

Project Documentation

Gebäude-Dokumentation



1 Abstract / Zusammenfassung



Detached house in Bishopstone, Wiltshire, UK

1.1 Data of building / Gebäudedaten

Year of construction/ Baujahr	2022	Space heating / Heizwärmebedarf	13 kWh/(m²a)
U-value external wall/ U-Wert Außenwand	0.095 W/(m ² K)		
U-value Floor slab/ U-Wert Kellerdecke	0.099 W/(m ² K)	Primary Energy Renewable (PER) / Erneuerbare Primärenergie (PER)	31 kWh/(m ² a)
U-value roof/ U-Wert Dach	0.097 W/(m ² K)	Generation of renewable energy / Erzeugung erneuerb. Energie	23 kWh/(m ² a)
U-value window/ U-Wert Fenster	0.98 W/(m ² K)	Non-renewable Primary Energy (PE) / Nicht erneuerbare Primärenergie (PE)	79 kWh/(m ² a)
Heat recovery/ Wärmerückgewinnung	86.4 %	Pressure test n ₅₀ / Drucktest n ₅₀	0.3 h-1
Special features/ Besonderheiten	ASHP for space heating and DHW generation		

1.2 Brief Description

Blackthorn House is a detached 230m² dwelling in Bishopstone, Wiltshire. The building is of timber frame construction with flint, render and timber cladding. It is a two-storey dwelling with living areas on the ground floor and four bedrooms on the first floor. The building has a relatively high heat-loss form factor (3.3) to fit in with the local vernacular and therefore has low U-value constructions (opaque elements less than 0.1 W/m²K) to compensate.

1.2 Responsible project participants / Verantwortliche Projektbeteiligte

Architect/ Entwurfsverfasser	Affinity Architects / Inkbox Architecture https://www.affinityarchitects.co.uk/		
Implementation planning/ Ausführungsplanung	Affinity Architects / Inkbox Architecture https://www.affinityarchitects.co.uk/		
Building systems/ Haustechnik	Greengauge Building Energy Consultants https://ggbec.co.uk/		
Structural engineering/ Baustatik	Cullen Timber Design https://www.cullentimberdesign.com/		
Building physics/ Bauphysik	Greengauge Building Energy Consultants https://ggbec.co.uk/		
Passive House project planning/ Passivhaus-Projektierung	Greengauge Building Energy Consultants https://ggbec.co.uk/		
Construction management/ Bauleitung	Maidment & Carter https://www.maidmentandcarter.com/		
Certifying body/ Zertifizierungsstelle	Etude Consulting Limited https://etude.co.uk/		
Certification ID/ Zertifizierungs ID	41506_ETUDE _PH_20240202 _NG	Project-ID (www.passivehouse-database.org) Projekt-ID (www.passivehouse-database.org)	(7755)
Author of project documentation / Verfasser der Gebäude-Dokumentation	Mr Andy Cane https://ggbec.co.uk/		
Date, Signature/ Datum, Unterschrift	29.01.2025 		

2 Views of the Passivhaus, Bishopstone.

The view shown from the north-east is shown on the cover page.



North side of the Passivhaus in Bishopstone, Wiltshire: MVHR ventilation grilles are just visible (circled red).



East side of the Passivhaus in Bishopstone, Wiltshire: Outward opening windows for summer comfort ventilation can clearly be seen.



South side of the Passivhaus in Crouchestron, Wiltshire: South-facing windows are shaded by fixed horizontal overhangs to balance winter and summer solar gain. The roof mounted PV is also shown.

