

# Passivhaus – an introduction



Elstreebury Hill  
Primary School

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## What is Passivhaus?

**Passivhaus is the leading international low-energy design standard. With over 30,000 Passivhaus buildings completed worldwide, it offers a robust, proven and cost-effective method to help the UK achieve its challenging carbon reduction targets for the built environment sector.**

Passivhaus buildings provide significantly improved comfort and indoor air quality, as well as much lower heating bills. They are built with meticulous attention to detail and rigorous design and construction, according to principles developed by the Passive House Institute (PHI) in Germany, and can be certified through an exacting quality assurance process.

This guide provides a brief introduction to Passivhaus and highlights some of the UK's leading examples.



The Passivhaus standard can be applied to new build and retrofit buildings of all types, providing a robust method to help the industry achieve the carbon reductions leading towards Zero Carbon. Through improved fabric and services, Passivhaus can achieve real energy demand reductions below the level proposed for building regulations.

Additionally, there is growing evidence that Passivhaus buildings are achieving savings expected, in energy and running costs, largely due to the robust quality assurance process they undergo.

## The definition

The definition of Passivhaus is driven by air quality and comfort:

A Passivhaus is a building in which thermal comfort can be achieved solely by post-heating or post-cooling the fresh air flow required for a good indoor air quality, without the need for additional recirculation of air.

Passivhaus Institut(PHI)

### The Passivhaus criteria for a central European climate:

Space heating demand  $\leq 15\text{kWh/m}^2/\text{yr}$   
or space heating load  $\leq 10\text{W/m}^2$

Space cooling demand  $\leq 15\text{kWh/m}^2/\text{yr}$   
or space cooling load  $\leq 10\text{W/m}^2$

Primary energy demand  $\leq 120\text{kWh/m}^2/\text{yr}$   
(including hot water, space heating & cooling, fans, lighting, appliances)

Airtightness  $n_{50} \leq 0.6\text{ac/hr}$



## EnerPHit

Passivhaus certification is also possible for very low energy retrofit projects: EnerPHit is a slightly relaxed standard for retrofit projects, where the existing architecture and conservation issues mean that meeting the Passivhaus standard is not feasible.

### The EnerPHit criteria:

Space heating demand  $\leq 25\text{kWh/m}^2/\text{yr}$

Primary energy demand  $\leq 120\text{kWh/m}^2/\text{yr}$  + heat load factor

Airtightness  $n_{50} \leq 1.0\text{ac/hr}$

Alternative approaches are possible. See *Renovating with Passive House Components*, Zeno Bastian, Innsbruck 2011

# Benefits of Passivhaus



**Bushbury Hills Primary School**  
Photo: Architype Architects

## Comfortable and healthy

- Summer and winter comfort
- No draughts
- No cold surfaces or downdraughts
- Good indoor air quality
- Silent ventilation

*“The children are more alert in the afternoon, and are more attentive because the air is so fresh and comfortable.”*  
Sara Morris, Head teacher of Oakmeadow Primary School



**Grove Cottage**  
Photo: Thermal Inspections Ltd 2009

## Low energy

- Minimal heating
- Efficient services, lighting and appliances
- Addresses energy security

*“All year round the house is the right temperature, no messing with controls, fretting about getting the children to shut doors and no excessive clothing!”*  
Lorna Pearcey, Resident, Grove Cottage



**High Barn**  
Photo: Hanse Haus

## High quality

- Robust and long lasting
- Real performance matching predictions
- Certified designers and products

*“Our house is manufactured to a very high quality. The same goes for the windows and external doors, which are really solid and robust as well as being triple-glazed.”*  
Richard Stent, Resident, High Barn



**Wimbish Passivhaus**  
Photo: Mark Baigent

## Affordable

- Can be achieved for capital costs comparable with standard build
- Lower running costs
- Alleviates fuel poverty

*“These properties can deliver savings of more than 90% in heating bills compared to a modern conventional build. And at the same time they should be affordable to many of the younger generation seeking to make their home in the village near to their parents and families.”*  
Sue Chalkley, CEO, Hastoe Housing Association

