Why choose Passivhaus?

Passivhaus Trust

ARCHITYPE

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Contents

1 Why choose Passivhaus?

The standard for healthy, affordable low energy buildings

Passivhaus provides a crucial opportunity for addressing two major challenges presently facing the UK construction industry:

1 Building regulations are tightening, requiring more energy-efficient buildings, and targeting zero carbon new homes by 2016.
2 Many conventional buildings designed and built in the past few years are demonstrating a performance gap (poor performance compared to predictions) in terms of:
a energy use[1]
b ventilation and indoor air quality[2]
c thermal comfort and overheating[3]

Passivhaus was developed to close this performance gap and provides an approach that is quality assured throughout, ensuring that Passivhaus buildings really deliver reduced energy use, good indoor air quality and comfortable temperatures throughout the year. Many designers and developers are realising that Passivhaus is the only sensible approach to meeting the increasing challenges set by regulation.

As understanding of Passivhaus grows in the UK, close to two hundred units have been completed and certified (February 2013). From small-scale self build projects, both new build and refurbishment, through to large-scale housing developments, schools and offices, Passivhaus is driving real innovation in design and construction, across all regions of the UK.

Recent growth in the UK follows the spread of Passivhaus around the world over the past 20 years, with over 37,000 Passivhaus buildings completed in a range of climates, documented by the International Passivhaus Association (iPHA).

In the 2012 guide, *Passivhaus – an introduction*, the Passivhaus Trust set out the definition of Passivhaus together with some of the benefits:

- **Comfortable and healthy**
- **Very low energy**
- **High quality**
- **Affordable**
- **Environmental**
- **Meets and exceeds UK policy requirements**

This new guide aims to address some of the questions that have been raised as a result, and to encourage developers and others to consider Passivhaus. It covers questions centring on 'Why choose Passivhaus' as opposed to another approach, and includes information about: costs, complexity, aesthetics, air quality, overheating, materials, embodied energy and usability.

Cover: Underhill House
Photo: Dow Building Solutions

[1] Zero Carbon Hub, *Carbon Compliance for Tomorrow's New Homes: a review of the modelling tool and assumptions* – Topic 4 Closing the gap between designed and built performance, NHBC Foundation, Aug 2010.
[2] Crump D, Dengel A, Swainson M. *Indoor Air quality in highly energy efficient homes.* Review, Watford: NHBC Foundation, 2009 & McKay S, Ross D, Mawditt I, Kirk S. Ventilation and Indoor Air Quality in Part F 2006 Homes: BD2702. DCLG, March 2010
[3] Dengel A, Swainson M. *Overheating in New Homes: a review of the evidence.* NHBC Foundation, Nov 2012


Photo: Michael Wolchover | GAIA Architects

"Everyone talks about how comfortable Passivhaus buildings are and how little energy they use, but in an era of spiraling energy costs, the economic argument is one of the strongest reasons to choose Passivhaus. Any organisation which is responsible for the operational costs of a building should look no further."

Ben Humphries Associate Director, Architype


Photo: Green Building Store


Photo: Green Building Store


Photo: Mark Tiramani

"Having gone through the Denby Dale process, I feel, more than ever, that Passivhaus is the way forward for the UK. It can help create quality, comfortable buildings while also achieving 90% cuts in occupants' fuel bills. It offers the UK an easy win solution towards the massive cuts in CO_2 emissions we need to make – urgently."

Bill Butcher Project Leader on the Denby Dale Passivhaus and Director of Green Building Store

Top: Plummerswood, Innerleithen, Scotland
Above left: Denby Dale Passivhaus, West Yorkshire
Above right: Y Foel, North Wales


Photo: Orbit Heart of England

1a Why invest in Passivhaus?

Prioritising value over cost

Increasing numbers of developers and clients choose to invest in Passivhaus because they know that it will deliver a building of real value. While this may initially add to capital costs, there are ways of reducing these to a minimum, and they should be off-set over time by reduced running costs. In particular, good design can simplify the building form and services, reducing capital costs as well as those associated with heat loss. In Germany, estimated extra construction costs are typically somewhere between 3–8% compared with standard buildings. However, experienced Passivhaus designers have managed to build Passivhaus buildings at no extra cost both in Germany and Austria[4], and in the UK[5].

Additional capital costs for a Passivhaus building are likely to include the costs of extra thermal insulation for walls, roof and slab; Passivhaus triple glazed windows; and ventilation with heat recovery. Each of these items brings health and lifestyle benefits to the buildings' occupants – these are described further in Section 3. Conversely, savings can be made by reducing, or even doing without, a conventional heating system. Whilst extra capital costs can amount to around 8%, heating bills are typically reduced by 90%, so operational cost savings can help to finance the extra investment[6].

In fact, Passivhaus is a construction concept, which ensures healthy, comfortable, low energy buildings are delivered for the lowest lifetime costs, by reducing the capital costs and energy costs to a minimum[7]. See graph on page 12.

On top of this, there is, of course, the additional value that a well-designed and constructed Passivhaus building provides, in terms of build quality and comfort benefits.


Photo: Tim Crocker | Bere Architects

"I feel very fortunate to be one of the customers involved in this project. Moving out so that the refurbishment could happen had its moments but it has all been worth it and I am delighted with my new home. It's amazing to think that things such as improving the insulation and the installation of the triple glazed windows could all add up to such a huge saving on energy bills. As well as being good for the environment, it's good for the pocket too and I am grateful to Orbit Heart of England for investing in my home."

Mrs Baggerley
Orbit Heart of England Resident

Above: Sampson Close, Coventry
Left: Mildmay Community Centre (formerly Mayville), London

