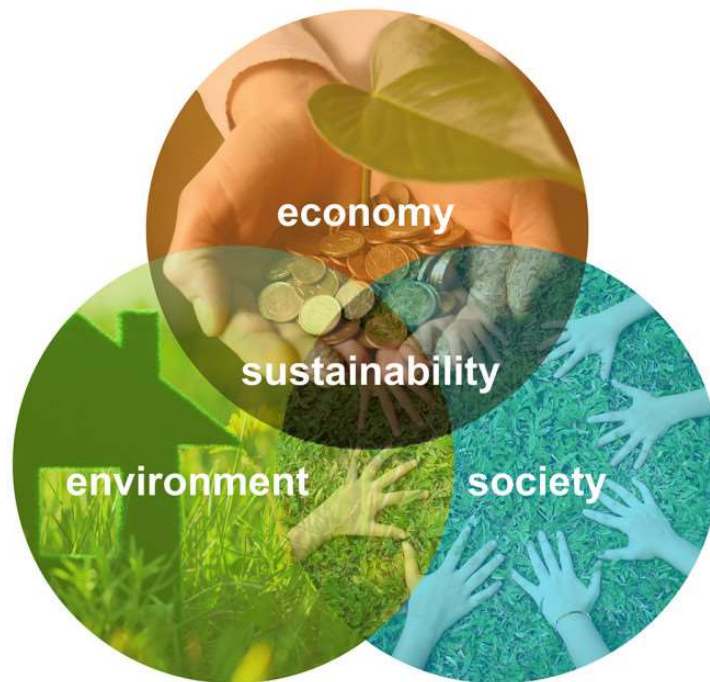


BREEAM New Construction Assessment/Energy Assessment

M5X01883/M5X01847

BREEAM Principles: Assignment 1



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Introduction

The aim of this report is to analyse the advantages, disadvantages and differences of Passivhaus and BREEAM (Building Research Establishment Environmental Assessment Method) Certification Schemes as specified in the assignment brief.

Sustainable Construction Schemes (SCS)

Schwarz-Herion (2015) states that the constant development of sustainable Certification Schemes (SCS) such as BREEAM and Passivhaus are imperative. Furthermore, ascertaining that improved building methods will not only promote healthier environments but also conciliate the environmental impact of carbon emissions (Fig 1.0) and the sustainability of natural resources (Fig 1.1).

BREEAM: Advantages and disadvantages

Controlled application

Bre Global (2017) avers that its Environmental Assessment Method is regulated by UKAS (2017). Further asserting, that BREEAM is subject to BS EN ISO 17024 and BS EN ISO/IEC 17065:2012. Standards “Regulating bodies often issue various guidance’s suggesting areas of good practice” (HIMMS, 2011).

A possible negative aspect is political influence on sustainability which may enforce changes which contradict the current SCS “huge political barriers to any transition to more sustainable forms of development” (Dale, 2011)

Practicality

Brebbia (2012) asserts that by utilising a 5 Level rating system (FIG 1.2), the SCS provides opportunity to obtain certification at multiple levels of sustainability. Moreover, adding that a Pass is just above the requirements set for building regulations, making it attainable to developments with variable budgets or knowledge base.

A domestic dwelling may implement aspects to achieve certain criteria, however financial restrictions will not achieve certification “Breeam does not use budget aspects to evaluate projects” (Oostra, 2011)

Standardised Framework

Malina (2012) proffers that developers have consistent framework by using the comprehensive 10 category check box system in the Breeam Technical Manual (Fig 1.3). Insisting that a universal benchmarking tool is advantageous to compare building performance and comply with category requirements. Furthermore, asserting that it is most effective when applied at the earliest stage of planning to obtain a maximum possible rating.

Quantified Assessment

Rushton (2016) declares, that by using a licenced Breeam assessor at the earliest point in a project will provide the benefit of:

- Involvement at key stages of the project
- Expert knowledge of specifications and Product selection
- Indication to possible rating of initial design
- Sustainability reports for planning

Further justifying that an assessor enhances the process of appointing a sustainability champion on site.

Thorne et al (2012) Reasons that a negative aspect which could arise is abuse of power for personal gain or human error.

Build Quality and Lifecycle

Anderson (2009) states that BREEAM sets benchmarks for alternating types of development (FIG 1.4). Furthermore, summarising that materials not only require to be sustainably sourced and graded, but must also comply with all 60-year life cycle assessment (LCA) criteria within ISO 15686 (FIG 1.5). Woolley (2017) affirms that this system promotes future proofing. Moreover, adding that it gives opportunity for higher scoring through the innovation category. This gives developers the incentive to research new methods of construction. WWF (2017) challenge this and suggest that material supply chains are not adequately governed. Further stating, that an estimated 10% of timber in the UK is obtained through illegal logging.

Environmental Performance (EP)

BREEAM (2017) accentuates environment design to promote EP e.g. lower emissions, waste management, energy use (FIG 1.6). Stating that technologies realising water and energy saving will incur higher costs in its construction but will pay back within 3 and 8 years respectively (FIG 1.7 & 1.8) which is financially beneficial to inhabitants once initial costs are recovered. Issac et al (2012) affirms this, instructing that further methods such as electric vehicle bays and cycling storage are applied to encourage greener modes of transport, however contends that elements are subject to the inhabitant's lifestyle choice and not be controlled by the SCS post-handover.

Health & Wellbeing

The international Well Being Standard (IWBS) proclaim affiliation to BREEAM through strategy implementation. Further adding that its core values promote minimum standards for key areas in BREEAM (FIG 1.9)

Aston (2012) opposes the effectiveness of developer's abilities to execute all standards required. "There is no doubt that BREEAM is not perfect. There are many improvements that could be made to create an assessment that was less complicated to administer"

Passivhaus: Advantages and disadvantages***Regulated***

Hopfe et al (2015) proclaims that Passivhaus certification scheme (PCS) primary focus is provide the end user a building with high energy efficiency, stating that it meets building regulations (2014) in sustainability but does not necessarily challenge environmental issues. Additionally, maintaining that it satisfies ISO EN 10211:2011 Thermal bridging standards and BS EN 13829:2011 Building Envelope Airtightness.

Practicality

BRE (2017) professes, that by implementing a Pass or Fail system (FIG 2.0) a Passive unit must meet exact criteria for performance, it gives developers precise instructions of mandatory requirements at design stage. Moreover, adding that it is a simpler system to execute in comparison to other SCS. This is affirmed by Yudelson (2012) “The basic concept behind passivhaus is quite simple”.