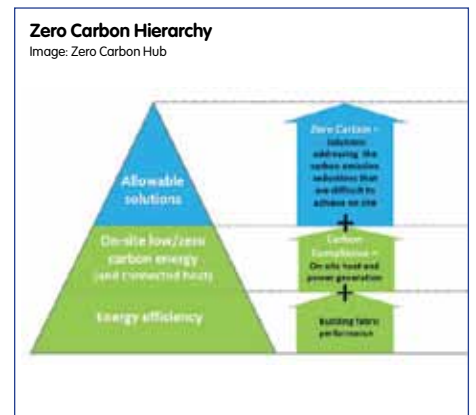


**The Green Base**  
Photo: Paragon Construction

## Environmental

- Focus on minimising energy consumption
- Can incorporate other environmentally friendly features
- Helps raise awareness of general environmental issues

*“Providing education and learning opportunities about the environment is high on the agenda for Helena [Homes], and the Green Base is at the heart of supporting that work ... The Passivhaus standard shows how environmentally friendly the Green Base is.”*  
Helena Partnerships



## Meets policy requirements

- Performs better than current building regulations
- Will help to meet the 2016 Zero Carbon target
- Measured performance meets the new 'as-built' proposals

*“Passivhaus, for me, represents above all a pragmatic energy standard. Through its rigorous quality assurance processes it helps to ensure that the as-built performance of buildings matches their design predictions, and as such Passivhaus offers a new level of reassurance to central government as well as local building control bodies.”*  
Dr Neil Cutland, Director of Cutland Consulting Limited

# The Passivhaus approach

## Passivhaus schematic

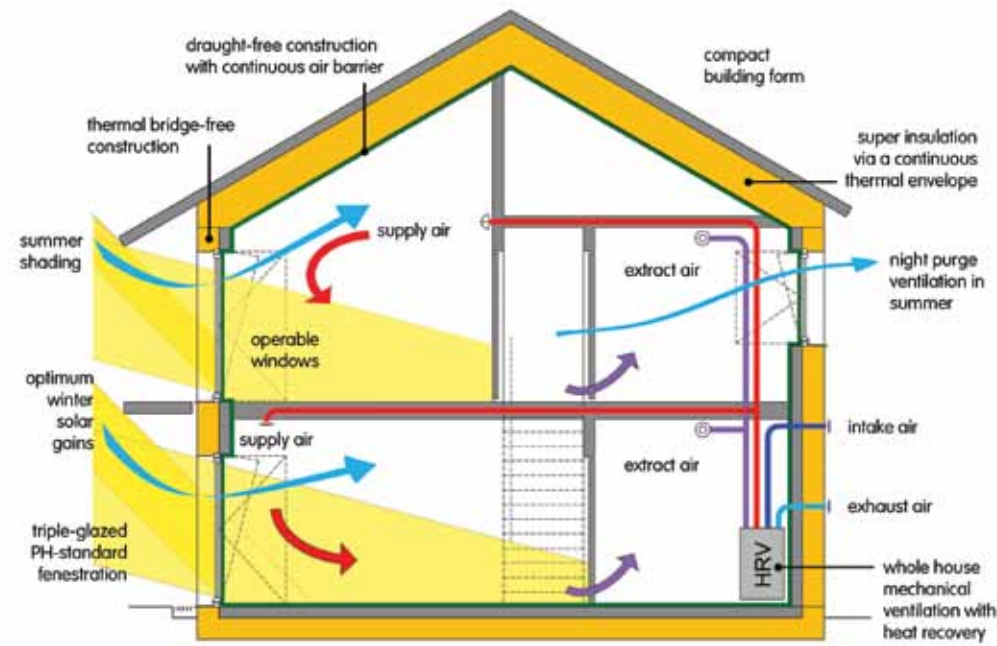


Image: ECD Architects

### Design and modelling

- Efficient form
- Using solar gains
- Good daylight and shading
- Openable windows

### Reducing heat loss through the fabric

- Very high levels of insulation
- Draught-free construction
- Thermal bridge free construction

### Efficient services

- Whole house mechanical ventilation with heat recovery (MVHR)
- Efficient hot water
- Efficient lighting and appliances.



High Barn  
Photo: Hanse Haus



Wimbish Passivhaus  
Photo: Samuel Ashfield Photography

## Cost

Although it is reasonable to expect a high-quality Passivhaus to cost more than a basic building, a number of projects are being delivered within standard budgets. This is because the cost of a building depends on so many factors.

