Passivhaus Introduction

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CIBSE SOUTH WEST SEMINAR
25th January 2012
A Passivhaus may be defined as a building in which a comfortable internal temperature is achieved solely by heating or cooling the fresh air that is introduced in order to meet the occupants’ ventilation requirements.
When did it begin?

1988: concept conceived

Dr. Wolfgang Feist

Prof. Bo Adamson
First Passivhaus? – the Fram

The first fully-functioning ‘Passivhaus’ was not actually a house but a C19th Norwegian polar research ship!

- Hull insulated with cork and felt
- Triple glazed hatch
- Fresh air via air sail into ventilator
- Heated with one burning lamp – redundant stove
1991 Passivhaus: Darmstadt, Kranichstein

- Four private clients commissioned the planning and construction of a row of highly energy efficient houses, each with 156m² of living space.

- The building incorporated a highly precise data measurement system to continually monitor the property to compare the reality to the theoretical plan.
Why Passivhaus?
Why Passivhaus?

- High quality air
- Can heat solely via the air
- Even without heating, won’t drop below 16°C on the coldest winter day
- Smaller (and potentially cheaper) heating system and renewable energy systems
- Lower fuel bills
- Not restricted to particular technologies
- More cost effective than renewables
- Winter space heating is not ideally matched to renewables.
- Almost all types of construction possible
- CSH compliance
Spot the PH?

Five of these houses are NOT Passivhaus.
Basic Principles and Outline Specification
Passivhaus principles

The reduction of the heating demand to the point where a traditional heating system is no longer required...

Means the typical features of a Passivhaus are:

- Super-insulated
- Minimized thermal bridging (ideally eliminate!)
- Extremely airtight building envelope
- Mechanical ventilation with heat recovery (MVHR)
- Triple-glazed windows, largely south oriented
- High thermal comfort

Passivhaus dwellings do not need to differ aesthetically from conventional dwellings
Passivhaus Headline Requirements

Space heating demand: <15kWh/m$^2$/annum
Or, heating load <10W/m$^2$

Comfort:
- Airtightness <0.6 ACH @ 50Pa
- Overheating <10% over 25°C
- Window surface >17°C

Primary energy: <120 kWh/m$^2$/annum
Guideline targets

**U-values**

- Opaque construction elements \( \leq 0.15 \, \text{W/m}^2\text{K} \)
- Windows and doors \( \leq 0.8 \, \text{W/m}^2\text{K} \)
  (installed) \( \leq 0.85 \, \text{W/m}^2\text{K} \)

**Ventilation heat exchanger efficiency** >75%

**Ventilation efficiency (fans)** \( \leq 0.45 \, \text{W/m}^3\text{/h} \)

**Thermal bridge free construction** \( \leq 0.01 \, \text{W/m}.\text{K} \)
Passivhaus principle

- How much heat can we introduce via fresh air?

- People require 30m$^3$ per hour for good air quality:

\[
30 \text{ m}^3/\text{hr}/\text{person} \times 0.33 \text{ Wh/(m}^3\text{K)} \times 30\text{K} = 300\text{W/person}
\]

Minimum ventilation rate of required for good indoor air quality
Specific heat capacity of air
Maximum heat input provided via the fresh incoming air

• Therefore if we assume 30m$^2$ living space per person, we arrive at a peak heat load figure of 10W/m$^2$, a primary certification criterion for Passivhaus
Overview of a Passive House

- Super-insulation $U < 0.15 \text{ W/(m}^2\text{K)}$
- 3-pane low-e-glazing
- Supply air
- Exhaust air
- Fresh air
- Filter
- Air to air heat exchanger
- Subsoil heat exchanger
Passivhaus in the UK, CSH and BREEAM
European and National legislative drivers

- EPBD
  - Building regulations must be reviewed every 5 years
  - Updates EPBD on the horizon post-Kyoto in 2012
- Energy White Paper
  - 80% cut in CO₂ emissions by 2050
  - Primary energy use also important
- CSH
- EPC
## UK legislation – Conservation of fuel and power

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<tbody>
<tr>
<td>1990</td>
<td>20% improvement over 1985 regs</td>
<td>25% improvement over 1990 regs</td>
<td>20% improvement over 1995 regs</td>
<td>20% improvement over 2002 regs</td>
<td>25% improvement over 2006 regs</td>
<td>Circa 100% improvement</td>
<td>CSH level 5</td>
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<tr>
<td>1995</td>
<td>Standard Assessment Procedure is accepted as an alternative way of demonstrating compliance</td>
<td>Elemental, calculation and energy use methods</td>
<td>Elemental, Target U-value and Carbon Index methods</td>
<td>Approved document split L1A and L1B</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>2002</td>
<td>EcoHomes first introduced</td>
<td>Elemental trade offs allowed</td>
<td>SAP required to be produced</td>
<td>TER/DER assessment</td>
<td>Increased low-energy lighting and quality of workmanship and airtightness req.</td>
<td></td>
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<tr>
<td>2006</td>
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<tr>
<td>2010</td>
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<td></td>
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<td>CSH level 3</td>
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<td>2016</td>
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**NOTE:** New-build English regulatory timetable - implementation in Scotland, Northern Ireland and Wales differs.
Passivhaus, Code for Sustainable Homes and BREEAM