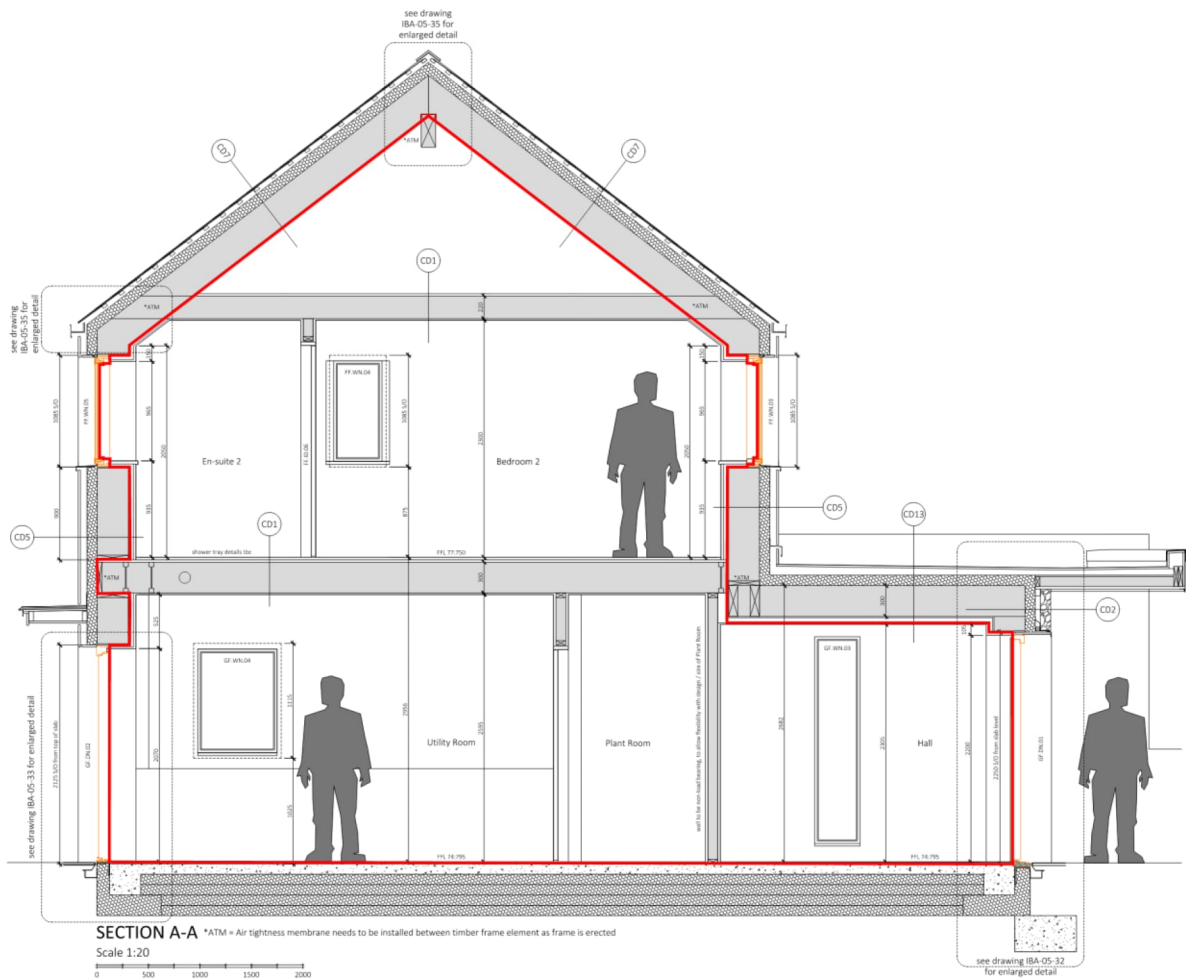


West side of the Passivhaus in Bishopstone, Wiltshire: Outward opening windows for summer comfort ventilation and the utility room porch canopy are shown.