### Additional costs:

- Quality Passivhaus windows currently cost more
- Whole house mechanical ventilation costs more
- Thicker insulation costs more

### Savings:

- Simplified building form reduces build cost and saves energy
- Thermally stable envelope remains at a steady, even temperature eliminating the need for complex controls, expensive underfloor heating, radiators under windows etc.
- Significant carbon reductions are possible without expensive on-site renewables.

**“Passivhaus is a very marketable product, due to its built-in quality and very low energy/running costs, and is a very attractive future rental proposition.”**

**Raynsway Properties**

## Quality assurance

The Passivhaus Institut has developed a series of certification processes to ensure the quality of any official Passivhaus buildings and practitioners:

- The Passive House Planning Package (PHPP), used to inform the design process and to assess or verify compliance with the Passivhaus Standard
- Certification for designers, consultants and tradesmen who have the expertise to deliver Passivhaus buildings
- A certification process for Passivhaus buildings, which applies both to the proposed design and the completed building.

# Passivhaus buildings: Domestic

## Social housing: **Wimbish**



A development of 14 new houses and flats, near Saffron Walden. Built to Code for Sustainable Homes Level 4, the dwellings also comply with: Secure by Design, Lifetime Homes, Housing Quality Indicators and Hastoe Housing's Design Brief. The properties use mechanical ventilation with heat recovery (MVHR), and a condensing gas boiler for hot water. The first 6 months of occupation have resulted in gas bills as low as £30 and monitoring is being carried out by the University of East Anglia.

**Location:** Near Saffron Walden **Construction type:** Masonry  
**Year completed:** 2011 **Cost:** £1,555/m<sup>2</sup>

*"We made only one stipulation; that the properties be as 'green' and environmentally friendly as possible. With the design of Passivhaus properties Hastoe has more than exceeded our expectations."*

*Clr Mike Young, Chairman, Wimbish Parish Council*

**Contact:** Hastoe Housing Association; Parsons + Whitley Architects

## Private housing: **High Barn**



A 250m<sup>2</sup> self-build 4-bed detached house in Somerset. Constructed with the Hanse Haus insulated solid wall system and heated with heat pump and solar thermal. Completed in July 2010, this was the first of this type in the UK

**Location:** Somerset **Construction type:** MMC SIP panels  
**Year completed:** 2010 **Cost:** £1,495/m<sup>2</sup>

*"The super-insulated shell and windows, together with a highly efficient 'Paul' mechanical ventilation heat recovery, take the annual heating consumption down to 13kWh/m<sup>2</sup>."*

*Scottish Passive House Centre*

*"The quality and speed of build is excellent, the crew work with great precision and efficiency. All in all, it's been a really good experience."*

*Richard Stent, Resident*

**Contact:** Hanse Haus

## Social housing: **Sampson Close**



Orbit Homes' Sampson Close scheme of 18 flats and 5 houses is the first and largest social housing scheme in the Midlands to obtain Passivhaus Certification. High-performing insulation gives U values less than 0.15W/m<sup>2</sup>K to walls, floors and roofs. Large solar thermal panels are used for the domestic hot water system and a district gas fired heating system provides space heating when required. Performance data is analysed by Orbit and used to plan maintenance and investment.

**Location:** Coventry **Construction type:** Prefabricated timber frame  
**Year completed:** 2011 **Cost:** £1,652/m<sup>2</sup>

*"Designing affordable housing to the Passivhaus standard provides the most energy-efficient housing for those who are most in need of it. With energy costs rising, being able to make homes affordable to heat for all is surely a target to aspire to."*

*Marcus Lewis, Architect, Baily Garner LLP*

**Contact:** Orbit Heart of England

\* Note that cost figures may have been calculated by different measures and may not be directly comparable.

# Passivhaus buildings: Non-domestic

## Primary schools: Oakmeadow & Bushbury Hills



Two Passivhaus primary schools in Wolverhampton received full certification in 2012. Constructed with a lightweight super-insulated timber frame, both schools were delivered on time, meeting Wolverhampton Council's proviso that they cost no more than standard schools. Early indications show outstanding performance and user comfort.

**Location:** Wolverhampton **Construction type:** Timber frame  
**Year completed:** 2011 **Costs:** Oakmeadow £1,754/m<sup>2</sup>  
Bushbury £1,768/m<sup>2</sup>

"The daylight is just fantastic and the spaces make a big difference. It has raised our spirits – the children and teachers absolutely love their new Passivhaus school."