Sustainable Construction

Energy performance and comfort standard
- Passivhaus
  - Residential and non-domestic
    - PHPP
- BREEAM
  - Non-domestic & Multi-residential
- CSH
  - Residential
- SAP

Environmental Assessment Method
<table>
<thead>
<tr>
<th><strong>Renewable energy</strong></th>
<th><strong>UK Building Regulations 2006 and 2010</strong></th>
<th><strong>Passivhaus</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Not required</td>
<td>Roof 0.25 (0.20)</td>
<td>Recommended</td>
</tr>
<tr>
<td></td>
<td>Ext wall 0.35 (0.3)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Floor 0.25 (0.2)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Windows 2.20 (2.0)</td>
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</tr>
<tr>
<td>Air tightness</td>
<td>≤10.0 m³/m²h</td>
<td>≤0.6 ACH</td>
</tr>
<tr>
<td>U Values (W/m²K)</td>
<td>Normal distribution</td>
<td>All opaque surfaces = 0.15</td>
</tr>
<tr>
<td></td>
<td>No requirements</td>
<td>Windows 0.85</td>
</tr>
<tr>
<td>Heat distribution</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Electrical appliances</td>
<td>Usually A++</td>
</tr>
<tr>
<td></td>
<td>No requirements</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Warm air syst</td>
<td></td>
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<tr>
<td></td>
<td>MVHR</td>
<td></td>
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<tr>
<td></td>
<td>≤15 kWh/m²a</td>
<td></td>
</tr>
<tr>
<td>Ventilation</td>
<td>Trickle vents</td>
<td></td>
</tr>
<tr>
<td>Heating requirement</td>
<td>No reqs: Usually ≤ 90 kWh/m²a</td>
<td></td>
</tr>
<tr>
<td>Primary energy</td>
<td>200 kWh/m²a</td>
<td>40 kWh/m²a</td>
</tr>
<tr>
<td>consumption</td>
<td>124 kg CO₂/m²a eq</td>
<td>24 kg CO₂/m²a eq</td>
</tr>
</tbody>
</table>
Passivhaus: the requirements

**Passivhaus**

- **Air tightness**
  - ≤0.6 ACH @50Pa

- **Space Heating requirement**
  - Or
  - **Heating Load**
    - ≤15 kWh/m²a
    - ≤10 W/m²

- **U Values (W/m²K)**
  - All opaque surfaces
    - U = 0.15 W/m²K
  - Windows
    - 0.85 W/m²K

- **Primary energy consumption**
  - <120 kWh/m²/annum

- **Overheating**
  - <10% over 25°C

- **Ventilation heat exchanger efficiency**
  - ≥ 75%

**New build Residential and non-residential**

- **Primary energy consumption**
  - <120 kWh/m²/annum

**Refurbishment (ENERPHIT)**

- **Target value** ≤ 0.6 ACH @50Pa
- **Limit value** ≤ 1.0 ACH @50Pa

- Qₜ ≤ 25 kWh/m²a
  - *Certification can be issued alternatively if the criteria for individual building components as given below. In this case the reqs for heating demand doesn’t apply.*

- **Ext wall and storey ceiling above outside air**
  - External wall ins U ≤ 0.150 W/m²K
  - Internal wall ins U ≤ 0.300 W/m²K

- **Ext wall to ground, ceiling of unheated basement and floor slab on ground**
  - f* U ≤ 0.150 W/m²K

- **Roof or top floor ceiling**
  - U ≤ 0.120 W/m²K

- **Roof terrace**
  - U ≤ 0.150 W/m²K

- **U Windows**
  - ≤ 0.85 W/m²K

- Qₚ < 120 kWh/m²a + ((Qₜ - 25 kWh/m²a) * 1.2)
Technical Aspects of Passivhaus
How is heat lost from a building?

