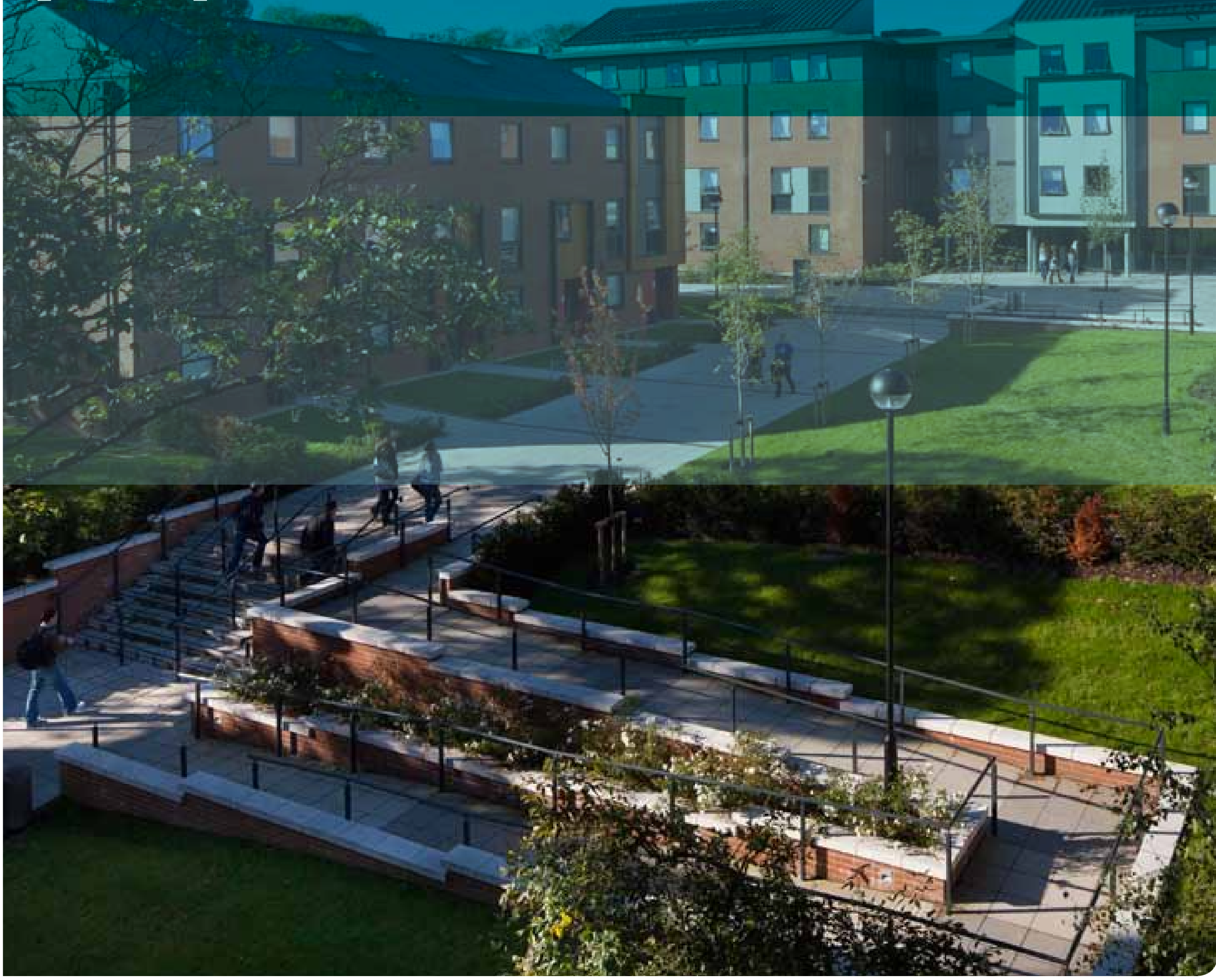
www.passivhaus.org.uk

Passivhaus primer: Introduction
An aid to understanding the key principles of the Passivhaus Standard



BRE is registered with the Passivhaus Institut as an official Certifier for Passivhaus Buildings

Background

This primer is an aid to all those interested in understanding the key principles of the Passivhaus Standard. The term Passivhaus refers to a low energy construction standard developed by Dr. Wolfgang Feist of the Passivhaus Institut, Germany.