Sara Morris, Headteacher, Oakmeadow Primary School  
**Contact:** Architype Architects; Thomas Vale Construction

## Education: Hadlow College Rural Regeneration Centre



This iconic building is enjoyed by the staff, students and local community and shows that high-quality, Passivhaus architecture can be delivered at less than the standard cost.

**Location:** Kent **Construction type:** Prefabricated timber system  
**Year completed:** 2010 **Cost:** <£1,500/m<sup>2</sup>

"One of the things that I like best, and some people find hard to get used to at first, is the consistency of the temperature. We're so accustomed to draughty, poorly insulated buildings."  
Sue Brimlow, Sustainability Co-ordinator, Hadlow College

"Eurobuild delivered a fantastic, innovative sustainable design that has won numerous awards – exactly what we asked for and more – and investing in the early stage design development really paid dividends during the construction phase."  
Mark Lumsden-Taylor, Finance Director, Hadlow College  
**Contact:** Eurobuild

## Office: Interserve office



For Interserve's new regional office building in Leicester, building materials and methods were selected that would optimise the build's eco-credentials and position it at the cutting edge of commercial property design. The result is a £1.5 million project, which is the first certified Passivhaus Carbon Neutral commercial office to be built in the UK.

**Location:** Leicester **Construction type:** Timber-clad masonry  
**Year completed:** 2011 **Cost:** Not available

"New premises were needed to replace the company's increasingly outdated existing offices in the area, which were energy-hungry. One of the company's core business values is improving our performance through continual learning and innovation. Sharing our knowledge and the design concept of our new building reflects these values through its simplicity, elegance and efficient energy use."

Gordon Kew, Director of Regional Building for Interserve  
**Contact:** Interserve Construction Ltd

\* Note that cost figures may have been calculated by different measures and may not be directly comparable.

# Passivhaus buildings: Community and other projects

## Community centre: **The Green Base**



In the heart of Helena's Queensland Estate, the Green Base provides a training centre for the Green Space Service, as well as a centre for the community to learn more about horticulture, green space and how they can be more eco-friendly. Passivhaus was chosen to reflect the environmental aims of the place.

**Location:** Merseyside **Construction type:** Masonry walls, timber roof  
**Year completed:** 2011 **Cost:** Not available

*"Working with Helena Partnerships on the Greenbase project was a wonderful experience. We worked seamlessly together to deliver this award-winning, ground-breaking facility. The partnering arrangement was truly adopted by all parties involved, the success of which is a testament to the principles set out by Sir John Egan. We were very pleased to be part of the team and worthy recipients of the Gold Award for Sustainable Construction at the Green Apple awards in 2011."*

**Paul Barrow, MD of Paragon Construction**

**Contact:** Simmonds.Mills Architects

## Education centre: **Canolfan Hyddgen**



This two-storey building in Machynlleth, Wales, houses a training and education centre and the Council's Customer Service Point (CSP), and has been built to BREEAM Excellent Standard. Co-funded by the Wales Assembly Government's Pathfinder programme and Powys County Council, this was the first public sector building in the UK to be certified. Two years of monitoring has revealed actual energy consumption to be only 80kWh/m<sup>2</sup>/yr, much less than the 144kWh/m<sup>2</sup>/yr predicted at design stage. Last year the 443m<sup>2</sup> building's gas bill was only £130.

**Location:** Machynlleth **Construction type:** Masonry/prefab timber frame  
**Year completed:** 2009 **Cost:** £1,784/m<sup>2</sup>

*"Much hard work has been done to get the energy demand down – and the energy monitoring data has been provided to show that this has been achieved. There is also clear evidence of good user feedback."*

**Judge, CIBSE Building Performance Awards 2011**

**Contact:** JPW Construction

## Community centre retrofit: **Mayville**



The first Passivhaus retrofit community centre in the UK, this helps demonstrate how deep retrofit of existing buildings is an achievable and viable solution for much of the UK's existing building stock. Prior to refurbishment the Mayville Community Centre had a primary energy demand of 581kWh/m<sup>2</sup>/yr, which is predicted to reduce to 127kWh/m<sup>2</sup>/yr. Refurbishment has transformed this Victorian local authority owned building, located within the deprived Mayville estate, into a community centre which will serve the needs of local residents while saving financial resources for key services.