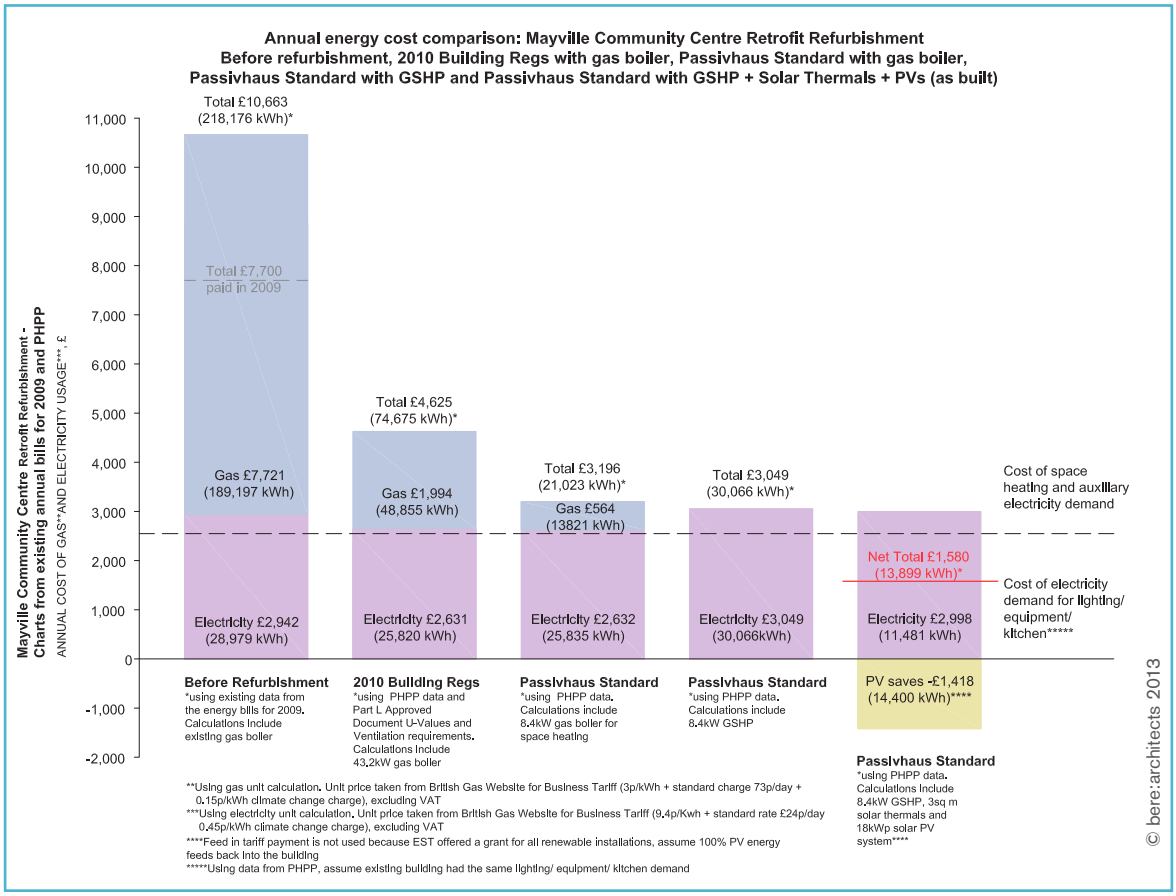
[4] Passipedia article: Are Passive Houses cost-effective? http://passipedia.passiv.de/passipedia_en/basics/affordability/investing_in_energy_efficiency/are_passive_houses_cost-effective?s[]=cost
[5] Hines J, Delivering the UK's first Passivhaus schools at no extra cost. 16th International Passive House Conference 2012 conference proceedings, p. 253-258
[6] Passipedia article: Are Passive Houses cost-effective? (as above)
[7] Passipedia article: What is a Passivhaus http://passipedia.passiv.de/passipedia_en/basics/what_is_a_passive_house
[8] Newman N, *Passivhaus cost comparison in the context of UK regulation and prospective market incentives.* 16th International Passive House Conference 2012 conference proceedings. http://www.bere.co.uk/sites/default/files/research/16PHT_Nick%20Newman%20submission.pdf

Photo: Abi Dennington-Price | Parsons&Whittley

Above: Ditchingham Passivhaus, Norfolk by Hastoe Housing Association
Below: Annual energy cost comparison graph for refurbishment options at Mayville Community Centre. This shows that the Centre had high heating bills and was cold in winter before refurbishment, and that Passivhaus refurbishment provided warmer indoor temperatures and lower heating and electricity bills.

"Under a low interest rate scenario our research showed that Passivhaus investment presented a more economically viable solution for a prospective home owner than an equivalent house built to current UK building regulations[8]. This is even without taking into account economies of scale, form, potential rising fuel prices, or increases in the inherent residual value of the house after a 25-year period".

Nick Newman bere:architects[8]



1b What is it like to live or work in a Passivhaus building?

Ensuring fresh air, daylight and comfort.

The benefits for occupants living and working in a Passivhaus building can be impressive. In fact, the Passivhaus standard was originally derived from considering how to provide an ideal comfortable and healthy indoor environment whilst minimising the energy demand of the building[9].

The warm surfaces, lack of draughts and comfortable temperatures during both winter and summer make Passivhaus buildings more comfortable than a standard building[10]. Additionally, many occupants feel that the quality of the air supplied by the effective ventilation system is very good[11], and this can help to reduce the risks of allergies and other health problems.

If the building and systems are well designed and kept simple, controlling the building can be easy. This makes living in a Passivhaus building simpler and more flexible than many assume.

For instance, one of the main concerns is that occupants won't be able to open windows. But, as well as being encouraged in the summer to aid cooling, window opening is of course possible in winter and studies show that doing so will not usually increase heating demand by a significant amount[12].

Photo: Leigh Simpson | Architype Architects

"We feel that our children are more alert and attentive in lessons due to the amount of daylight in classrooms and the fresh air throughout the school. The fact that the new school is built to Passivhaus standards means that learning has been enhanced; our pupils love coming to school and enjoy their impressive surroundings. They are comfortable, secure and stimulated by their new environment; hence they learn very well!"

Sara Morris Headteacher, Oakmeadow Primary School

Photo: Photo: Green Building Store

Left: Bushbury Hill Primary School, Wolverhampton
Above: Denby Dale Passivhaus, West Yorkshire
Right: Crossway, Kent

[9] Passipedia, The Passive House – definition, http://www.passipedia.org/passipedia_en/basics/the_passive_house_-_definition
[10] Feist W, Peper S, Gorg M, CEPHEUS Final Technical Report, Passiv Haus Institut, Enercity & Energieinstitut Vorarlberg, July 2001. p.79
[11] Ibid,
[12] Passipedia article: User behaviour: Opening windows in the Passive House? – It's possible and allowed. http://passipedia.passiv.de/passipedia_en/operation/operation_and_experience/user_behaviour?s[]=open&s[]=windows

Photo: Hawkes Architecture Ltd

1c How I learned to stop worrying and love Passivhaus

Enriching design choices through an evidence based approach.


Photo: Architype Architects

There are those who still have questions about Passivhaus. But there are also increasing numbers of 'Passivhaus converts'. Practitioners who have for many years tried to deliver low energy buildings, and then have tried out Passivhaus for themselves, finding that it provides one of the only effective solutions for low energy building design.

When something new comes along, we rightly ask questions about the claims that surround it. For example, there are still some myths around Passivhaus, including concerns about aesthetics, materials and ventilation. This publication presents a range of examples which demonstrate that Passivhaus buildings can be designed in a variety of forms, serving many different functions, and using a wide range of building materials and methods. Rather than being prescriptive, experienced practitioners believe that the Passivhaus approach is liberating.

Of course, as with any approach, care must be taken to ensure that solutions are appropriate, and result in a building that performs as expected. The following sections set out some of the important aspects of Passivhaus. However, it must be remembered that these should not be considered as solutions in isolation, as they influence each other. The Passivhaus approach considers the building as a whole, and whilst not mandatory, the quality assured certification process ensures that the resulting building performs as planned.