The term 'Passivhaus' refers to a low-energy construction standard developed in the 1990s by Dr Wolfgang Feist of the Passivhaus Institut in Germany. It is the fastest growing energy performance standard in the world with over 30,000 buildings having been constructed in accordance with Passivhaus principles, the majority of those since 2000 with several projects completed in the UK.

The core focus of the Passivhaus Standard is to dramatically reduce the requirement for space heating and cooling, whilst also creating excellent indoor comfort levels. This is primarily achieved by adopting a fabric first approach to the design, by specifying high levels of insulation to the thermal envelope with exceptional levels of airtightness and the use of whole house mechanical ventilation.

The first dwellings to be completed to the Passivhaus standard were constructed in Darmstadt, Germany, in 1991. The Passivhaus Institut (PHI) subsequently monitored the performance of these dwellings, along with another 250 Passivhaus projects around Europe, as a part of the European CEPHEUS project (www.cepheus.de/eng/).

Since the completion of the CEPHEUS project, the concept of Passivhaus design has seen widespread adoption initially around Europe and the in recent years the World.

The Passivhaus Standard can be applied not only to residential dwellings but also to commercial, industrial and public buildings.

This has led to the following functional definition of a Passivhaus.

The Passivhaus - definition

"A Passivhaus is a building, for which thermal comfort can be achieved solely by post-heating or post-cooling of the fresh air mass, which is required to achieve sufficient indoor air quality conditions – without the need for additional recirculation of air."

...meaning the heating requirement in a Passivhaus is reduced to the point where a traditional heating system is no longer considered essential. Cooling is also minimised by the same principles and through the use of shading and in some cases via the pre-cooling of the supply air. Night purging and the use of natural cross-ventilation through open windows is encouraged during the summer months.

An important factor of a Passivhaus is that they do not conform to any one design style; therefore a Passivhaus can either be of traditional, or a more contemporary design.

Cae Gliesion, Bridgend, Wales

Camden House, Camden, London

The Passivhaus Standard

Basic principles

As Passivhaus is a performance based ‘energy’ assessment the following targets define the standard and need be met in order for certification to be achieved.

Specific Heating Demand	≤ 15kWh/m².yr
(or) Specific Heating Load	≤ 10W/m²
Specific Cooling Demand	≤ 15kWh/m².yr
Specific Primary Energy Demand	≤ 120kWh/m².yr
Airtightness	≤0.6ach @50pascals (n50)

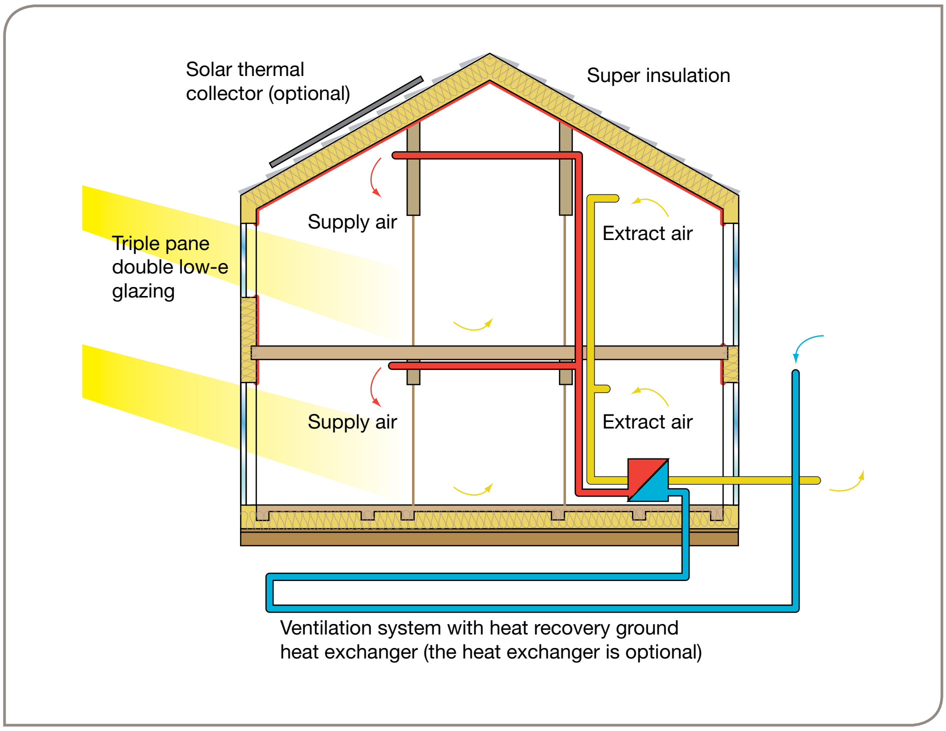
The standard requires that the Primary Energy Demand target is met in all cases. This figure must include the space heating, domestic hot water, lighting, fans and pumps and also all of the projected appliance consumption. In addition to the primary energy demand the standard permits that either the Specific Heating Demand (SHD) or the Specific Heating Load (SHL) must be met.