**Location:** London **Construction type:** Solid masonry  
**Year completed:** 2011 **Cost:** £2,000/m<sup>2</sup>

*"The building has been described as a breath of fresh air for the community, and the users are far happier with the comfortable temperature of the centre, especially the hall."*

**Teena Philips, Centre Manager, Mayville Community Centre**

**Contact:** bere:architects

\* Note that cost figures may have been calculated by different measures and may not be directly comparable.

# Passivhaus buildings: Domestic retrofit

## Private house: **Lena Gardens**



This refurbishment of a London terraced house in a conservation area is certified to Passivhaus standard. Central to the success of the retrofit was installing the correct level of insulation. This included closing thermal bridges, such as steel beams sitting in a foamglass pocket. Challenges solved by the team included how to minimise loss of internal space, how to address moisture issues and how to fix insulation to old, badly built brick walls.

**Location:** London  
**Year completed:** 2010

**Construction type:** Solid masonry  
**Cost:** 25% above ordinary build costs\*

*"The high comfort of the property is just as important as the financial and carbon savings. It's testament to the skill and attention of the construction team that during the first year of operation, the house has performed almost exactly as we predicted."*

**Tom Pakenham, Client & Director of Green Tomato Energy**  
**Contact:** Green Tomato Energy

## EnerPHit certified: **Grove Cottage**



Grove Cottage is the first refurbishment in the UK to be formally certified under the Passive House Institute's new refurbishment standard 'EnerPHit'. Its energy performance and comfort over the last two years has been outstanding, with c. 80% less gas used and 50% less electricity than an equivalent-sized home, whilst being maintained at 21 degrees throughout the heating season. Indoor air quality is excellent, and there has been no overheating during hot weather. Gas for space heating, hot water and cooking has cost approximately £250 each year.

**Location:** Hereford  
**Year completed:** 2008

**Construction type:** Solid masonry  
**Cost:** Architect estimates £400-600/m<sup>2</sup>

*"We all feel we that we learned more about successful energy efficient refurbishment in this one EnerPHit project than we might have hoped for in a decade."*

**Andrew Simmonds, Partner, Simmonds.Mills Architects**  
**Contact:** Simmonds Mills Architects

## Social housing: **100 Princesdale Road**



The first certified Passivhaus retrofit project in the UK, this Victorian terraced house in a London conservation area was retrofitted to meet an 80% CO<sub>2</sub> reduction target as part of the UK Government programme 'Retrofit for the Future'

**Location:** London  
**Year completed:** 2010

**Construction type:** Solid masonry  
**Cost:** £1,520/m<sup>2</sup>

*"I hadn't heard of Passivhaus before but it has been much easier to live in than I expected; it's more comfortable than any house I've lived in before – it just feels normal, it feels like home. I thought it would be nice for a local person from the community to get involved in this type of project. The main benefit is the savings we will make on bills – that will mean a lot. I haven't been able to take the kids on holiday before; it will mean a brighter future for me and the kids."*

**Bouchra Bakali, Resident**  
**Contact:** Octavia Housing

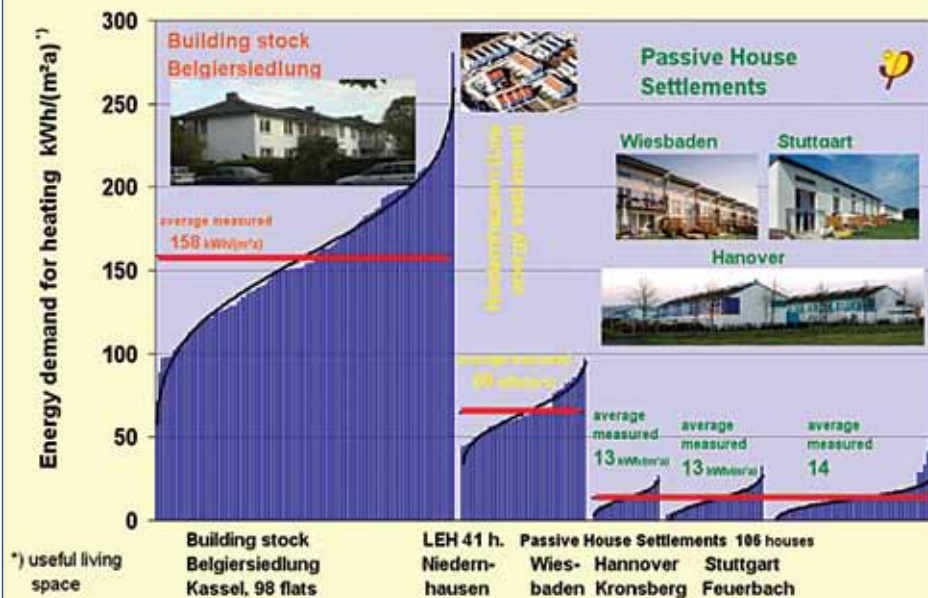
\* Note that cost figures may have been calculated by different measures and may not be directly comparable.