Standardised Framework

Passivhaus.org (2017) state that to meet PCS standards, each passive house must achieve pre-set performance requisites:

- insulation and thermal bridging
- Window and door selection
- Airtightness
- Mechanical Ventilation and Heat Recovery Systems (MVHR)

See (FIG 2.1)

Passiv.de (2017) avers, that achieving PCS with existing buildings is difficult due to the building envelope assessment criteria. Furthermore, surmising that alternatively, Enerphit or PHI standard can be alternatively implemented by attaining the criteria specified in Component and Energy demand methods (Fig 2.3 & 2.4).

Quantified Assessment

Cerezuela (2017) Proffers, to obtain PCS, specified Pre- and Post-construction requirement must be fulfilled Passivhaus Certified Designer. Furthermore, summarising that design phase must be commenced by using Passivhaus Planning Package (PHPP) Software to submit data for analysis to a certifying institute. Further Signed and accredited documentation is required at variable stages of the construction process (FIG 2.5).

Passivhaus.de (2017) affirm this and declare that the PCS is regulated by the Passivhaus Institute, but a certified designer may carry out assessment. Moreover, indicating that only 4 Accredited Building Certifiers are currently operating in the UK (FIG 2.6).

Build Quality and lifecycle

Passivhaus CP (2017) indicate that it is not the material selection e.g. Structural Insulated Panels, which is important to achieve certification. Insisting, that the construction method is of higher construction value when correctly applied to create a thermal-bridge free and airtight envelope (FIG 2.7). “Whether solid construction, wood or composite- architects can design passive houses according to their own preference” IPHA (2017). Passivhaus Designers Guide (2016) affirms this, expressing that it is possible to attain negative PSI levels through methodical design methods.

Siddall et al (2013) proffers that all material components within PCS must be conductively tested to meet the requirements within all current EN standards and stamped with official certifications (FIG 2.7). Adding that window and door performance is crucial with a triple

glazed units surface temperature must not drop below 17 degrees on the coldest day of the year.

Environmental Performance

IPHA (2015) Proffer that by constructing with emphasis of low u-values, thermal bridging techniques and airtightness of the buildings envelope, energy requirements are reduced to 10% of standard construction methods (Fig 2.9). Confirming, that via careful site orientation solar gains will be exploited and the installation of a heat recovery system, extinguishes the necessity for a traditional boiler (Fig 3.0).

Andreou et al 2015, argues that a negative aspect of PCS is the exclusion of environmental assessment method in it design. Additionally, stating that this is a fundamental flaw in PCS System, reasoning that even though local building regulations are met, it does not contribute to appease the Carbon reduction regulations in certain countries.

Health & Wellbeing

Cooper et al (2014) stipulates that PCS promotes health and wellbeing by providing improved allergy protection and improved indoor air quality (IAQ). Moreover, adding that reduced energy bills help to eradicate current issues such as fuel poverty, therefore improving the mental health of occupants.

Littlewood et al (2017) argues that the long-term effects of PCS have not been researched adequately with minimum professional documentation available on the subject. Furthermore, expressing that the latest findings have indicated that Passivhaus systems are being underachieved by a lack of knowledge regarding the installation of heat exchange systems and the evident risk that passive buildings will over-heat.

Analysis

Sklair (2017) avers that comparing Breeam and Passivhaus is an unfair process due to the different natures for which they were intended. However, proffers that both Breeam and Passivhaus possess merits and shortcomings.

Strange et al (2016) expresses that the 2 SCS both benefit from individual design specifications to achieve sustainability in Energy and environmental standards. Additionally, averring that a combined universal standard of both schemes which still realise standard requirements would be highly beneficial. Not only to the construction industry but to the environment and end user.

GBP (2014) state that the STEM Building at the University of Bradford has achieved both PCS and BREEAM outstanding. "Clients like the University of Bradford, are increasingly demanding an in depth understanding of low carbon techniques". (FIG 3.1)

Bateman (2011) Insists that difficulty in obtaining a universal rating system is the alternating values offered for materials. Stating that even though a straw bale offers excellent thermal properties in wall construction for Passivhaus. It would be penalised when used in the Breeam assessment criteria, achieving a lower rating via lifecycle categories in the technical guide.

Conclusion

To compare Passivhaus and Breeam Certification Schemes is difficult. The evidence discovered indicates that a unification of the 2 systems would be beneficial to the construction industry and environment. It is evident that qualitative research is required to provide a simpler implementation of current methods of certification.

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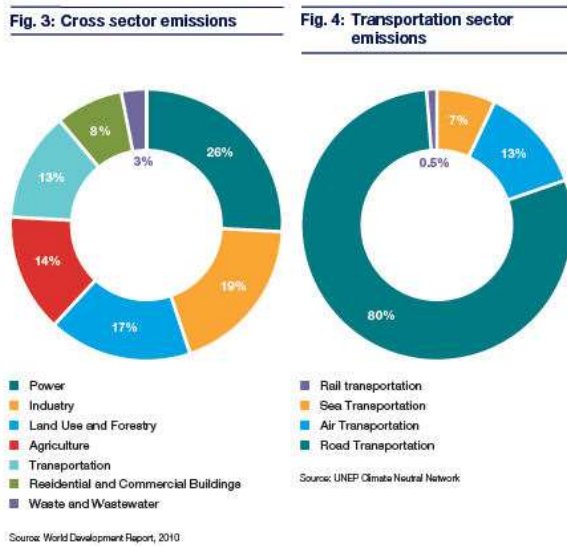
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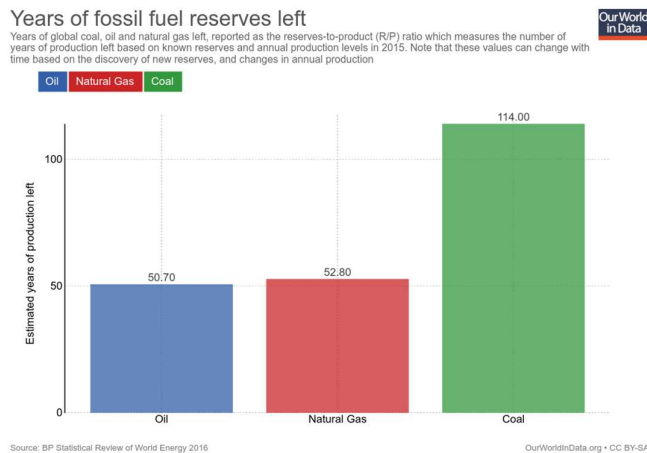
Appendix

(Fig 1.0)



Climate Neutral Network (2010). *Global Transport Industry Lags Behind in Carbon Reduction Plans*. [image] Available at: <https://www.environmentalleader.com/wp-content/uploads/2010/08/CDPtransportemissions.jpg> [Accessed 30 Oct. 2017].