"I have been anti-Passivhaus for a long time. I have always preferred naturally ventilated buildings with fresh air. But I seem to have ended up here by accident .... as there was nowhere else to go, really. In the past I worked on some lovely eco-houses, which were sometimes draughty and cold, despite lots of insulation. This co-housing development of 41 individual homes is not just Passivhaus,it also has food growing plots, rentable workspace stations, bike stores, shared laundryand community centre spaces."

Andrew Yeats Eco Arc Architects, Lancaster Passivhaus Co-housing project


Photo: Andrew Yeats Eco Arc Architects

Above: Passivhaus Design Team
Left: Lancaster Passivhaus Co-housing
Opposite page: Hadlow Rural Regeneration Centre, Kent

"This was a very brave project for Hadlow College Group. Eurobuild delivered a fantastic, innovative sustainable design that has won numerous awards – exactly what we asked for and more."

Mark Lumsden-Taylor Finance Director, Hadlow College

Photo: Eurobuild

2 Why choose Passivhaus – technical performance?

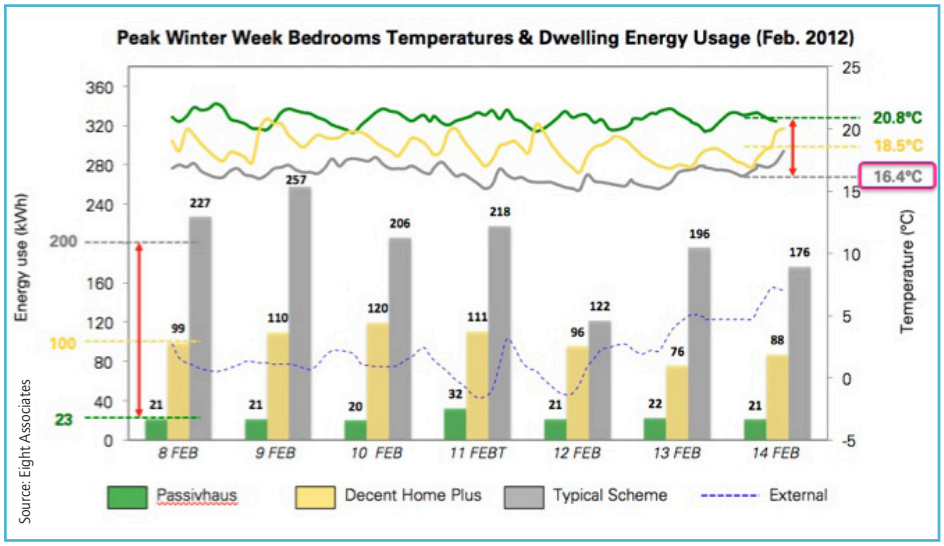
Passivhaus is increasingly chosen as an effective approach for reducing energy demand and CO_2 emissions to the level required by UK building regulations. As the UK's targets tighten on the route to 'zero carbon', this will require even further CO_2 reductions, as well as improvements to quality assurance[13].

It is no longer enough to use a standard building design and construction process, with bolted-on energy supply solutions. Research into the real performance of buildings has revealed serious problems with this approach. A significant 'performance gap' has been identified with many new buildings, relating to evidence that they are using more energy than expected, whilst also experiencing problems with both indoor air quality and overheating[14].

Passivhaus offers a cost-effective, quality assured alternative to the standard approach, and it has been shown to deliver the required levels of performance on a consistent basis[15]. By considering improved performance in terms of the whole building and the processes throughout, and bringing these together into a design tool – the Passivhaus Planning Package (PHPP) – the Passivhaus approach also simplifies the work needed to deliver a real high quality, healthy, comfortable, low energy building.

In addition, a Passivhaus building that is designed to respond to the climate, and is well insulated and ventilated, provides protection from summer overheating as well as winter cold. The qualities that prevent heat from leaving the building in the winter also prevent heat from entering the building in the hot summer months. Careful design using PHPP guides the appropriate use of orientation, solar shading, thermal mass, and bypass of the heat recovery ventilation system in order to reduce heat gains..

All these factors, when added together ensure that a Passivhaus building will deliver a high quality internal environment that will support and enhance the health and well-being of the building's occupants.



Princedale Road temperature and energy use graph showing that Passivhaus refurbishment provides warmer temperatures and one tenth of the energy use compared to a typical scheme.

"As a new housing developer with a mission to improve the quality and sustainability of housing in the UK, we decided to adopt Passivhaus as our basic standard – because it enables us to offer consumers a quality assured construction with guaranteed low energy consumption and excellent internal comfort. Passivhaus is the best way to protect consumers from ever rising fuel prices and many of our clients with respiratory problems or who simply wish to protect their children welcome the excellent indoor air quality of Passivhaus. Our innovative scheme for 150 houses in Herefordshire is gaining both important political support and strong market interest, mainly because it is Passivhaus standards."

Lars Carlsson ArchiHaus director

[13] Zero Carbon Hub, Carbon Compliance for Tomorrow's New Homes: a review of the modelling tool and assumptions – Overview of Findings and Recommendations, NHBC Foundation, July 2010.
[14] Zero Carbon Hub, Carbon Compliance for Tomorrow's New Homes: a review of the modelling tool and assumptions – Topic 4 Closing the gap between designed and built performance, NHBC Foundation, Aug 2010
[15] Feist W, Peper S, Gorg M, CEPHEUS Final Technical Report, Passivhaus Institut, Enercity & Energieinstitut Vorarlberg, July 2001.

- 78% Reduction in Heating Demand
- 84% Reduction in Energy Demand
- 88% Reduction in C02 Emissions