# Quality assured as-built performance

Passivhaus is a quality assurance standard. This means that the process, from the earliest stages of design through construction to delivery and occupation of the building, are managed to ensure that the finished building performs as expected.

## Passivhaus measured performance



© Passivhaus Institut; provided by IPHA passivpedia.org

### Quality Assurance

- Certified designers, consultants and trades
- Certified products
- Certified buildings

### As-built performance

- Minimal heat demand
- Reduced electricity use
- Good comfort conditions

### High quality

- Lower running costs
- Robust long-lasting components
- Exceeds policy requirements

## Measured performance

The chart above illustrates the close match between measured heat demand of Passivhaus buildings compared with levels modelled by PHPP. Similar analysis of standard new-build construction in the UK has revealed measured energy demand to be 50-100% more than predicted by SAP. As a result, proposed new legislation is likely to require some level of evidence that the real performance of the building can match modelled predictions. The quality assurance process required by Passivhaus certification provides one such example.

## What it means to claim the Passivhaus standard in the UK

Passivhaus (also Passive House) is clearly defined with its own terms and references. In order to achieve the Passivhaus standard, a project must clearly demonstrate that it meets the validated quality assurance requirements of the standard.

The Passivhaus Trust recommends that the best way to achieve quality assurance for a Passivhaus project is through certification by a registered Passivhaus Certifier. However, it is also reasonable to claim that a building is a non-certified Passivhaus provided that it meets all the requirements of the standard. Read more about this in the Passivhaus Trust technical briefing paper, "Claiming the Passivhaus Standard – Technical Briefing Document." [www.passivhaustrust.org.uk/guidance.php](http://www.passivhaustrust.org.uk/guidance.php)

"We have adopted Passivhaus as our target because of the tangible benefits that Passivhaus offers clients compared to other standards such as BREEM – that is, radically reduced running costs and better internal comfort. We find that PHPP is an effective tool to optimise design, and the rigorous certification process ensures delivery to the Passivhaus standard." Jonathan Hines, Director, Architype



Image BRE

# How to get started

If you want to get involved in Passivhaus, there is a range of guidance and support available to you from the Passivhaus Trust, its partners and its members:



## Guidance

The Passivhaus Institut provides a list of steps covering how to achieve the Passivhaus standard all stages of the project. In particular, the Passivhaus Planning Package (PHPP) will typically be used to inform the design process and assess or verify compliance with the Passivhaus standard. Much of this guidance can be accessed through the Institute's website or through Passivpedia.

The Passivhaus Trust and others provide guidance on Passivhaus in the UK, aiming to ensure the integrity and success of UK Passivhaus buildings.

## Training

In the UK, a number of organisations provide training about Passivhaus principles, how to use PHPP and how to meet the Passivhaus standard. In particular, several have been approved to provide training for Certified Passivhaus Designers and Consultants, including the following Passivhaus Trust partners:

- The AECB through its CarbonLite programme
- University of Strathclyde
- Building Research Establishment (BRE)

## Design support

A number of UK architects and designers have undertaken the training and are certified to help with the design of your Passivhaus. These will all have expertise in using PHPP, and many now have experience of delivering Passivhaus buildings in the UK.

A link to the full list of Certified Passivhaus Designers/Consultants, and details of those who are Passivhaus Trust members can be found on the Passivhaus Trust website.