Thermal comfort is also a very important issue within Passivhaus. A certified Passivhaus should not fall below 16°C, even without heating during the coldest winter months; this is due to the excellent thermal performance and low air infiltration rates.

Guideline targets

Achieving a space heating requirement of 15kWh/m²/yr or less means that the following guideline targets need to be achieved as a minimum:

- A recommended opaque fabric U-values of ≤ 0.15W/m².
- U-values for windows and doors (for both the frame and glazing) need to be ≤ 0.8W/m²K (0.85W/m².K installed).
- Thermal bridging ideally needs to be eliminated or minimised, a psi value of <0.01W/m²K is considered thermal bridge free.
- An air pressure test must result in an n50 airtightness level of 0.6ach, averaged over pressurisation and depressurisation.
- Whole house mechanical ventilation with heat recovery (MVHR) that is 75% efficient or better, with a low specific fan power.



EnerPHit

Whilst it is possible to achieve the new build Passivhaus Standard in the refurbishment of an existing building and be fully certified as a "Quality-Approved Passivhaus", it is often difficult to achieve without undertaking major works which involve greater costs.

The EnerPHit Standard has been developed as a good practice refurbishment guide for Passivhaus renovations and, provided the verification criteria are met, certification to the EnerPHit Standard can be achieved by achieving slightly more generous standards compared to Passivhaus.

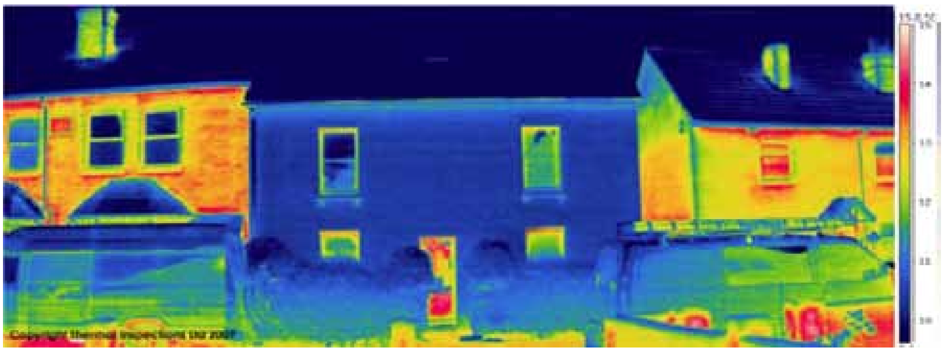
The EnerPHit specific energy demand criteria, compared to Passivhaus, are as follows:

Criteria	Passivhaus	EnerPHit
Specific Heat Demand	≤ 15 kWh/ m^2.yr	≤ 25 kWh/ m^2.yr
Primary Energy Demand	≤ 120 kWh/ m^2.yr	≤ 120 kWh/ m^2.yr
Airtightness	n50 ≤0.6	n50 ≤1.0

First refurbishment in the UK certified to the EnerPHit Standard

Grove Cottage is a detached cottage built in 1869 in Hereford. The cottage was recently refurbished by Simmondsmills architects to achieve an energy performance of 15-25 kWh/m^2.yr using triple glazing with high performing u-values utilizing external insulation to the walls and an MVHR unit.

