measurement period.

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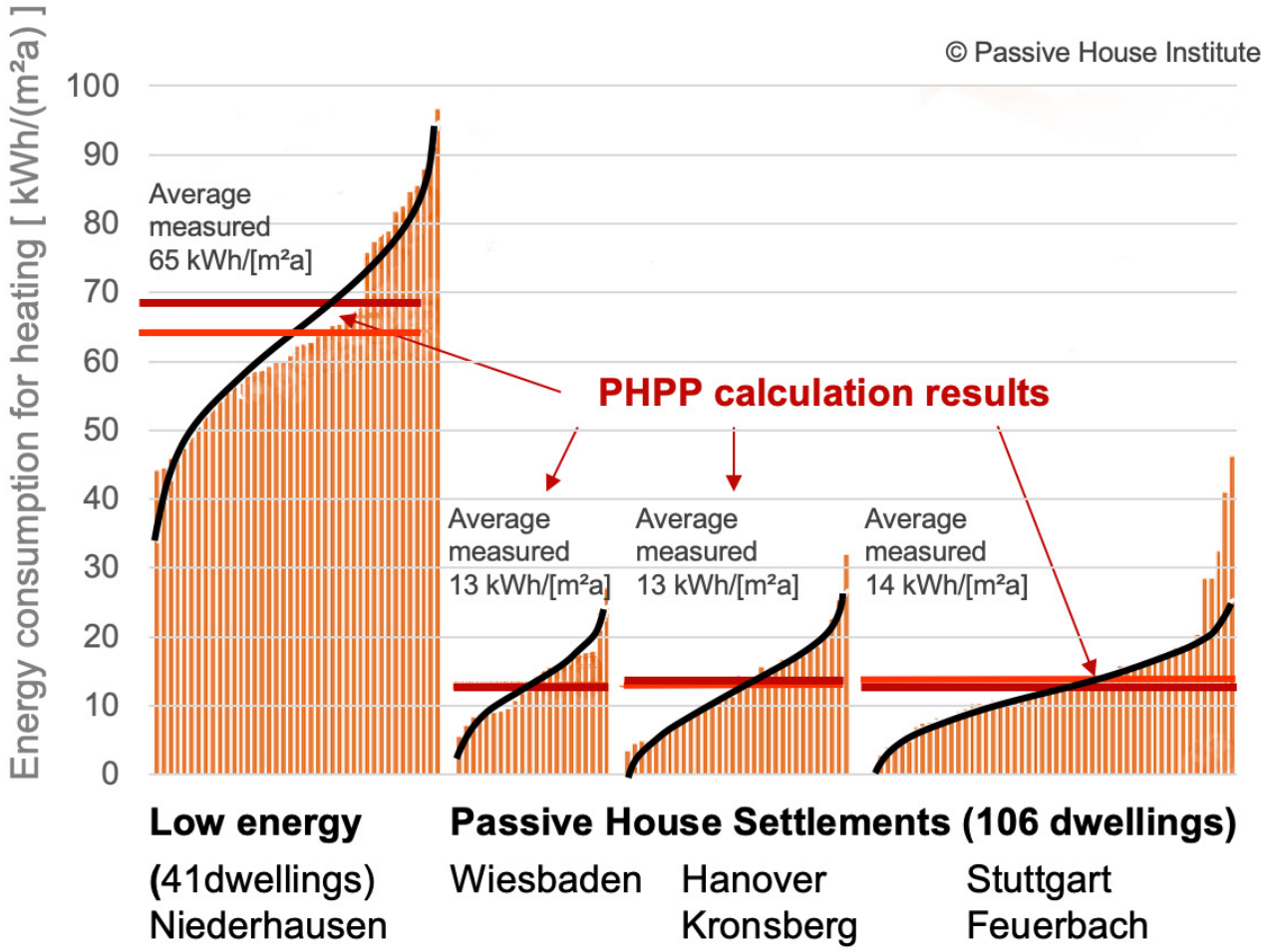
It is very important to keep this in mind when comparing any measured energy consumption with energy calculations. Deviations between predictive calculations (e.g. from the Passive House certification) and in-use consumption (e.g. from the ZE certification) are to be expected. It goes without saying that the assumptions used for the predictive energy modelling must be as realistic as possible. In order to gain a better understanding of possible variation of the future in-use energy consumption, it is recommended the influence of user behavior be assessed during the design stage by varying the relevant parameters in the PHPP (e.g. appliances, hot water demand etc.). For a meaningful comparison of in-use consumption with the PHPP energy calculation, all boundary conditions and user behavior assumptions need to be adjusted to actual in-use conditions (for example average measured room temperature, measured weather conditions, electricity consumption for appliances, hot water consumption, ventilation rate). A data preprocessing tool is available for this purpose from the Passive House Institute.

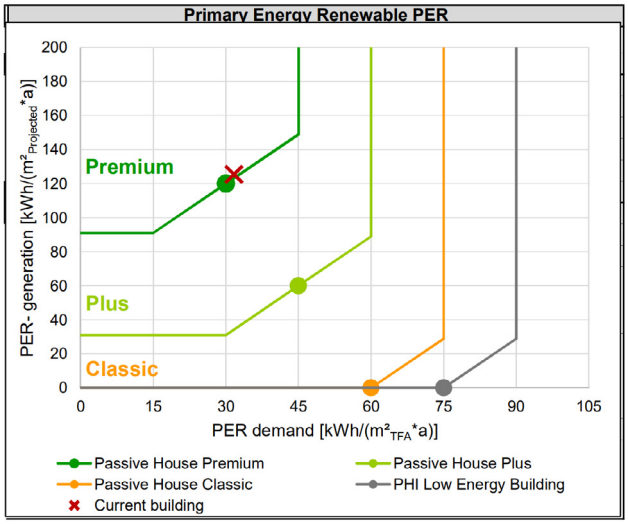


ZE Relevant Site Energy Data in PHPP

The screenshot below is an extract of the PER worksheet of PHPP (version 9.6) with an indication of the data that is relevant to assessing potential achievement of ZE.

- Total site energy demand is outlined in blue (cell S84 in PHPP v9.6)
- Total renewable energy production is outlined in orange (cell S85 in PHPP v9.6)
- Site energy balance is outlined in red (cell S86 in PHPP v9.6). This number should be zero or negative to indicate high potential for achieving ZE. In the given example it is negative, meaning that this building is predicted to generate more energy than it will consume. In fact, this building is targeting Passive House Premium certification, as can be seen on the side graph.

Summary Though, from the scientific point of view, not entirely correct, different energy carriers will be added together here. This is done to meet the criteria of other energy standards.	**Final energy** MWh/a	**PER specific value** MWh/a	**PE value** 1-PE factors (non-renewable) PHI Certification MWh/a	**CO2eq emissions** 1-CO2 factors GEMIS (Germany) kg/a	**CO_2eq substitution balance** 1-CO2 factors GEMIS (Germany) kg/a
Demand	**5,2**	**4,9**	6,26	1929	1929
Generation	**-11,4**	**-10,1**	-2,11	1226	-4345
Demand, cumulative generation (annual balance)	-6,16	-5,21	4,15	3155	-2416
Demand w/o household electricity	**4,0**	**3,3**	4,02	1266	1266
Demand w/o household electricity, cum. generation	-7,40	-6,83	1,91	2492	-3078



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