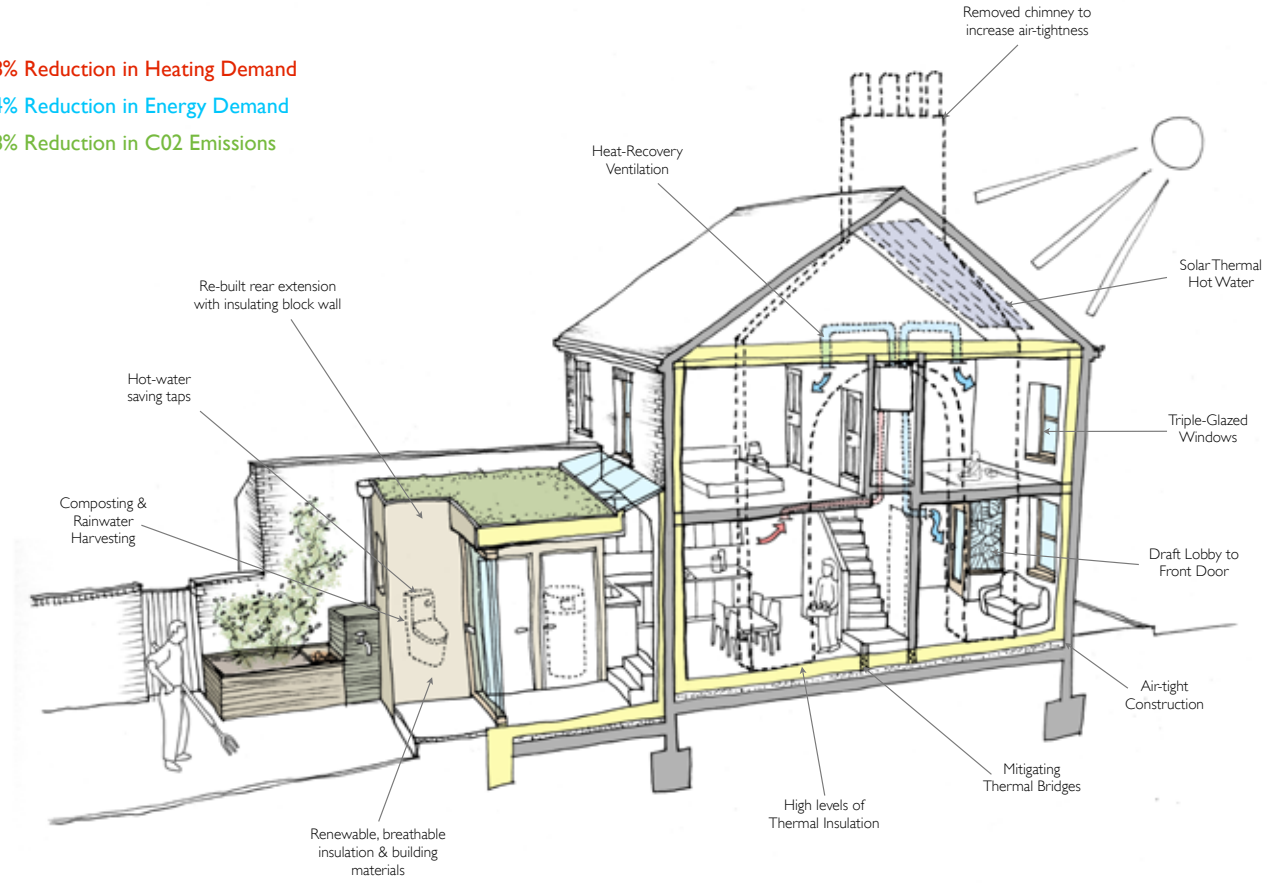


Image: Anne Thorne Architects

Photo: Hawkes Architecture Ltd

Top opposite page: Solar shading at Wimbish Passivhaus, Essex
Top: Elements of the Passivhaus standard
Above: Crossway, Kent

"Our findings at Sampson Close, Coventry provide strong evidence that Passivhaus does work – providing low cost (affordable) housing to occupiers. Improved health and well-being are also recognised and attributed to Passivhaus, as well as improved occupier satisfaction with their home... Importantly, within a social housing context, satisfied customers do result in reduced management and maintenance costs. This is a 'product' the people want, a product which works, and a product we can continue to refine and develop while driving down cost."

John Barnham Head of Sustainable Investment for Orbit Heart of England

2a Why aim for 15kWh/m²/yr?

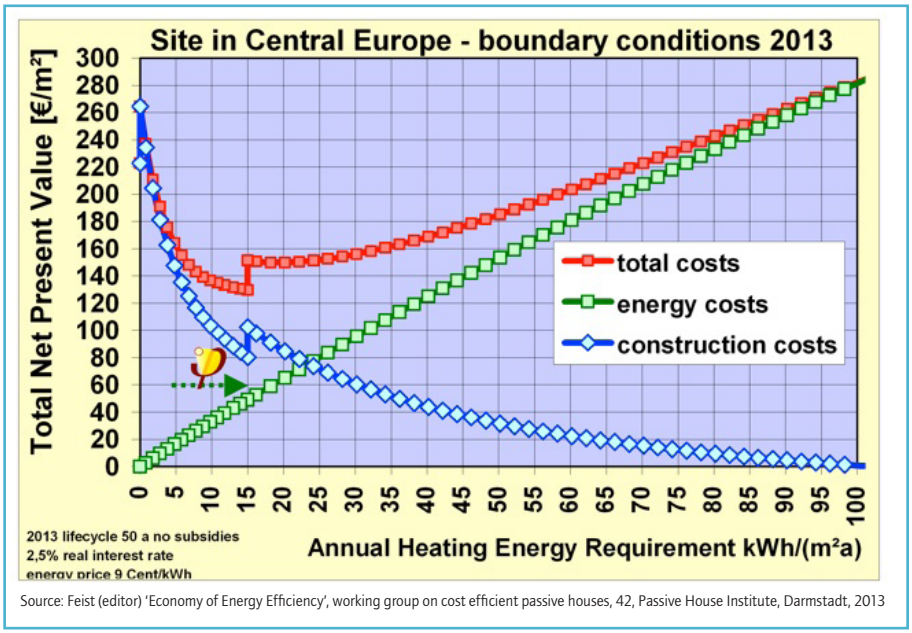
The Passivhaus target of 15kWh/ m²/ yr means a great reduction in space heating, carbon dioxide emissions and costs to around one tenth of typical levels. It also implies significant improvements in thermal performance (increasing insulation and reducing thermal bridges) compared to regulatory requirements; as well as a much better level of air-tightness than currently required.

The energy needed to heat a building is quantified in the number of kilowatt hours (unit of energy) used per m² of useful floor area, per year. This amount varies greatly between different buildings depending on how well insulated they are, how efficient the heating system is and how the occupants use the building. People living in an average UK house might use around 278kWh/m²/yr in total, of which around 140kWh/m²/yr would be used for space heating[16].

Improvements to Part L of the building regulations due in 2013 will aim to reduce carbon emissions primarily through a 'fabric first' approach, replacing the previous drive towards micro renewables as a solution. It is expected that a Fabric Energy Efficiency Standard will ensure a baseline for energy demand reduction, and be supplemented by requirements for further reductions in overall CO_2 emissions through additional energy efficiency or energy supply measures. The importance of quality assurance, and its role in closing the performance gap, is also to be addressed[17].

In Passivhaus, a target of 15kWh/m²/yr is set as a maximum energy demand for space heating. This is achieved by reducing the heat lost from the building to a minimum.[18] Of course, the figure of 15kWh/m²/yr is a modelled prediction[19], based on assumptions regarding how the building will be used, so different occupants may use more or less than this to heat their homes. It is striking, however, that evidence from a large sample of real Passivhaus buildings demonstrates that the average remains incredibly close to 15kWh/m²/yr (See the graph on page 20).

The target of 15kWh/m²/yr is used because this is the level of performance that is the most cost-effective approach over the lifetime of the building. Aiming for levels much below 15kWh/m²/yr would push costs above a level where the extra benefits pay for themselves; aiming for higher than 15kWh/m²/yr[20] would require a larger or additional heating system and the extra cost and complexity that comes with it.



Source: Feist (editor) 'Economy of Energy Efficiency', working group on cost efficient passive houses, 42, Passive House Institute, Darmstadt, 2013

Our gas bill at Oakmeadow has been reduced by approximately 90% compared to our old school – it's a great saving!'