Specific heat demand	25kWh/m^2yr
Air pressure result	1 ach
Specific primary energy demand	108 kWh/m^2yr
External walls	0.12W/m^2K
Ground Floor	0.17 W/m^2K
Roof	0.09 W/m^2K
Windows	0.9 W/m^2K



Simmonds.Mills / Thermal Inspections Ltd

How can Passivhaus requirements be achieved?

In order to achieve the energy requirements of Passivhaus the following performance parameters are recommended. These are guidelines only and slightly higher levels may be required in certain circumstances.

Insulation and thermal bridging

All opaque thermal construction elements (external walls, floors and roofs) should have U-values ≤0.15 W/m²K. In addition to this, all significant thermal bridges should be designed out: in Passivhaus, this is considered to be a Psi (Ψ) value of ≤ 0.01W/ m²K.

The most important principle of a Passivhaus is insulation. This should be applied continuously around the building envelope without being thermally bridged. This significantly reduces heat losses, so much so that even during winter they are negligible.

Another consequence is that the temperatures of the internal surfaces are the same as the indoor air temperature. This leads to a very comfortable indoor climate and avoids damages caused by moisture due to the humid indoor air condensing on cold surfaces.

During hot periods in summer, high thermal insulation is a protection against heat too. To ensure high thermal comfort during summer, well designed shading and sufficient ventilation are important.

All construction methods can be used for Passivhaus and have been tested successfully: masonry, timber (lightweight), prefabricated elements, insulating concrete formwork, steel and all combinations of these methods.

Passivhaus windows and doors

Window units should be triple glazed and both should achieve a U-value of 0.8W/m²K (0.85W/m²K installed). Ideally, PHI certified units should be specified.

In the milder UK climate, triple glazed Passivhaus windows need to be specified – without triple glazing the heat loss is too high and it is not possible to achieve the Passivhaus standard. A benefit for triple glazing is that the surface temperature of the windows is similar to that of the surrounding internal surfaces, which means that the occupants will not experience any thermal discomfort from large temperature differentials, even on the coldest winter day.

Airtightness

The airtightness of the property must have an n50 pressure test result of ≤0.6ACH/hr @ 50 Pa. This must be the average of pressurisation and depressurisation.

Unwanted air leakage can significantly increase the space heating requirement of a dwelling, cause localised discomfort due to draughts and possibly cause moisture to build up within the building fabric which may eventually reduce the performance and lifespan of the building. Achieving Passivhaus levels of airtightness can eliminate these problems.

Achieving this level of airtightness requires a strategy to be developed at the design stage, with the final result also being sensitive to the quality of workmanship. Achieving airtightness on site requires careful use of appropriate membranes, tapes, wet plastering and/or vapour membranes to form a continuous airtight barrier.

Mechanical ventilation with heat recovery (MVHR)

An MVHR unit must be specified and its heat recovery efficiency must be greater than 75% and also have a low specific fan power (SFP). Ideally, a PHI certified unit should be specified.

The necessity for an extremely airtight building fabric means that MVHR is required to maintain the quality of indoor air by replacing unwanted odours, moisture and carbon dioxide generated through habitation with oxygen rich fresh air.

Occupants can still freely open and close the windows as they see fit, however to achieve adequate ventilation rates in such an airtight building the occupant would be required to open all the windows at least once every three hours for some 5 to 10 minutes at a time – even during the night. This may be fine during the warm summer months, but would obviously be impractical and would cause unacceptable heat loss during the winter.

Since MVHR can be closely controlled, it ensures that the correct levels of ventilation can be achieved in all rooms and provides excellent indoor air quality when specified and installed correctly. The heat exchanger does not mix the fresh incoming air with the exhaust air, but simply exchanges heat to reduce the heating requirement.

Larch House Ebbw Vale - South Facing

Larch House Ebbw Vale - North Facing

How does Passivhaus fit with the Code for Sustainable Homes and BREEAM?