(Fig 1.1)



Our World in Data (2017). *How long before we run out of fossil fuels?*. [image] Available at: <https://ourworldindata.org/wp-content/uploads/2017/06/years-of-fossil-fuel-reserves-left.png> [Accessed 2 Nov. 2017].

(FIG 1.2)

BREEAM Rating	% Score
Outstanding	85%
Excellent	70%
Very Good	55%
Good	45%
Pass	30%
Unclassified	<30%

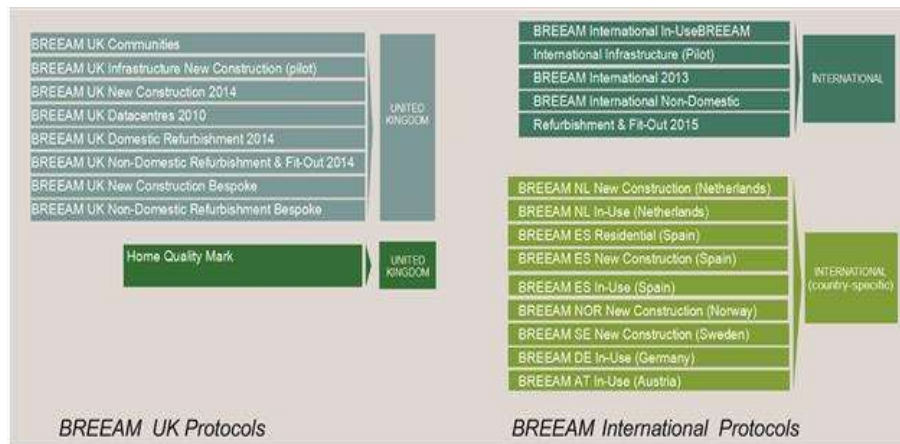
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(Fig 1.3)

BREEAM Category	Weighting
Management	12.5%
Health and Wellbeing	14.5%
Energy	19.5%
Transport	8%
Water	6%
Materials	13%
Waste	5%
Land Use and Ecology	10.5%
Pollution	9.5%
	100%
Innovation	+10%

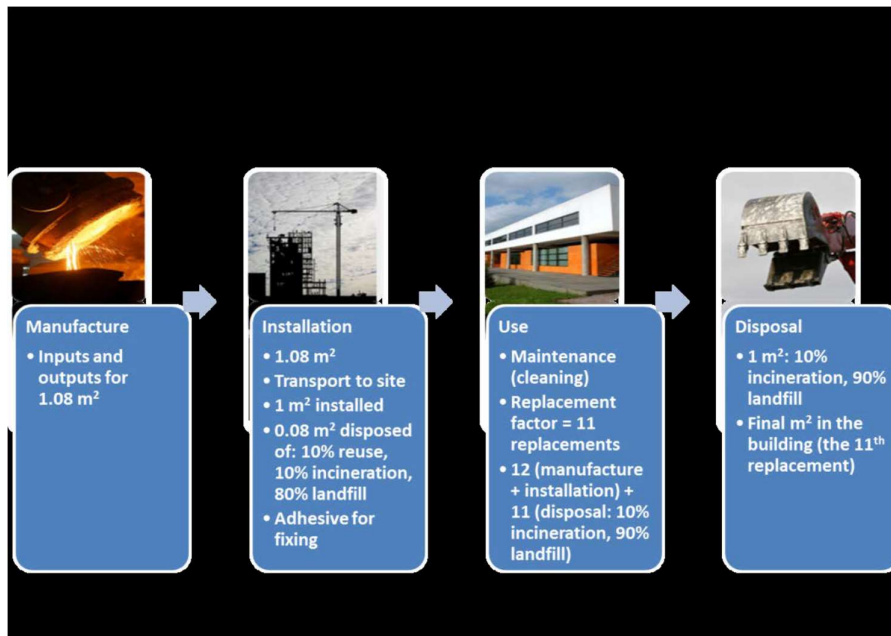
BREEAM Scoring. (2017). [image] Available at: <http://www.engineersjournal.ie/wp-content/uploads/2015/06/BREEM-1-300x294.jpg> [Accessed 9 Nov. 2017].

(Fig 1.4)



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https://ongreeningstorage.blob.core.windows.net/cache/2016_06_13%20BREEAM%20International%20%20Protocols-05_notizie_1294__630_0.jpg [Accessed 11 Nov. 2017].

(FIG 1.5)



The Green Guide Explained. (2017). London: BREEAM, p.8.

(Fig 1.6)



Bohara, O. (2017). *An assessment on Green Building Assessment systems*. [image]
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(Fig 1.7)



Water consumption life cycle costs and savings

BREEAM credits	Capital Cost (over baseline) (£)	Payback period (Higher tariff)	Payback period (Lower tariff)	Water saving per annum (m ³ /years)
1 st	0	0	0	2847
2 nd	1220	1	1	3566
3 rd	8570	1	1	5014
4 th	14,150	1	2	6017
5 th	74,150	3	9	6425

Lower tariff (Ofwat figures) assumes a tariff of £1.692/m³ (Thames Water) plus a 0.5% tariff increase per annum.
Higher tariff (Ofwat figures) assumes a tariff of £4.351/m³ (South West Water) plus a 0.5% tariff increase per annum.

Delivering Sustainable Buildings: Savings and Payback – Breakfast Briefing. (2017). 1st ed. [ebook] London: BRE, pp.11-13. Available at: <http://www.breeam.com/filelibrary/Presentations/DeliveringSustainableBuildingsSlides.pdf> [Accessed 4 Nov. 2017].

(Fig 1.8)



Energy consumption life cycle costs and savings: Contribution to BREEAM Excellent rating – Option 2

Energy Solution	Energy price scenario	Capital Costs (£)	Lifecycle savings (£)	Payback period (years)	Annual Gas Savings (kWh)	Annual electricity Savings – (kWh)	Annual CO ₂ savings – (kgCO ₂)
Option 1 - Passive chilled beams	Central DECC energy prices	167,250	479,352	8	-1450	153,870	79,264
Option 2 - Active chilled beams	High DECC energy prices		503,313	8			

Lifecycle savings equate to the net electricity and gas bill savings less any additional maintenance or replacement costs over 25 years.