- Heat loss through the opaque fabric
  - Party walls
- Heat loss through the glazing and doors
- Heat loss via thermal bridges at the junctions of building elements
- Heat loss through thermal bridges where building components are installed
- Infiltration (not useful)
- Ventilation (required)
Potential heat gains

- Solar
- Incidental gains from
  - DHW generation and storage
  - Lighting
  - Appliances
- Occupants
- Heating system

Heat gains and losses in kWh/m²a:
- Solar gains: 17.9 kWh/m²a (43 %)
- Internal gains: 10.6 kWh/m²a (26 %)
- Heating: 12.8 kWh/m²a (31 %)
- Ventilation: 6.6 kWh/m²a (16 %)
- Transmission: 34.7 kWh/m²a (84 %)
Passivhaus Build Up

- Opaque building fabric
  - U values, constructions, geometry, thermal bridging
- Airtightness
- Glazing
- Ventilation
- Heating
Building Fabric – Impact of Geometry

Increase of 10%
Insulation = 20mm

Increase of 20%
Insulation = 40mm

Quelle: R. Borsch-Laaks
Building Fabric - Thermal Bridging

- Regular
- Irregular
- Geometric

- PassivHaus requires continuous insulation; must be thermal bridge free
Thermal bridges

Identify and eliminate possible thermal bridges
Thermal Bridging – Eaves Detailing
Thermal Bridging Rules

• Avoidance

• Penetration of insulation

• Geometry; blunt angles
Passivhaus Build Up

- Opaque building fabric
  - U values, constructions, geometry, thermal bridging
- Airtightness
- Glazing
- Ventilation
- Heating
Airtightness requirements

- q50 – $m^3/m^2/hour$ (UK)
- n50 – ACH (Germany)

- Requirement: 0.6 ACH @ 50Pa test conditions. Pressurisation and depressurisation
Why is airtightness important?  
Impact on thermal comfort

– Not just about energy savings – maintains good thermal comfort
– Localised air leakage can have impact on an occupants perception of comfort; make a room feel subjectively colder than the mean internal air temperature suggests
– German research into comfort standards showed that avoiding air movement above 0.1 m/s dropped the demand temperature by 2°C
Why is airtightness important?

Impact on heat loss

– Limits heat loss from infiltration, improves comfort
Why is airtightness important? Impact on durability

Problem: A gap with airflow from inside out

0°C; 80% r.F. 360 g water / day / m

20°C; 50% r.F.

For comparison: with vapor diffusion
Only 1 g water / day / m²

1 mm gap in construction
Strategy, detailing and strong management on site is required to achieve 0.6 ACH @ 50Pa
Passivhaus Build Up

- Opaque building fabric
  - U values, constructions, geometry, thermal bridging
- Airtightness
- Glazing
  - Ventilation
- Heating
Mechanical Ventilation with Heat Recovery

Characteristics:
- Centrally located ventilation unit with fans and heat recovery
- Supply and extract air in separate ducts

Main components:
- Ventilation unit with fans, control, HR, filters
- Ducting with silencers
- Supply air inlets
- Extract air outlets
- Directed flow through the internal rooms, transfer openings in internal doors
- Exhaust air outlet
- Fresh air inlet
Ventilation concept and planning

![Graph showing ventilation rate (ac/h) for Typical situation, Typical UK Best Practice, and PassivHaus. The Target Zone is 0.4 to 0.3 ac/h.](image-url)
Cross Ventilation Principle

- Supply air zone
- Transferred air zone
- Extract air zone

- Living room
- Master bedroom
- Bedroom
- Study
- Corridor
- Kitchen
- Bathroom
- WC
- Utility room
Certification Requirements
# Certification Overview

## Building certification
- Must be certified by one of the registered bodies
  - BRE
  - AECB
  - Inbuilt
- Building must be completed, tested and verified (by PHI)

## Designer certification
- PHI exam (CEPH)
  - BRE
  - AECB
- By practice (PHI approval)

## Component certification
- Performance has been assessed and approved by PHI
  - Windows
  - MVHR
  - Construction systems
Passivhaus Certification Requirements

Space heating demand: <15kWh/m²/annum
Or, heating load <10W/m²
Airtightness <0.6 ACH @ 50Pa
Overheating <10% over 25°C
Primary energy: <120 kWh/m²/annum
Ventilation efficiency (fans) ≤0.45 W/m³/h
Ventilation heat exchanger efficiency >75%
• For MVHR systems seeking approval from PHI as an appropriate passive component:

• Fan power limited to 0.45 W/m³/hour

• Heat recovery efficiency of at least 75%

• Acoustic performance requirements met
Passivhaus Certification Process

- Clearly defined process
- Two Key Stages
  - Design Stage Approval
  - Post Construction Certificate
- Certificates issued on behalf of the Passivhaus Institute
Microsoft Excel based package

Core is based on EN ISO 13790 (same as SAP)

Custom PHI algorithms based on CEPHEUS research and PassivHaus specific features

Single zone model

A fully completed PHPP workbook forms the basis of initial certification
CEPH Consultant / Designer

– Globally recognised qualification
  – 40 hours distance learning
  – 7 days training at BRE (over two weeks)
  – 3 hour examination
– Registered on European and National databases
– Use of the CEPH logo in advertising
– Streamline certification for CEPH designers with BRE

www.passivhauscertification.com
Passivhaus Certification Scheme (PCS)