Sara Morris Headteacher, Oakmeadow Primary School

Above: Oakmeadow primary school, Wolverhampton
Left: Graph of lifecycle costs for different heating energy targets showing that 15kWh/m²/yr incurs the lowest lifecycle costs.

[16] AECB, Reducing CO_2 emissions from new homes, 2006.
[17] CLG, 2012 consultation on changes to the Building Regulations in England – section two: Part L (conservation of fuel and power), Jan 2012
[18] An un-insulated house will lose approximately 35% of heat through the walls, 25% through the roof, 15% through the floor and 10% through the windows, with the remaining 15% lost through draughts and ventilation McMullan R, Environmental Science in Building, 5th edition, Palgrave 2002.
[19] This figure is based on PHPP which uses conservative assumptions, part of the solution to closing the performance gap.
[20] Feist (editor) 'Economy of Energy Efficiency', working group on cost efficient passive houses, 42, Passive House Institute, Darmstadt, 2013

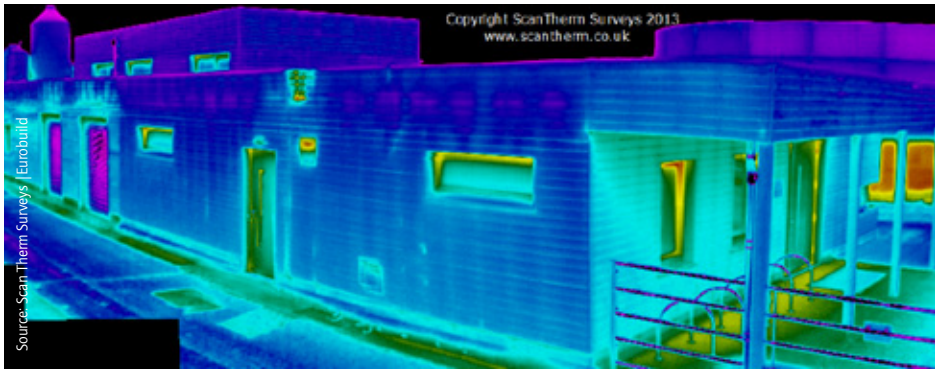
2b Why maximise fabric insulation and minimise thermal bridges?

As well as using well-insulated windows, Passivhaus buildings reduce the heat lost through the building fabric by insulating the walls, roof and floors in a continuous layer, with typical U-values between 0.1 and 0.15W/ m²K.

It is crucial to ensure that thermal bridges, often found at junctions between elements, are dealt with effectively in this process. As insulation thickness increases, the heat loss due to thermal bridges becomes very significant, leading to cold patches that cause condensation and mould growth. However, by ensuring continuous warm surfaces, heat loss, condensation and mould growth are eliminated, which makes the building comfortable and healthy for the occupants.

The UK Government uses carbon dioxide as an indicator of environmental impact, so regulation sets limits to CO_2 emissions associated with the operation of buildings. This allows the inclusion of low and zero carbon technologies to reduce the overall $CO_2/m^2/yr$ figure. Using an energy metric, such as $kWh/m^2/yr$, means that the Passivhaus target is focussed on improvements to the building fabric and system efficiencies, rather than bolt-on, or off-site energy supply solutions.

While renewable energy supply systems are a crucial tool for reducing UK carbon emissions, reliance on such systems for meeting target reduction levels has added complexity and risk to the real performance of the building. Well-insulated walls, roofs and windows require little attention as they reduce energy demand, whereas renewables require maintenance and may not supply as much energy as expected[21].



"The thermal images of Hadlow College RRC indicate the most impressive thermal performance I have seen. The first thing that struck me was the lack of thermal bridging at floor level. Secondly the air tightness of the building under natural pressure conditions results in very low heat build up under soffits and overhangs. Additionally, the evenness of the wall insulation was very clear and there were no visible thermal bridges externally."

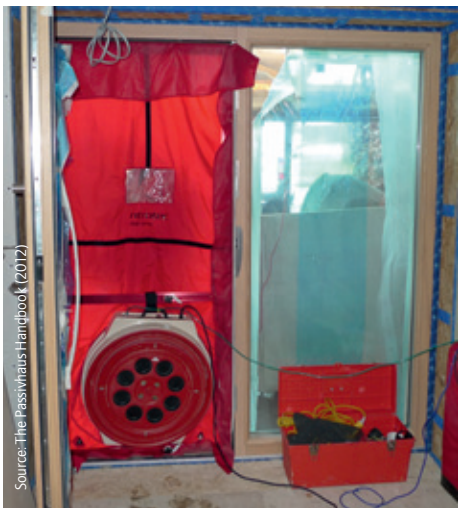
Mark Colyer Thermographer and director of ScanTherm Surveys

Above left: Hadlow Rural Regeneration Centre, Kent – Thermal image showing the evenness of wall insulation and no visible thermal bridges externally.
Left: Wimbish Passivhaus, Essex – Insulation being installed below the floor slab to reduce heat loss through the building fabric.

[21] Parsons J, Metering and Monitoring of domestic embedded generation. BEAMA, 2007

2c Why make the fabric so airtight?

Once the walls, roof, floor and windows are insulated effectively, the main route for heat loss is through air leakage. By targeting an extremely low airtightness level, the Passivhaus approach takes full control of the ventilation strategy, reducing draughts and noise and allowing for the recovery of heat from outgoing stale air. It also prevents moist air from condensing on the structure as it leaves, which would cause structural damage if allowed to continue.


Source: The Passivhaus Handbook (2012)

The present UK regulation limit of 10m^3/m^2/hr relates to the volume of air that passes through each square metre of building fabric, per hour. The Passivhaus target of 0.6ACH (Air Changes per Hour) describes the number of times the whole volume of air inside the building is transferred through the fabric. A direct comparison between the two is difficult without knowing the building volume and external surface area, but for homes the two numbers are roughly equivalent, meaning that we do know that the Passivhaus standard is over ten times tighter than the UK regulations.

Many still confuse airtightness and ventilation. A draughty building will typically be over ventilated in cold windy weather and under ventilated in still conditions. What is more, there is no guarantee that the ventilation will be where it is required. It is crucial that a suitable ventilation strategy is established, appropriate for the specific levels of airtightness achieved.

Airtightness at a level of 0.6ACH is a challenge but it is achievable, if it is designed in and teams are provided with sufficient training and support. Many teams have reported that aiming for such a good airtightness result has a motivational effect, creating a real sense of pride when the target is achieved. Right from the start, an informed detailed design is crucial, if the construction team are to be able to manage the airtightness process effectively. Simplifying the design and eliminating structural penetrations reduces thermal bridges and simplifies airtightness detailing, at the same time as reducing costs. This takes time at the design stage, but details can be reused and the approach becomes second nature with practice.

Photo: Passivhaus Associates

"…the lack of draughts is a real bonus. It's very comfortable. I think it's the constancy of the temperature, it just doesn't vary very much because it is so well insulated."