Delivering Sustainable Buildings: Savings and Payback – Breakfast Briefing. (2017). 1st ed. [ebook] London: BRE, pp.11-13. Available at: <http://www.breeam.com/filelibrary/Presentations/DeliveringSustainableBuildingsSlides.pdf> [Accessed 4 Nov. 2017].

(Fig 1.9)

WELL BUILDING STANDARD FEATURES MATRIX

This table shows which features are preconditions and optimizations for the different project types of the standard for commercial and institutional offices. Refer to the tables in the beginning of each concept for details about the applicability of specific parts.

		Core and Shell	New and Existing Interiors	New and Existing Buildings
Air				
01	Air quality standards	P	P	P
02	Smoking ban	P	P	P
03	Ventilation effectiveness	P	P	P
04	VOC reduction	P	P	P
05	Air filtration	P	P	P
06	Microbe and mold control	P	P	P
07	Construction pollution management	P	P	P
08	Healthy entrance	P	O	P
09	Cleaning protocol		P	P
10	Pesticide management	P		P
11	Fundamental material safety	P	P	P
12	Moisture management	P		P
13	Air flush		O	O
14	Air infiltration management	O	O	O
15	Increased ventilation	O	O	O
16	Humidity control		O	O
17	Direct source ventilation	O	O	O
18	Air quality monitoring and feedback		O	O
19	Operable windows	O	O	O
20	Outdoor air systems	O	O	O
21	Displacement ventilation		O	O
22	Pest control		O	O
23	Advanced air purification	O	O	O
24	Combustion minimization	O	O	O
25	Toxic material reduction		O	O
26	Enhanced material safety		O	O
27	Antimicrobial activity for surfaces		O	O
28	Cleanable environment		O	O
29	Cleaning equipment		O	O
Water				
30	Fundamental water quality	P	P	P
31	Inorganic contaminants	P	P	P
32	Organic contaminants	P	P	P
33	Agricultural contaminants	P	P	P
34	Public water additives	P	P	P
35	Periodic water quality testing		O	O
36	Water treatment	O	O	O
37	Drinking water promotion	O	O	O

		Core and Shell	New and Existing Interiors	New and Existing Buildings
Nourishment				
38	Fruits and vegetables		P	P
39	Processed foods	P	P	P
40	Food allergies	P	P	P
41	Hand washing		P	P
42	Food contamination		P	P
43	Artificial ingredients	O	P	P
44	Nutritional information	O	P	P
45	Food advertising	O	P	P
46	Safe food preparation materials		O	O
47	Serving sizes		O	O
48	Special diets		O	O
49	Responsible food production		O	O
50	Food storage		O	O
51	Food production	O	O	O
52	Mindful eating	O	O	O
Light				
53	Visual lighting design		P	P
54	Circadian lighting design		P	P
55	Electric light glare control	P	P	P
56	Solar glare control	O	P	P
57	Low-glare workstation design		O	O
58	Color quality		O	O
59	Surface design		O	O
60	Automated shading and dimming controls		O	O
61	Right to light	O	O	O
62	Daylight modeling	O	O	O
63	Daylighting fenestration	O	O	O
Fitness				
64	Interior fitness circulation	P	O	P
65	Activity incentive programs		P	P
66	Structured fitness opportunities		O	O
67	Exterior active design	O	O	O
68	Physical activity spaces	O	O	O
69	Active transportation support	O	O	O
70	Fitness equipment	O	O	O
71	Active furnishings		O	O
Comfort				
72	Accessible design	P	P	P
73	Ergonomics: visual and physical		P	P
74	Exterior noise intrusion	P	O	P
75	Internally generated noise	O	P	P
76	Thermal comfort	P	P	P
77	Olfactory comfort		O	O
78	Reverberation time		O	O
79	Sound masking		O	O
80	Sound reducing surfaces		O	O
81	Sound barriers		O	O
82	Individual thermal control		O	O
83	Radiant thermal comfort	O	O	O

The Well Being Standard. (2017). 1st ed. [ebook] UK: International Well Being Standard (IWBS), pp.16-17. Available at:
<https://www.wellcertified.com/en/system/files/WELL%20Building%20Standard%20v1%20with%202017%20Q4%20addenda.pdf> [Accessed 3 Nov. 2017].

(Fig 2.0)

Passivhaus Certification Scheme (PCS)

5

How does 'Passivhaus' Certification Work?

Application Criteria

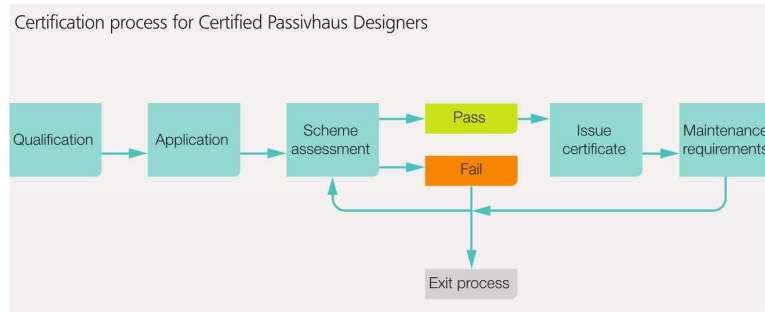
This scheme is open to Certified Passivhaus Designers.

Likely suitable professionals who may be interested in Passivhaus are:

- Architects and technologists.
- Low carbon energy consultants.
- SAP and Code Assessors.
- Building Services Engineers.
- Environmental Consultants.
- Energy Consultants.

Becoming a Certified Passivhaus Designer can be achieved by passing the Certified Passivhaus Designer Examination. BRE Training offer exceptional Passivhaus training packages, however the examination can be taken by designers who have undergone training through other organisations. In the case that the examination stage is not successful, designers have the option to be reassessed.

The BRE Global Passivhaus team are available to provide support in the application process. For further information on applications to the scheme, please contact BRE Global Passivhaus: email passivcert@bre.co.uk or phone +44 (0) 845 863 0014.



Passivhaus Certification. (2017). 1st ed. London: Bre Global, p.5.

(Fig 2.1)

HOW CAN PASSIVHAUS REQUIREMENTS BE ACHIEVED?

Insulation and thermal bridging

External walls, slabs to the ground, and roofs are within 0.1 to 0.15 W/m²K.

All significant thermal bridges should be designed out.

The most important principle of a PassivHaus is insulation applied continuously around the building envelope without thermal bridging – this significantly reduces heat losses. As a consequence the heat losses during winter are negligible. Another consequence is that the temperatures of the internal surfaces are almost the same as the indoor air temperature. This leads to a very comfortable indoor climate and avoids damage caused by the humidity of indoor air.