Many people are confused about where Passivhaus sits in relation to the Code for Sustainable homes and BREEAM ratings for non-domestic buildings. In reality the distinction is quite simple: Passivhaus is a specific energy performance standard that delivers very high levels of energy efficiency, whilst the Code and BREEAM are overarching sustainability assessment ratings which address a large number of environmental issues.

The two standards cannot be compared like for like as they each have a different focus – the Passivhaus standard is solely concerned with measuring and minimising absolute energy use, whereas building regulations and the CSH set standards according to reductions in carbon dioxide (CO_2) emissions, along with many other broader environmental issues.

However, a new-build Passivhaus would be expected to achieve the energy requirements of CSH Level 4 without renewable technologies being specified. It is not possible to go beyond code Level 4 without specifying renewable energy technologies.

The fabric performance requirements of the CSH (Ene 2 credit) required for Level 6 are based upon the Passivhaus standard. With the exception of flats, it is not generally possible to achieve CSH Level 6 without adopting a fabric performance specification similar to Passivhaus.

Code

The Larch House by bere:architects was the winning design in the Welsh Passivhaus design competition at the Future Works redevelopment site in Ebbw Vale. This three bedroom detached house was the first social Passivhaus project to be completed in the UK. This project was the result of a collaborative effort between United Welsh Housing Association, bere:architects, and BRE. Designed to the Passivhaus standard, the building also achieves Code Level 6 (Zero Carbon) status by virtue of the SHW collectors and south facing PV array. The dwelling was built from predominantly locally sourced materials and achieved one of the best airtightness levels yet recorded for a dwelling in the UK (0.2 ac/h @n50).

Larch House by bere:architects

BREEAM

On this project JPW Construction set out to achieve BREEAM Excellent and Passivhaus certification concurrently. Canolfan Hyddgen is a 410 m^2, £1.2m training, education and customer service center situated in the Dyfi Valley in North Wales. Canolfan achieved 84.4% Excellent and won the Welsh BREEAM 2009 award, and through this route achieved an EPC rating in band A. The project was co-funded by the Welsh Assembly Government's Pathfinder programme and Powys County Council and was the first building in the public sector to be certified by the Passivhaus Institute in the UK.