Ronnie Hair, Tenant, Craigrothie Passivhaus

Top: Site blower test
Above: Craigrothie Passivhaus, Scotland

2d Why use Mechanical Ventilation with Heat Recovery (MVHR)?

Many of us are used to living and working in 'leaky' buildings that rely on uncontrolled ventilation to ensure good indoor air quality. Once these leaks are reduced, fresh air needs to be supplied and stale air extracted, in a controlled manner. A mechanical ventilation system with heat recovery (MVHR) can transfer heat from the stale outgoing air to the fresh incoming air, therefore making the building much more energy efficient.

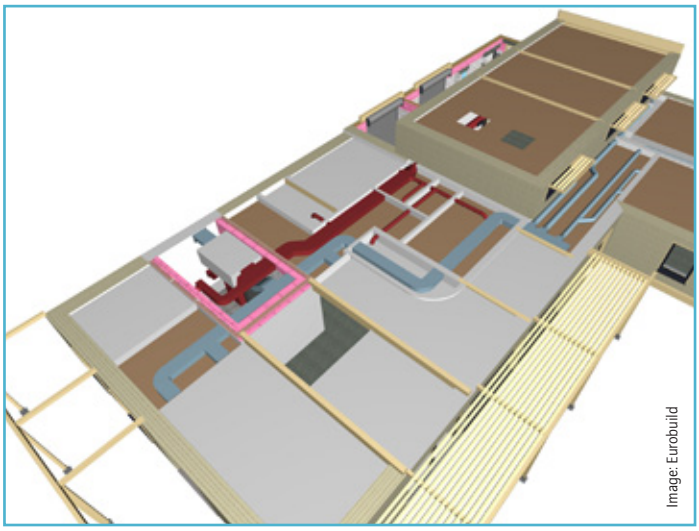


Image: Eurobuild

It must be remembered that any building relying on MVHR to save heating energy will need to achieve an airtightness standard of at least $3 m^3/m^2/hr$, otherwise the expected efficiencies will not be delivered. It is also important that very efficient systems are used, and maintained, in order that the electricity used to drive the ventilation fans does not replace the heating energy saved.

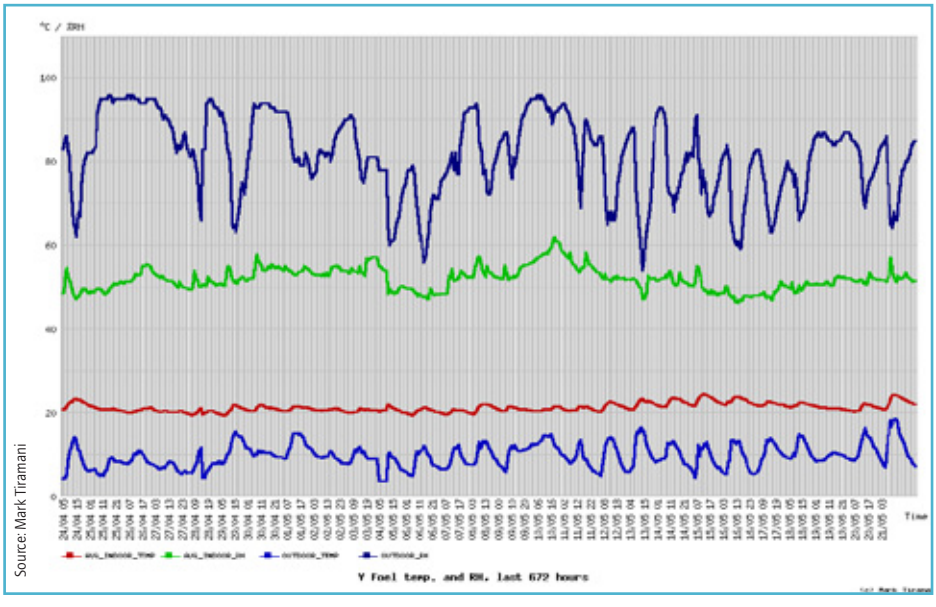
MVHR may not be the appropriate solution for every building. But a system that is well designed, installed and maintained, and understood by the users, can bring enormous benefits in terms of air quality and energy efficiency. MVHR is therefore a requirement for Passivhaus buildings. A well-designed Passivhaus MVHR system will be clear and simple, with controls and maintenance access conveniently located and easy to operate, plus it will be installed correctly; this will deliver a high quality ventilation system that will run efficiently, quietly, and deliver clean fresh air as needed.

"The comfort factor is there, the air quality in the teaching spaces makes a big difference and the pupils respond better. Pupils are more alert in the afternoon. They are more attentive because the air is so fresh and comfortable. The daylight quality is just fantastic."

Leigh Smith Headteacher
Bushbury Hill Primary School

" The MVHR has been a great success. There are no lingering smells, and bathroom mirrors, if they get steamed up at all, clear quickly. Three months after moving in we changed the paper filters; a simple five minute job, and the user control on the MVHR unit reminds you when to do it."

Adam Dadeby Resident & CEPH Designer,
Totnes Passivhaus



Source: Mark Tiramani

Graph of internal conditions at Y Foel, which illustrates consistent indoor air quality and temperature indoors, despite changing conditions outside. Top to bottom- Outdoor Relative Humidity (RH); Indoor RH; Indoor temperature; Outdoor temperature.

Top image: Hadlow Rural Regeneration Centre, Kent


Photo: Octavia Housing

2e Why use triple glazing?

Windows used in Passivhaus buildings not only have three layers of low-e glazing, but also have highly insulated frames, insulated spacers and optimised installation. These windows help to reduce the heat lost through the fabric (typically with a U-value of 0.8W/m²K), but also make buildings more comfortable for the building occupants. Gone are the days of radiators under every window and thick heavy curtains, to reduce draughts and cold radiation.

Triple-glazing means that the surface temperature of the glazing will be maintained at around 17°C and the way that the building is used can then be transformed, as space close to the windows can be enjoyed more effectively – occupants can sit next to them (or even place a bed against that wall) without feeling any discomfort. Additionally, the warm temperature of the glass means that condensation and the resulting damage is no longer a problem, as mould and associated maintenance are eliminated.

Noise from outside is also reduced to a minimum when these highly insulated windows are closed, providing a quiet and calm indoor environment. This ability to protect the internal environment from outside noise and pollution is a valuable quality for schools, offices and homes, particularly those close to busy roads.

Initially, there was a limited range of suitable windows available in the UK, which many users were not happy with due to awkward opening angles or handles. However, the range of designs and options has now widened significantly and designs specifically suitable for the UK market have been developed.

"Unlike older houses the temperature in winter is much the same throughout the house. Wall to wall, floor to ceiling. None of the internal surfaces ever get cold, not even the windows. So there is no condensation. Even when it's -5°C outside it is still comfortable to sit on the window banks and use the window as a backrest."