During hot periods in summer, a high level of thermal insulation is a protection against heat. To ensure high thermal comfort during summer, well designed shading and sufficient ventilation are important, too. All construction methods can be used for PassivHaus and have been tested successfully: masonry construction, lightweight construction, prefabricated elements, insulating concrete formwork construction, steel construction, and all combinations of the methods above.



PassivHaus windows and insulated doors

Windows to be triple glazed and achieve 0.8 W/m²K for both the glazing and the frame.

Doors must be insulated.

Even in the milder UK climate triple glazed PassivHaus windows need to be specified if the supply air is to be used to heat the dwelling – without triple glazing the heat loss is too high and it is not possible to achieve the PassivHaus standard. A benefit of triple glazing is that the surface temperature of the windows is similar to that of the surrounding internal surfaces – the occupants will not experience any discomfort, even on the coldest winter day, when seated near a PassivHaus window. Triple glazing also reduces sound transmission from outside.

Other design considerations

Utilisation of passive solar gains: An optimised design can reduce space heating and day-lighting requirements which helps achieve the PassivHaus design target.

Internal gains and overheating: All energy consumption ends up as heat. This means that all appliances and lighting which use energy contribute to heating the house. Whilst this is useful, the main issue for a PassivHaus is to reduce internal gains as this can increase the risk of overheating. Thus low-energy lighting and appliances should be fitted.

Renewable and low-carbon technologies: Specifying renewable energy technologies is not a core requirement of the Passivhaus standard, however implementing renewable energy technologies can further reduce running costs and carbon dioxide emissions – it is also readily possible to achieve the zero carbon requirements of level 6 of the Code for Sustainable Homes.

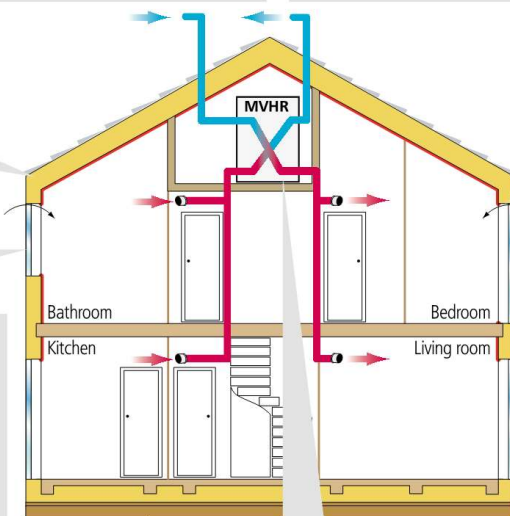
Airtightness

n_{50} of 0.6 h⁻¹ @ 50 Pa or less.

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

Achieving this level of airtightness requires a strategy to be developed at the design stage, with the final result also being sensitive to the quality of workmanship.

Achieving airtightness onsite requires careful use of appropriate membranes, tapes, wet plastering and/or vapour membranes to form a continuous airtight barrier.



Mechanical Ventilation and Heat Recovery (MVHR)

Heat recovery efficiency of greater than 75% and a low specific fan power is required.

The health and comfort of the inhabitants are the most important objectives of PassivHaus design. The necessity for an extremely airtight building fabric means that MVHR is required to maintain the quality of indoor air by replacing unwanted odours, moisture and carbon dioxide generated by the occupants with fresh air. Occupants can still freely open and close the windows as they see fit, however to achieve adequate ventilation rates in such an airtight building the occupant would be required to open all the windows at least once every three hours for some 5 to 10 minutes at a time – even during the night. This would obviously be impractical and would cause unacceptable heat loss during the winter.

Since an MVHR unit runs continuously, it ensures that the correct levels of ventilation can be achieved in all rooms and provides excellent indoor air quality when specified and installed correctly. The heat exchanger does not mix the fresh incoming air with the exhaust air, but simply exchanges heat to reduce the heating requirement. In a PassivHaus – and only in a PassivHaus – there will be another advantage when specifying an MVHR system: The opportunity to heat the dwelling by heating the supply air.



(Fig 2.2)


www.passivhaus.org.uk

Passivhaus Building Certification

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

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

Specific heating demand	$\leq 15 \text{ kWh/m}^2 \cdot \text{yr}$
(or) Specific heating load	$\leq 10 \text{ W/m}^2$
Specific primary energy demand	$\leq 120 \text{ kWh/m}^2 \cdot \text{yr}$
Airtightness	$\leq 0.6 \text{ ach}$ @ 50 pascals (n50)

Certifying Passivhaus units

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

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

Detached dwelling

A detached dwelling is considered to be one Passivhaus unit.

Semi detached dwellings

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

Terraced dwellings

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

Multi storey apartment block

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

Multi storey apartment block with non-domestic unit

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

Non domestic units

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



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

Passivhaus Building Certification. (2017). [ebook] Passivhaus Institute, p.1. Available at: http://www.passivhaus.org.uk/filelibrary/Building_Certification.pdf [Accessed 6 Nov. 2017].

(Fig 2.3)



EnerPHit Standard

Table 2 EnerPHit criteria for the building component method

Climate zone according to PHPP	Opaque envelope ¹ against...				Windows (including exterior doors)			Ventilation			
	...ground	...ambient air			Overall ⁴	Glazing ⁵	Solar load ⁶				
	Insulation	Exterior insulation	Interior insulation ²	Exterior paint ³	Max. heat transfer coefficient (U _{DW,installed})	Solar heat gain coefficient (g-value)	Max. specific solar load during cooling period	Min. heat recovery rate ⁷	Min. humidity recovery rate ⁸		
	Max. heat transfer coefficient (U-value)			Cool colours							
	[W/(m²K)]			-	[W/(m²K)]	-	[kWh/m²a]	%			
											
Arctic	Determined in PHPP from project specific heating and cooling degree days against ground.	0.09	0.25	-	0.45	0.50	0.60	U _g - g*0.7 ≤ 0	100	80%	-
Cold		0.12	0.30	-	0.65	0.70	0.80	U _g - g*1.0 ≤ 0		80%	-
Cool-temperate		0.15	0.35	-	0.85	1.00	1.10	U _g - g*1.6 ≤ 0		75%	-
Warm-temperate		0.30	0.50	-	1.05	1.10	1.20	U _g - g*2.8 ≤ -1		75%	-
Warm		0.50	0.75	-	1.25	1.30	1.40	-		-	-
Hot		0.50	0.75	Yes	1.25	1.30	1.40	-		-	60 % (humid climate)
Very hot		0.25	0.45	Yes	1.05	1.10	1.20	-		-	60 % (humid climate)

¹ Opaque building envelope

If the heat transfer resistance (R-value) of existing building components is taken into account for the improvement of the heat transfer coefficients (U-value) of modernised building components, this must be demonstrated in accordance with the accepted technical standards. It is sufficient to adopt a conservative approximation of the thermal conductivity of the present building materials from suitable reference charts. If building component assemblies of existing buildings are not clearly identifiable, standardised estimates according to the year of construction as taken from appropriate component catalogues (e.g. "EnerPHit-Planerhandbuch", PHI 2012, only available in German) can be used as long as these are comparable with the component at hand.