## Certification

A number of UK organisations have been approved to assess and issue the Quality Assured Passivhaus Certificate. Passivhaus Trust members and partners in the UK who can provide certification include:

- Building Research Establishment (BRE)
- Cocrete Consulting
- Scottish Passive House Centre
- WARM: low-energy building practice

## Forum and working groups

Passivhaus Trust members can access research and knowledge from international experts through the International Passive House Association (iPHA) forum.

The Passivhaus Trust and partners also coordinate a series of working groups and discussion forums to help resolve queries about the application of Passivhaus in the UK.

**“The Denby Dale Passivhaus proves that it possible to build an ultra low-energy house using British building techniques and materials, at a low cost. Good simple robust design, knowledge and care in application are all that are needed to achieve Passivhaus levels. Traditional British construction methods can be used to reach the performance levels that you need for 2050 carbon reduction goals.”**  
Bill Butcher, Director, Green Building Store

# The Passivhaus Trust

The Passivhaus Trust is an independent, non-profit organisation that provides leadership in the UK for the adoption of the Passivhaus standard and methodology.

The Passivhaus Trust aims to:

- 1 Preserve the integrity of Passivhaus standards and methodology
- 2 Promote Passivhaus principles to the industry and Government
- 3 Undertake research and development on Passivhaus standards in the UK.

The Trust was established by the AECB and has an inclusive governance structure, with representatives from all parts of the Passivhaus process and supply chain, including independent experts, academics, building-related charities and not-for-profit organisations.

The Trust's programme of research, education and policy lobbying is supported by a series of technical working groups, open days and events throughout the year, and culminating in the annual UK Passivhaus Conference organised in partnership with the BRE.

# Further information

## The Passivhaus Trust

[www.passivhaustrust.org.uk](http://www.passivhaustrust.org.uk)

The UK Passive House organisation.

## The Passivhaus Institut (PHI)

[www.passiv.de/07\\_eng/index\\_e.html](http://www.passiv.de/07_eng/index_e.html)

Founded in 1996 as an independent research institute under the leadership of Dr. Wolfgang Feist. The PHI developed and promoted the Passive House concept in Germany and worldwide.

## The International Passive House Association (iPHA)

[www.passivehouse-international.org](http://www.passivehouse-international.org)

The International network for Passivhaus knowledge, working to promote Passivhaus worldwide.

## Passipedia

[www.passipedia.passiv.de/passipedia\\_en](http://www.passipedia.passiv.de/passipedia_en)

iPHA's wiki-based Passivhaus resource featuring in-depth research and years of accumulated knowledge.

## The iPHA forum

[www.forum.passivehouse-international.org](http://www.forum.passivehouse-international.org)

A dynamic platform for the direct exchange of ideas on all things Passivhaus amongst iPHA members.

## Cepheus

[www.cepheus.de](http://www.cepheus.de)

A project within the THERMIE Programme of the European commission. Measurement and evaluation of 250 houses to Passivhaus standards in five European countries.

## Low Energy Building Database

[www.retrofitforthefuture.org](http://www.retrofitforthefuture.org)

A repository of low-energy building information, including many new and retrofit buildings built to Passivhaus standards.

## Passnet

[www.pass-net.net](http://www.pass-net.net)

Project to spread knowledge of the Passivhaus standard within Europe, through open days and a buildings database.



The Passivhaus Trust would like to thank the sponsors of this guide:

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**AECB**  
the sustainable building association

**Passivhaus**  
*Institut*

International  
**PASSIVE HOUSE**  
Association 

**“I read that the construction industry had experimented with adding insulation to new buildings and that energy consumption had failed to reduce. This offended me – it was counter to the basic laws of physics ... So I made it my mission to find out what (they were doing wrong) and to establish what was needed to do it right.”**

Professor Wolfgang Feist, Founder,  
Passivhaus Institut, Germany



**“Passivhaus is the leading international low-energy design standard. With over 30,000 Passivhaus buildings completed worldwide, it offers a robust, proven and cost effective method to help the UK achieve its challenging carbon reduction targets for the built environment sector.”**

Chris Herring, Chair, Passivhaus Trust

**Top Left: Denby Dale**

Photo: Green Building Store

**Top Right: Y Foel**

Photo: passivebuild.co.uk

**Bottom Left: Underhill Passivhaus**

Photo: Seymour-Smith Architects

**Bottom Right: Tygh-Na-Cladach**

Photo: Scottish Passive House Centre

**Cover: Bushbury Hills Primary School**

Photo: Architype Architects

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