Canolfan Hyddgen by JPW Construction

Regional climate data

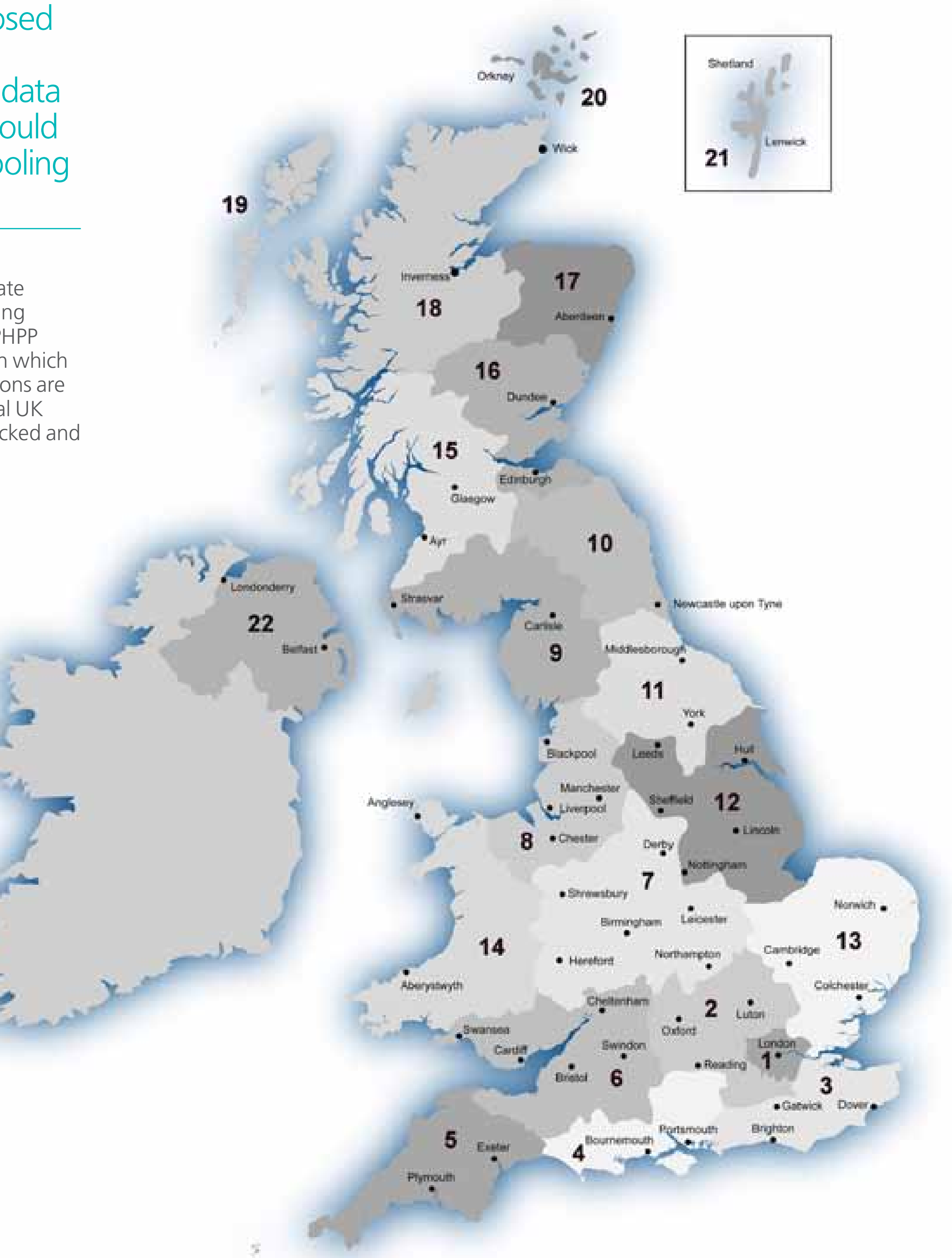
Global radiation and temperature values can be very site specific, as a result the PHPP outputs can differ for sites which have extreme exposures such as very dense urban, highly exposed or height above sea level compared to the default data sets for the region. This could affect the heating and cooling load results significantly.

The use of appropriate regional climate data is essential to accurately designing a Passivhaus as climate files used in PHPP define the boundary conditions upon which all of the thermal modelling calculations are based. BRE has produced 22 regional UK climate data sets that have been checked and ratified by the Passivhaus Institut.

These dataset provide Passivhaus designers with data suitable for certification across the UK.

Regional climate data key:

1 Central London
2 Thames Valley
3 South East England
4 South England
5 South West England
6 Severn
7 Midlands
8 West Pennines
9 NW England SW Scotland
10 Borders
11 North East Midlands
12 East Pennines
13 East Anglia
14 Wales
15 West Scotland
16 East Scotland
17 North East Scotland
18 Highlands
19 Western Isles
20 Orkney Isles
21 Shetland Isles
22 Northern Island



BRE can also provide a bespoke service for generating site specific climate data sets for your Passivhaus project. For more information please visit our website: www.passivhaus.org.uk

Picture courtesy of Matrix Bau Ltd

Global adoption

The Passivhaus Standard can be applied to any climate in the world and works equally as well in warm climates as it does in more moderate climates. Providing shading on South and West facing glazing plays a key role in preventing overheating in Passivhaus buildings. Natural cross ventilation and night purge ventilation may still be used to cool the building fabric in summer. Where additional active cooling is required, a number of low energy solutions may be used including the use of earth tubes and brine air heat exchangers, which effectively pre-cool the incoming supply air.

To date Passivhaus buildings have been designed and built in every European country, Australia, China, Japan, Canada the USA and South America. A research station has even been constructed to the Passivhaus Standard in Antarctica.

To encourage uptake globally there is an international membership organisation called the International Passive House Association (iPHA). iPHA is a network of Passivhaus stakeholders which include architects, planners, scientists, suppliers, manufacturers, and contractors.