In refurbishments of existing buildings, it is not always possible to achieve absence of thermal bridges with justifiable effort as is necessary for Passive House new builds. Nevertheless, thermal bridge effects must always be avoided or minimised as much as possible while ensuring cost-effectiveness. Thermal bridges that are part of the construction system, e.g. wall ties, must be taken into account in the evaluation of the heat transfer coefficient of this construction.

² Interior insulation

An important reason for the lower requirements for interior insulation (compared with exterior insulation) is that it reduces the useable area, therefore in principle only exterior walls are regarded as having interior insulation (if applicable), but roofs, basement ceilings and floor slabs are not.

³ Exterior colour

Cool colours: colours which have a low absorption coefficient in the infrared part of the solar spectrum.

This criterion is defined by the solar reflectance index (SRI) which is calculated from the absorptivity and emissivity in the PHPP in accordance with the international standard ASTM E1980-11.

Flat roofs (inclination ≤ 10°): SRI ≥ 90

Sloped roofs and walls (inclination > 10° and < 120°): SRI ≥ 50

Measured values of areas exposed to weathering for at least 3 years must be used. If measured values are only available for the new state then the absorptivity should be converted using the auxiliary calculation in the PHPP worksheet "Areas" provided for this purpose. For simplification, the emissivity can be kept as it is.

In the following cases, this criterion does not have to be met:

"greened" surfaces; areas which are covered with rear ventilated solar collectors or photovoltaic panels (including the distance required between the panels); penetrations in building components and the associated equipment; accessible (roof) terraces or paths; areas that are strongly shaded or do not face the sun.

Criteria for the Passive House, EnerPHit and PHI Low Energy Building Standard, version 9f, revised 15.08.2016 8/27
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Criteria for the Passive House, EnerPHit and PHI Low Energy Building Standard. (2017).
[ebook] Germany: Passivhaus Institute, pp.8 - 9. Available at:
http://www.passiv.de/downloads/03_building_criteria_en.pdf [Accessed 2 Nov. 2017].

(Fig 2.4)



EnerPHit Standard

Other measures can also be undertaken as an alternative to the use of cool colours (e.g. increasing the insulation thickness beyond the applicable criterion for the building component), if this does not increase the overall cooling demand compared with the use of cool colours.

4 Windows, overall

The illustrations show the respective inclination of the installed window. In each case the criterion for inclination of components will apply which most closely approximates the actual inclination of the window. There will be no interpolation between two criteria. However, since the glazing U-value changes with the inclination due to physical processes, the glazing U-value U_g corresponding to the actual inclination must be set for the window itself.

In the case of small windows above an average frame length to window area ratio of 3 m/m^2 the limit value mentioned in the table is steadily increased. The limit value to be applied is automatically calculated and shown in the PHPP worksheet "Verification" in accordance with the following formula:

Addition to the limit value $[\text{W/m}^2\text{K}]$: $(l/A-3)/20$

l: length of window frame

A: window area

5 Glazing

The limit value only applies for actively heated buildings with a heating demand above $15 \text{ kWh}/(\text{m}^2\text{a})$.

6 Solar load

The limit value only applies for actively cooled buildings with a sensible cooling demand above $15 \text{ kWh}/(\text{m}^2\text{a})$. It refers to the solar radiation entering the building per m^2 of glazing area after taking into account all reduction factors due to shading etc., and must be complied with for the average value of all identically aligned windows. If the limit value is exceeded, then suitable measures must be undertaken to reduce the solar load to the point where the limit value can be complied with again. These include movable shading elements, shading overhangs and anti-sun glazing (latter only in pure cooling climates).

7 Ventilation, minimum heat recovery efficiency

The heat recovery criterion must be complied with beyond the criteria for "Certified Passive House Components" for the entire ventilation system, i.e. also including the heat losses of the warm ventilation ducts located in the cold area and of the cold ducts located in the warm area.

8 Minimum moisture recovery efficiency A "humid climate" prevails with dry degree hours for dehumidification $\geq 15 \text{ kWh}$ (based on a dew-point temperature of 17°C). This is automatically determined in the PHPP.

Table 3 EnerPHit criteria for the energy demand method (as an alternative to Table 2)

Climate zone according to PHPP	Heating	Cooling
	Max. heating demand	Max. cooling + dehumidification demand
	$[\text{kWh}/(\text{m}^2\text{a})]$	$[\text{kWh}/(\text{m}^2\text{a})]$
Arctic	35	equal to Passive House requirement
Cold	30	
Cool-temperate	25	
Warm-temperate	20	
Warm	15	
Hot	-	
Very hot	-	

Criteria for the Passive House, EnerPHit and PHI Low Energy Building Standard. (2017). [ebook] Germany: Passivhaus Institute, pp.8 - 9. Available at: http://www.passiv.de/downloads/03_building_criteria_en.pdf [Accessed 2 Nov. 2017].

(Fig 2.5)

Achieving Passivhaus Certification

Documentation Required

- PHPP signed*
- Construction drawings
- Technical specs
- Blower door test certificate
- MVHR commissioning
- Photographic evidences of construction
- Declaration of Construction Manager

Certificate



Passivhaus Certification on Residential Projects

Francisco Cerezuola MSO MCAT CPD

PASSIVHAUS TALK Passivhaus Certification on Residential Projects. (2017). [Presentation Slides] Unknown: Cerezuola, F, p.Achieving Passivhaus Certification. Available at: http://moodle.uwtsd.ac.uk/pluginfile.php/115121/mod_resource/content/1/UWTSO%20Presentation%20-%20PH%20Presentation%20FINAL.pdf [Accessed 5 Nov. 2017].