Mark Tiramani Occupant, Y Foel

"I'm happy putting my children's bunk beds by the window as there's no draughts, and the glass is not cold"

Wimbish resident's feedback meeting in Nov 2012, 16 months after occupation


Photo: Mark Tiramani

Top: 100 Princedale Road Retrofit, West London
Right: Y Foel, North Wales
Opposite page: Denby Dale Passivhaus

Photo: Green Building Store

3 Why choose Passivhaus – a quality assured process?

In order to achieve the Passivhaus standard, a project must clearly demonstrate that it meets the validated quality assurance requirements of the standard[22]. This includes the requirements listed here; reference must also be made to any other applicable requirements or guidelines currently set by the Passivhaus Institute.


Photo: Thomas Vale Construction

The Passivhaus Trust recommends that the best way to achieve quality assurance for a Passivhaus project is through certification by a registered Passivhaus Certifier[23]. It is reasonable to claim that a building is a non-certified Passivhaus provided that it still meets the performance and quality assurance requirements.

Although the list below is not exhaustive the Passivhaus buildings standard requires that all of the following conditions be met[24]. Meeting these quality assurance conditions will ensure that the project performs as expected in delivering a comfortable low energy building.

If the quality assurance protocols endorsed by the Passivhaus standard have not been observed during the design and construction of a building, then claims that such a building is a Passivhaus are, at the very least, unfounded and at worst, under consumer law, both misleading and fraudulent. Such claims also risk bringing the Passivhaus standard into disrepute.

Quality Assurance Requirements[22]

1 The use of Passivhaus Planning Package (PHPP) – a bundle of both software and guidance notes – and the entry of the correct data

2 That all relevant design assumptions and boundary conditions (including internal gains) accord with those established by the PHPP

3 That the conductivities, of all materials, products, components and constructions (including thermal bridging) satisfy the relevant EN standards

4 That with regard to windows the internal surface temperature shall not fall below 17°C on the coldest day of the year, and that the solar heat gain coefficients (g-value) is >0.5

5 That pressure tests have been undertaken in accordance with EN 13829 (with the variant that both pressurisation and depressurisation should be undertaken and that the mean result be used during certification procedures)

6 That where mechanical ventilation heat recovery (MVHR) is utilised it satisfies the PHI's strict performance requirements for those systems.

7 That MVHR systems be commissioned in accordance with the requirements of the Passivhaus standard

8 That the contractor writes a declaration confirming that the building has been built in accordance with the contract documentation

9 That a photographic construction record of the project should be kept

10 A comprehensive set of construction drawings and documentation must be made

11 That the Primary energy calculations include the heating system, hot water distribution system (pipe size, average draw off length and insulation), renewable technology information (manufactures performance specification and quantity/area provided) and appliances and white goods specified (particularly details of clothes drying, low energy lighting, and any low energy appliances specified).

[22]Siddall M, Grant N, Satisfying the Passivhaus standard: The UK context. Technical briefing document version 1.1, Passivhaus Trust, October 14th 2011.
[23]http://www.passiv.de/03_zer/Zertifizierer/Zertif-PHI.htm
[24]Certification criteria: http://www.passiv.de/07_eng/phpp/Criteria_Residential-Use.pdf http://www.passiv.de/07_eng/phpp/Certification_Non-Residential.pdf

3a Why use the Passivhaus Planning Package (PHPP)?

The Passive House Planning Package (PHPP) is a spreadsheet modelling tool, which is sophisticated enough to consider the design variables that matter, but is simple enough to be understood and used by most practitioners. Architects using PHPP find that it builds their knowledge of how buildings work, allowing them the freedom to experiment with different designs, and the confidence to present their ideas to the client and other team members. It provides them with evidence to support and argue the case for measures that might otherwise be dismissed.

Photo: Anne Thorne Architects

By seeing the impact of design decisions on the predicted performance of the building, designers can explore different forms, orientations and materials. This allows them to balance functional and aesthetic requirements within the framework that Passivhaus provides. It also allows overheating risks to be highlighted, and design measures such as shading, orientation etc to be incorporated.

Because of the range in the ways that people use buildings, no tool can provide exact predictions of real performance. However, PHPP has been validated by 15 years of real building performance evidence, and therefore provides very accurate indications of real average building performance, including overheating risks.

As Passivhaus is a performance standard, it can be achieved with a variety of forms, materials and has been in various climates and cultures around the world. The main requirement is that the building must be considered as a whole. This means that the cost-engineering and processes of the past cannot work with Passivhaus. Instead of the old piecemeal approach, a systematic approach is necessary for Passivhaus. But by being flexible enough to respond to the users and designers ambitions, it can be liberating for all involved.

"As the need to create ever more energy-efficient housing to mitigate against the rise in fuel prices becomes more critical, so the use of systems like Passivhaus will become more common as the standard to deliver affordable low energy housing.

John Frankiewicz Willmott Dixon Capital Works CEO

Source: Parsons&Whittley

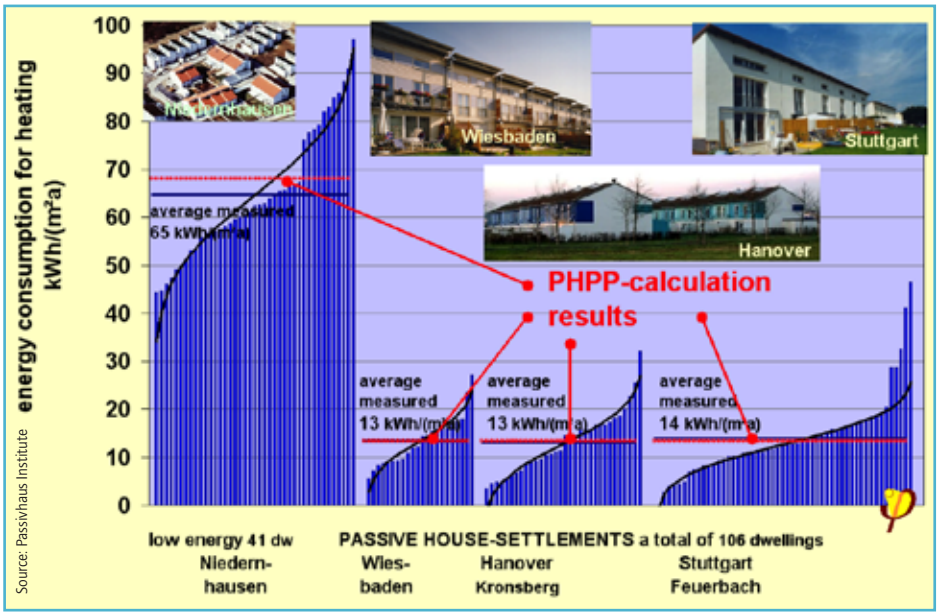
"At ATA we have have found the Passivhaus methodology and use of PHPP an enormous support to our design work. The rigorous research and accumulated experience behind the standard make it completely different from anything else. Its basis in calculable building physics make it comprehensible and informative at the design stage, and we think the design of our buildings have improved as a result of using it."