<table>
<thead>
<tr>
<th>Project classification</th>
<th>Passivhaus Certification cost for members for a single unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dwellings</td>
<td></td>
</tr>
<tr>
<td>1st project submitted</td>
<td>£1,500+vat €1,700</td>
</tr>
<tr>
<td>2nd project submitted</td>
<td>£1,100+vat €1,300</td>
</tr>
<tr>
<td>Every project submitted thereafter</td>
<td>£800+vat €900</td>
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<tr>
<td>Non-domestic</td>
<td>Please contact BRE for pricing <a href="mailto:passivhaus@bre.co.uk">passivhaus@bre.co.uk</a></td>
</tr>
<tr>
<td>Annual scheme licence management fee</td>
<td>£250+vat or €300</td>
</tr>
</tbody>
</table>

For multi unit projects all additional Passivhaus' will be charged £2 per m² of Treated Floor Area (TFA)

If you are a Certified Passivhaus Designer or Consultant and would like to register your interest in our PCScheme please email us on passivcert@bre.co.uk
PASSIVHAUS PROJECTS IN THE UK
Passivhaus Uptake in UK and around the World

- Passivhaus has been around since 1990
- 7000 Passivhaus’ worldwide
- The majority are in Germany and Austria
- Also in Japan, USA
- ~15 in the UK and Ireland
- Maybe as many as 20 by 2011!
- Could be over 150+ by 2013
Canolfan Hyddgen, offices and education centre

- BREEAM Excellent and Passivhaus certification
- Training, education and customer service centre in North Wales
- BREEAM Welsh 2009 awards
- Co-funded by Welsh Assembly Government’s Pathfinder programme and Powys County Council
- 1st building in the public sector to be certified by the PassivHaus Institute in the UK
Ebbw Vale – ‘Hwylus Haus’ @ The Works

- The design won the ‘Welsh PassivHaus’ competition (2009) - Completion summer 2010
- Re-development of former steelworks site
- Two 3-bed houses
- Timber frame construction

Certified as a ‘Quality Assured’ PassivHaus

www.theworksebbwvale.co.uk
www.bere.co.uk
Leeds Met. University - Carnegie Village

- 2 completed semi-detached units of student accommodation
- BREEAM Multi-residential award winner

Certified as a ‘Quality Assured’ PassivHaus
Bill Butcher, Denby Dale, West Yorkshire

- New-build 118m² three-bed detached house
- First UK Passivhaus to be built with cavity wall construction.
- One of the first certified Passivhaus homes in the UK
- Minimal heating - using 90% less energy for space heating than the UK average
- £141K build costs

Certified as a ‘Quality Assured’ PassivHaus
Matrix Bau, Aubert Park, Islington

• 4 5-storey terraced houses
• Construction cost of £1500m² including appliances
• Market value 2.5million per dwelling
Cae Gliesion (Bridgend) - Wales

- Semi detached dwellings
- Specific space heating demand 14 kWh/m2a
- Heating load 8 W/m2
- Pressurisation test result 0.5 h⁻¹
- Specific Primary energy demand 84 kWh/m2a

Certified as a ‘Quality Assured’ PassivHaus
Gentoo – 28 units in Sunderland
Hastoe – Wimbish, 14 units

Proposed Passivhaus Affordable Housing, Tye Green, Wimbish for Hastoe Housing Association

Sketch Perspectives
Viking House, Menzies Road, Dover

- 3 storeys commercial office
- **Client:** WCR Property Ltd
- **Architect:** Dudley Marsh Architects
- 80% more efficient
Obstacles

- Availability of products
  - Some products need to be imported
  - Clients will have to drive the market
  - Supply chains need to be developed
- Architects
  - Increase knowledge of energy efficiency
  - Improve detailing
- Build Process
  - Developers need to raise importance of energy measures
  - Incorporate QA checks in construction schedule
Obstacles

– Trade skills
  – Training
  – Site supervision
– Airtightness
  – Can 0.6 ACH be achieved throughout development/en-masse?
– Standardized details
  – No redesign, remodelling
  – Familiar to workers
– Mechanical ventilation installation quality
What’s next?

UK Passivhaus Design Competition 2011

- Stage 1 submission deadline: 30th November 2011
- Finalists announced: 19th December 2011
- Stage 2 presentation & interviews: January 2012 (date TBC)
- Winner announced: 31 January 2012

All entries to be sent to phcomp@bre.co.uk
Thank you for attending!

Twitter: www.twitter.com/passivhausuk
Website: www.passivhaus.org.uk
Email helpline: passivhaus@bre.co.uk
Phone helpline: +44 (0) 845 873 5552
LinkedIn: www.linkedin.com/in/passivhausuk

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