(Fig 2.6)

Organization ▲	Country ▲	Website ◆	Certifiers ◆
Building Research Establishment (BRE) NN NN	United Kingdom	www.passivhaus.org.uk	
Cocreate Co-operative Ltd. Will South	United Kingdom	www.cocreateconsulting.com	• Will South, Languages: en • Paul Smyth, Languages: en
Mead Energy & Architectural Design Kym Mead	United Kingdom	www.meadconsulting.co.uk	• Kym Mead, Languages: en
WARM - Low Energy Building Practice Peter Warm	United Kingdom	www.peterwarm.co.uk	• Peter Warm, Languages: en • Sally Godber, Languages: en • Mike Roe [mike@peterwarm.co.uk, Languages: en

Passivhaus.de (2017). *List of accredited building certifiers*. [image] Available at: http://www.passiv.de/en/03_certification/02_certification_buildings/03_certifiers/01_accredited/01_accredited.php [Accessed 7 Nov. 2017].

(Fig 2.7)

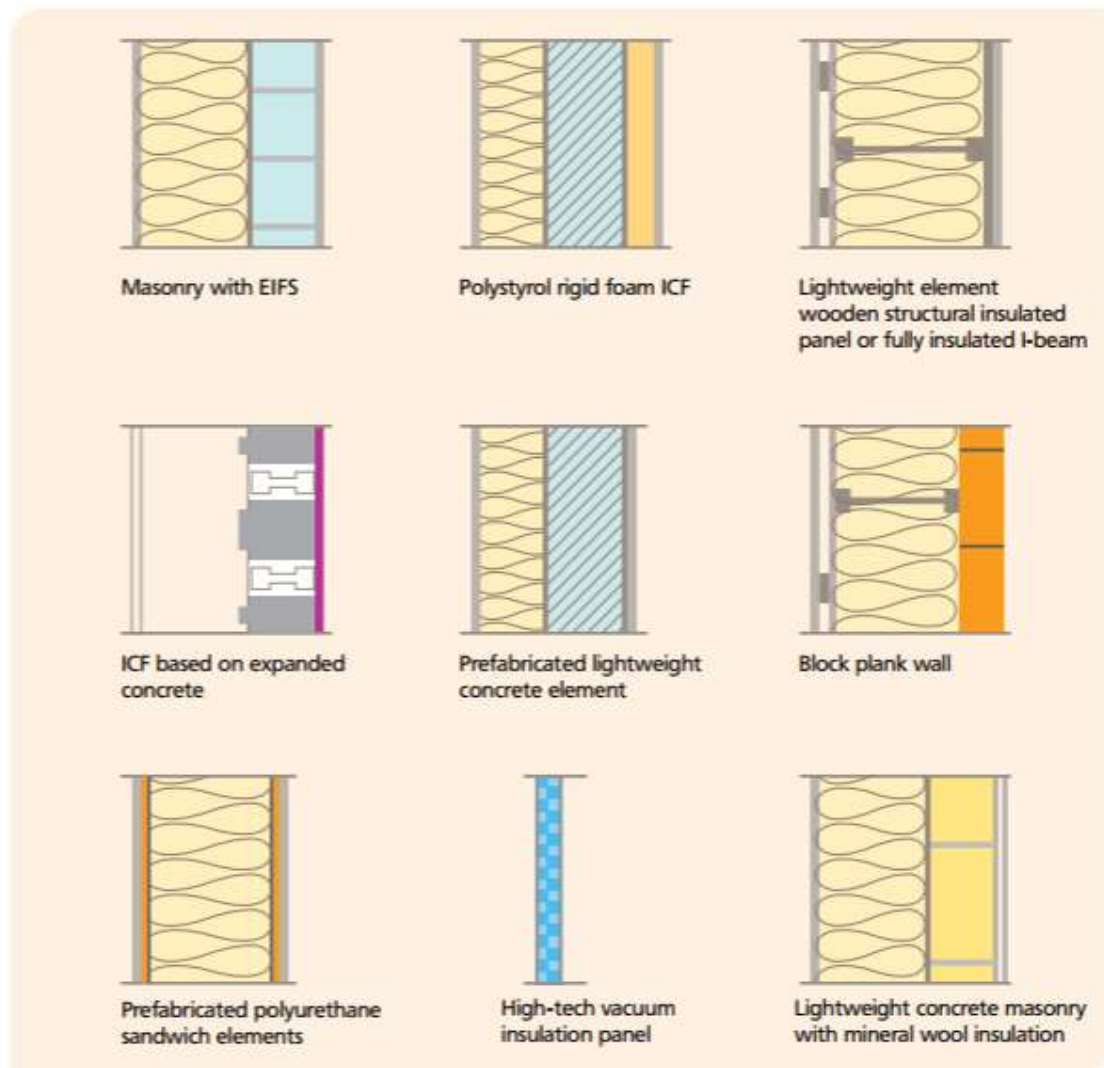


Figure 2 Passivhaus construction possibilities

Passivhaus construction possibilities. (2017). [image] Available at: http://www.passivhaus.org.uk/filelibrary/Primers/Passivhaus_Contractors_Guide.pdf [Accessed 7 Nov. 2017].

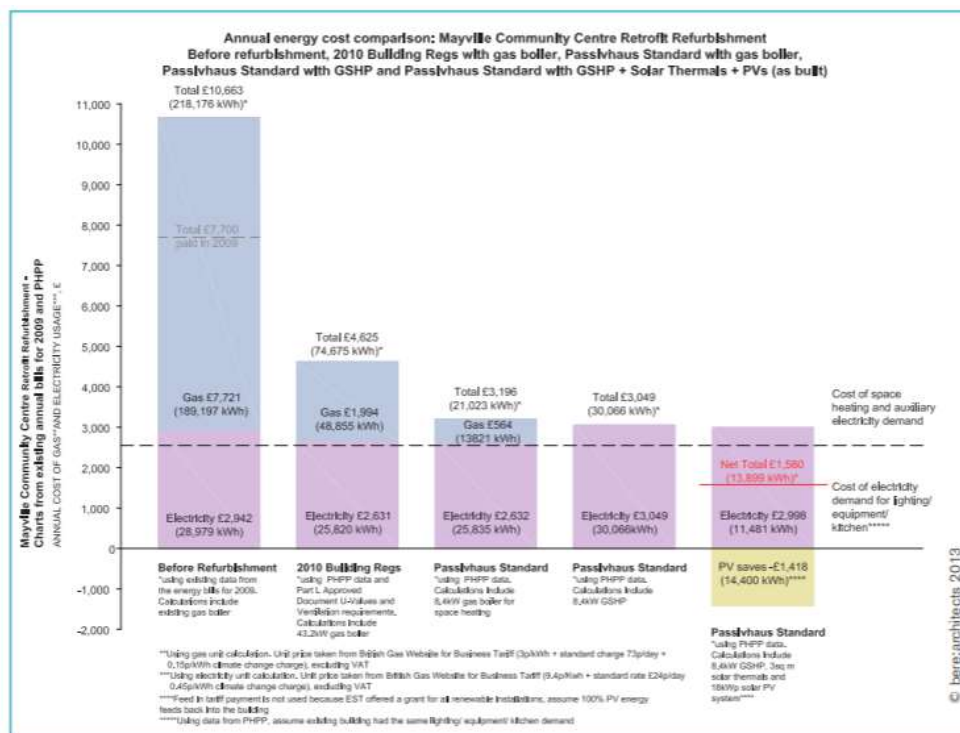
(Fig 2.8)