Primarily iPHA serves as a communication platform where the listing of members and their activities in the member database helps connect the global Passivhaus community both online and through Passive House events.

More information about iPHA can be can be found on their website www.passivehouse-international.com

International PASSIVE HOUSE Association iPHA

Passipedia

Passipedia provides basic Passivhaus information and insights into the Passivhaus Standard. Passipedia is the tool with which new Passivhaus findings from around the world are being presented, as well as where the highlights of almost 20 years of Passivhaus research on Passivhaus buildings is being posted.

To access Passipedia visit www.passipedia.com

passipedia

PHPP Passivhaus Planning Package (PHPP)

The Passive House Planning Package (PHPP) is a Excel based energy calculation tool. It is based around the same core energy calculation methods used throughout Europe.

It is produced by the Passivhaus Institut as a design tool to model the performance of a proposed Passivhaus building. The PHPP is intended for use by anyone involved in the design of a Passivhaus, and a Passivhaus must be modelled by using the PHPP to verify that the Passivhaus criteria have been met.

Within PHPP there are a series of tools designed for:

- calculating energy balances
- calculating U-values
- designing comfortable ventilation
- calculating the heating and cooling load
- summer comfort calculations
- localised climate data
- many other aspects of Passivhaus dwellings.

BRE provides Passivhaus certification using PHPP and it can also be purchased as a design tool for more information please visit www.passivhaus.org.uk.

Certification

Passivhaus certification is a quality control process that ensures your building will perform as designed

The following targets define the standard and need be met in order for certification to be achieved.

Specific heating demand	≤ 15kWh/m^2.yr
(or) Specific heating load	≤ 10W/m^2
Specific primary energy demand	≤ 120kWh/m^2.yr
Airtightness	≤0.6ach @50pascals (n50)

Certifying Passivhaus units

A single Passivhaus unit can be a detached house or multiple dwellings, meaning a row of terraced houses, a multi-storey apartment block or a single story bungalow can all be certified as one Passivhaus unit. The reason is that Passivhaus certification always assesses the thermal envelope of the entire block.

To calculate the treated floor areas it is important that all areas outside the thermal envelope but are still within the construction of the development are excluded ie, integrated garages, entrance lobbies, unheated loft space (cold roof), unheated basements and stairwells in multi-residential buildings that are not heated are to be excluded from the floor areas. These areas may introduce some sheltering effect and require a temperature reduction factor calculation; hence, details of their thermal properties (if any) may be required.

Detached dwelling

A detached dwelling is considered to be one Passivhaus unit.

Semi detached dwellings

A semi detached dwelling is considered to be one Passivhaus unit even though there are two dwellings, as these dwellings would normally form part of the same thermal envelope, they therefore should be certified as one Passivhaus unit. [Note it is possible to certify each dwelling separately provided they are thermally separated and the party walls have a known thermal resistance].

Terraced dwellings

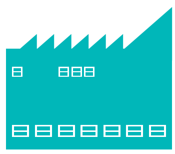
Terraced dwellings are considered to be one Passivhaus unit even though there are multiple dwellings, as these dwellings would normally form part of the same thermal envelope, they therefore should be certified as one Passivhaus unit. [Note it is possible to certify each dwelling separately provided they are thermally separated and the party walls have a known thermal resistance].

Multi storey apartment block

Multi Storey apartment blocks whether they are single story, double or triple storey should be certified as one Passivhaus unit, provided the dwellings form part of the same thermal envelope. If there is an unheated space or stairwell separating the habitable areas then this requires further assessment.

Multi storey apartment block with non-domestic unit

Multi storey apartment blocks with non domestic units can be assessed separately provided they are sufficiently thermally separated between the building structures of both units, or if there is an unheated space or stairwell separating the habitable areas from the commercial unit. If the dwellings and non-domestic unit are not thermal separated then they should form part of the same certification.



Non domestic units

Non-domestic Passivhaus units are treated in the same way as domestic Passivhaus units and the thermal envelope should always form the boundary of the certified Passivhaus.

For more information on our certification services please contact BRE on passivhaus@bre.co.uk or 0845 873 5552.