Fran Bradshaw, Anne Thorne Architects

Opposite page: Oakmeadow Primary School, Wolverhampton during construction
Top: Designer using PHPP
Right: PHPP Verification page

3b What are the advantages of Quality Assurance?

Passivhaus is a clear performance claim that can be validated. The quality assurance (QA) process of allocating each responsibility to specific parties is crucial. The methodical QA process also helps the team to work together, as everyone understands what is expected of each of them throughout.



Everyone should feel that the buildings they live and work in are safe, healthy, comfortable and affordable. However, some new buildings cost more than expected to run, have problems with condensation and air quality, or can be too hot or too cold. This performance gap is a serious problem that the construction industry needs to address, along with recognition of the need for a rigorous QA process; this was highlighted in the Government's recent consultation on building regulations.[17] Passivhaus has an established QA process, which tests the building at various stages, ensuring that the final result performs as expected.

The CEPHEUS project (Cost Efficient Passive Houses as European Standards) studied the performance of 221 housing units built to Passivhaus standards. These were built in a variety of construction types and architectural styles, located at 14 sites across five different European countries. The measured results demonstrate that the average space heating energy consumption matches the prediction of 15kWh/m²/yr, and that occupants rate comfort as excellent in both winter and summer months, and indoor air quality as good or very good.[10]

"One of the reasons I love Passivhaus is that no other approach delivers results so reliably. All other approaches to low carbon building feel a bit nebulous or a stab in the dark. Energy usage of buildings is largely unknown even in so-called green buildings. Rarely measured and poorly modelled in SAP, the industry is building low-energy and zero-carbon buildings with no independent verification of those claims. Passivhaus, on the other hand, offers an absolute measure – a way of cutting through all the ecobling and greenwash."

Bill Butcher Project Leader on the Denby Dale Passivhaus and Director of Green Building Store

"From extensive Post-Occupancy Evaluation you can be confident that the results of PHPP will be pretty much bang on"

Tom Mason Architect & Certified Passivhaus Designer, Architype

Above: The CEPHEUS Project results graph illustrates that measured space heating energy use varies between individual homes, but averages below 15kWh/m²/yr for Passivhaus dwellings.

3c What are the advantages of certification?

The Passivhaus process includes a series of certification processes to ensure the quality of any official Passivhaus buildings, practitioners, products and components.

1 The Passivhaus Planning Package (PHPP), used to inform the design process and to assess or verify compliance with the Passivhaus Standard.

2 Certification for designers and tradespersons who have the expertise to deliver Passivhaus buildings.

3 A certification process for Passivhaus, which applies both to the proposed design and the completed building.

4 Certification of Passivhaus products and components.

Photo: passivhausassociates.co.uk

Certification by an approved certifier is a quality assurance mechanism that ensures that all of the requirements have been met, and that a high quality building is delivered. Not just an element or two, but the whole building. The client and team can be assured that that they will get the building, performance and quality that they expect, working together and motivated by a common clearly defined cause.

When considering building products and components, certification will act as a mark of quality, differentiating certified products from others that may claim to be suitable for Passivhaus buildings. This can help the UK supply chain to develop quality assured products for a growing market.

"Hastoe currently has around 100 Passivhaus homes in its future build programme and we are looking forward to delivering these. To have this hard work and dedication honoured by Passivhaus certification is fantastic."

John Lefever Regional Head of Development, Hastoe Group


WARM: Low Energy Building Practice

Certificate

Quality Approved Passive House

Source: Architype Architects

'Carefully considered products and rigorously designed construction assemblies are often altered or substituted during the building phase of a project without adequate consideration of direct and knock-on effects. This often happens outside of the designers' influence or control and can result in a considerable performance gap in the completed building. The quality assurance provided by the Passivhaus design & certification process is a fantastic and effective way to ensure that this doesn't happen and to close the performance gap.'

Elrond Burrell, Associate, Architype.

Above: Certified Passivhaus plaque at Totnes Passivhaus, Devon
Left: Certificate of a Quality Approved Passivhaus

4 Why not choose Passivhaus?

Passivhaus may not be the right approach for every project, or may not have been considered at the planning stage. It is important that some common concerns – often misconceptions – about Passivhaus are addressed in order to ensure a full appraisal of its suitability. The client and team also need to understand that a commitment to detail and a systematic approach are necessary to deliver a successful Passivhaus project.

What are the concerns?

1 There are no openable windows!

Answer: Passivhaus quality assurance requires that there be at least one openable window in every habitable room.

2 Surely it's a German standard and not relevant to the UK?

Answer: It came from Germany, but has since been applied across Europe and is now being adopted around the World, in a variety of cultures and climates.

3 It's not suitable for the UK climate!

Answer: PHPP does consider different climate zones, and in the UK specific weather data is used for calculations. Passivhaus buildings have also been proven to work in widespread regions of the UK.

4 Passivhaus restricts design choice, particularly working with UK designs, and the buildings look like square boxes!

Answer: Look at the many examples of different buildings in this guide, and you will see the range of designs and materials that are available for Passivhaus buildings.

5 It uses MVHR, which doesn't work!

Answer: Mechanical ventilation systems (not just MVHR) must be designed and installed correctly in order to work, but adopting the quality control of Passivhaus should ensure that the system will work as intended.

6 It's only about energy, not broader environmental concerns!

Answer: Energy is a pressing environmental concern, and an indicator of wider environmental issues. However, there is no reason why other issues cannot also be addressed with Passivhaus design, for example, the choices that are made regarding materials, biodiversity planning etc.


Photo: Architype Architects

Above: Openable windows at Bushbury Hill Primary School, Wolverhampton
Below: Contemporary design at Crossway, Kent


Photo: Hawkes Architecture Ltd

"For me, the best thing about Passivhaus is that it is an open-source design standard. It is formed with a clear definition and has tools and accumulated information to share. The Passivhaus way is bringing a paradigm shift to our industry – working and building creatively and collaboratively".

Junko Suetake Anne Thorne Architects

5 Where to start?

Join the Passivhaus Trust, 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.

For membership and other information about the Trust please visit:

www.passivhaustrust.org.uk

Below: Shortlisted project teams at the UK Passivhaus Awards 2012 ceremony with Prof. Wolfgang Feist

Photo: Andy Perrin | Passivhaus Trust

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

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6 Further information

The Passivhaus Trust
www.passivhaustrust.org.uk
The UK Passive House organisation.

The Passivhaus Institut (PHI)
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 Passivhaus concept in Germany and worldwide.

The International Passive House Association (iPHA)
www.passivehouse-international.org
The International network for Passivhaus knowledge, working to promote Passivhaus worldwide.

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

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

Passnet
www.pass-net.net
Project to spread knowledge of the Passivhaus standard within Europe, through open days and a buildings database.

AECB the sustainable building association

Passivhaus Institut

International PASSIVE HOUSE Association IPHA

Passivhaus is the leading international standard for comfortable, healthy and affordable low energy buildings.

"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

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