Each window and door should be uniquely coded with the following information:

- Frame type and U_F value (EN 10077)
- Glazing type and U_G value (EN 673)
- Solar energy transmission g-value (EN 410)
- Daylight transmission (EN 9050)
- Glazing and gap dimensions
- Spacer type used
- Special low emissivity coatings
- Inert gas fill type

Passivhaus primer: Contractor's guide So you've been asked to build a Passivhaus?. (2017). [ebook] Germany: Passivhaust trust, p.7. Available at: http://www.passivhaus.org.uk/filelibrary/Primers/Passivhaus_Contractors_Guide.pdf [Accessed 9 Nov. 2017].

(Fig 2.9)

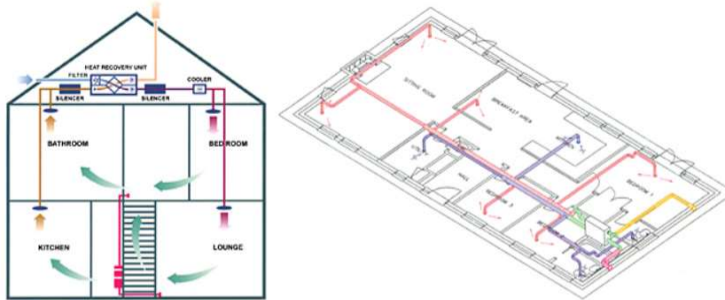


BRE, ., 2013. Why Invest in Passivhaus. *Why Choose Passivehaus*, [Online]. 1, 5. Available at: <http://www.passivhausttrust.org.uk/UserFiles/File/Why%20choose%20Passivhaus%202013%20FINAL.pdf> [Accessed 2 November 2017].

(Fig 3.0)

A carefully planned heat recovery and ventilation system is designed to extract stale air from wet areas such as the kitchen, utility, bathroom, and toilet as well as unpleasant odours from other rooms in the most efficient manner.

Whilst doing so it also provides a controlled quantity of clean, filtered, warm air back to living areas and work places. The heat exchanger system is designed to recover an average of 70% of the heat contained in the unwanted stale extracted air whilst combining this with a fresh incoming air supply, giving substantial savings on energy costs. By mixing and controlling the recovered heat in this way, the internal atmosphere remains clean and healthy whilst the potential energy savings can be considerable.



Clean Fresh Air

The fresh air filter removes dust, pollen and other particles from the incoming air ensuring that you are provided with clean and natural environment which is free from draughts all year round.

The heat recovery unit also enables you to ventilate even when it is cold outside. This way you reduce the build up of radon gas and cooking odours which can penetrate carpets, curtains and soft furnishings. Condensation is also greatly reduced or even eliminated.

Quiet Comfort

Noise from external sources is considerably reduced as the system does not require open trickle vents or slots above windows for the supply of fresh air.

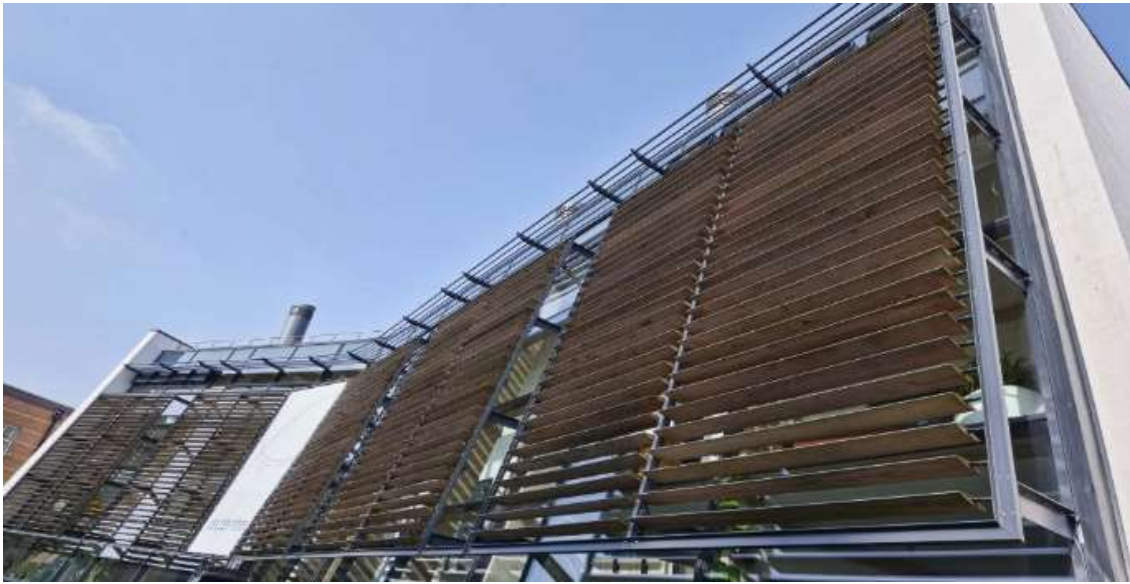
Full Control

The entire heat recovery system can be controlled by a separate electronic control unit mounted on the wall which has indicator lights for the fans, filter and heater element.

Activate Wi
Go to Settings

Paragon Systems (2017). *Heat Recovery and Ventilation Systems*. [image] Available at: http://www.paragon-systems.co.uk/heat_recovery/about_heat_recovery.htm [Accessed 6 Nov. 2017].

(Fig 3.1)



University Business (2017). *University of Bradford building, designed by architects Farrell & Clark, sets example for sustainability*. [image] Available at: <http://wildfirecomms-images.co.uk/-1434633417.jpg> [Accessed 11 Nov. 2017].