Project examples

Single family dwelling

Denby Dale, Yorkshire

The Denby Dale project in Yorkshire was built to a tight budget of £141K, the 118m² three-bed detached house was the first certified Passivhaus in the UK to be built using cavity wall construction.

Performance
- Specific heat demand: 15kWh/m²yr
- Air pressure result: 0.3 ach
- Specific primary energy demand: 87 kWh/m²yr

Fabric
- External walls: 0.11 W/m²K
- Ground Floor: 0.10 W/m²K
- Roof: 0.10 W/m²K
- Windows: 0.76 W/m²K


Picture courtesy of green build store

Multi residential terrace

Nash Terrace, Aubert Park, London

Aubert Park consists of terrace of four 3142 sq ft town houses. This four/five stories residential development was erected within five weeks using factory manufactured solid timber structural panels for walls and floors.

Performance
- Specific heat demand: 11 kWh/m²yr
- Air pressure result: 0.4 ach
- Specific primary energy demand: 95 kWh/m²yr

Fabric
- External walls: 0.13 W/m²K
- Ground Floor: 0.13 W/m²K
- Roof: 0.11 W/m²K
- Windows: 0.78 W/m²K


Picture courtesy of BRE

Commercial office

Viking House, Menzies Road, Dover

WCR Property Ltd office development in Dover, which is England's first office built to Passivhaus standards is 80% more efficient than a conventional design built to current Building Regulations.

Performance
- Specific heat demand: 9kWh/m²a
- Air pressure result: 0.3.a ch
- Specific primary energy demand: 103 kWh/m²yr

Fabric
- External walls: 0.07 W/m²K
- Ground Floor: 0.08 W/m²K
- Roof: 0.07 W/m²K
- Windows: 0.76 W/m²K


Picture courtesy of BRE

Our services

Consultancy

All members of BRE's Passivhaus team have completed the Certified Passivhaus Designer training and are able to provide expert advice at all stages of the development, including:

- Design Concept and Strategy
- Low energy design advice
- Construction techniques
- Toolbox talks for on-site inductions and management
- Generating Passivhaus information packs for specific buildings
- Thermal modelling of construction details

Certification

BRE is registered with the Passivhaus Institut as an official Certifier for Passivhaus buildings

- Pre assessments
- Full Building Certification
- Reduced rate certification via the BRE Passivhaus Certification Scheme (PCS) for qualified CEPH Designers

Testing

- Airtightness detailing and testing to n50 and q50 testing methods
- Airtightness compliance reports for Passivhaus Certification and UK compliance
- IR Thermography
- Co-heating testing
- Monitoring and testing for 'as built' performance
- Post occupancy surveys

Training

BRE is registered with the Passivhaus Institut as an official training centre for Passivhaus training courses

Certified Passivhaus (CEPH) Designer

A fast track training programme leading to the examination required to become a fully Certified European Passivhaus (CEPH) Designer. This qualification is recognised as the industry standard for those intending to work professionally as a Passivhaus designer in the UK and abroad. BRE's CEPH Designer training course has one of the highest pass rates in Europe which has been acknowledged by Dr. Wolfgang Feist.

One-day Passivhaus Introduction and Workshop

An introductory course and workshop is aimed at all those with an interest in low-energy design, construction and the Passivhaus standard. It introduces the delegates to the Passivhaus principles, walking them through best practice construction techniques whilst highlighting the outline specification and certification criteria. The course also introduces the delegates to the Passivhaus Planning Package (PHPP).

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BRE are registered with the Passivhaus Institut as certifiers and designers for the Passivhaus and EnerPHit Standards.

Passive House Certifier – Passive House Institute accredited

EnerPHit – Quality-Approved Energy Retrofit with Passive House Components – Passive House Institute

DESIGNER – CERTIFIED PASSIVE HOUSE DESIGNER


Denby Dale © Green Building Store

BRE Trust
The BRE Trust uses profits made by BRE Group to fund new research and education programmes, that will help it meet its goal of 'building a better world'.

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Other Primers in this series:
Passivhaus Primer: Designer's Guide
Passivhaus Primer: Contractor's Guide
Passivhaus Primer: Airtightness Guide

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