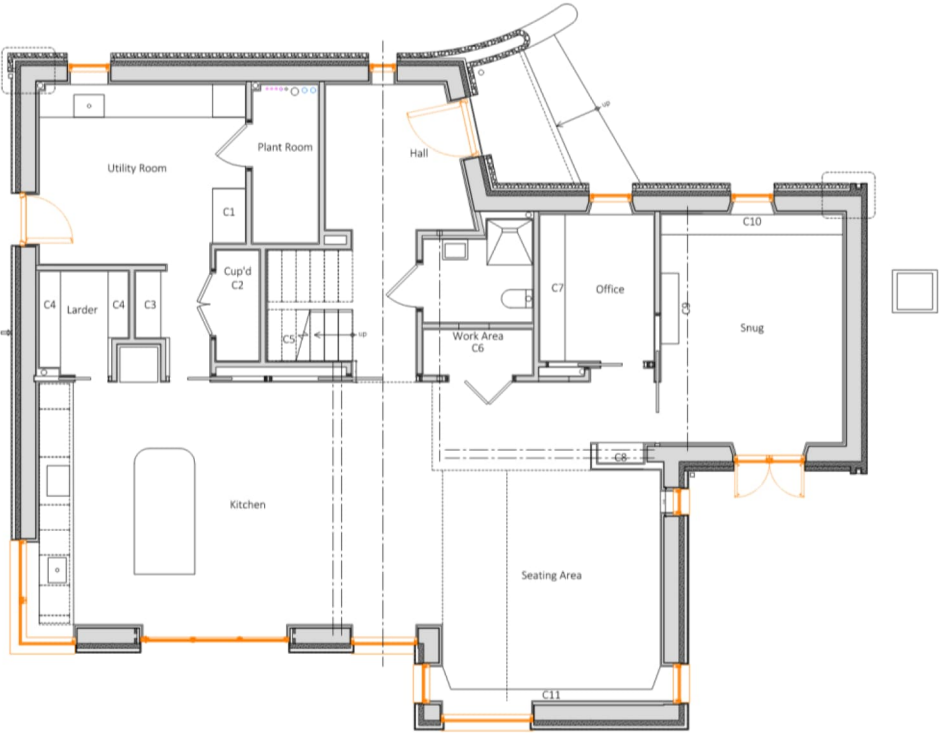
Internal view of the Passivhaus in Bishopstone, Wiltshire: Open plan living / kitchen areas with south facing windows showing views of the countryside beyond.

3 Sectional drawing of the Passivhaus, Bishopstone.

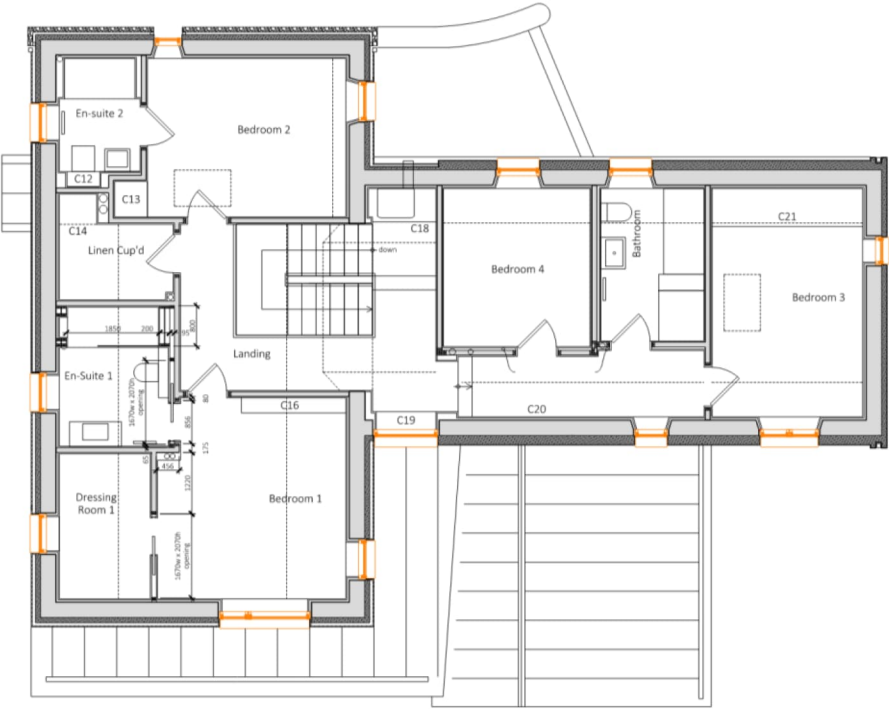


Typical cross-section through the Passivhaus in Bishopstone, Wiltshire: The continuous insulation layer can be seen and the building's airtightness layer layer is visible as a red line. OSB was used as the airtight layer on walls and roofs, taped at junctions, with mid-floor joists and the ridge beam wrapped with airtightness membrane. A solid concrete ground floor formed the airtightness layer at ground floor level.

4 Floor plans of the Passivhaus in Bishopstone.



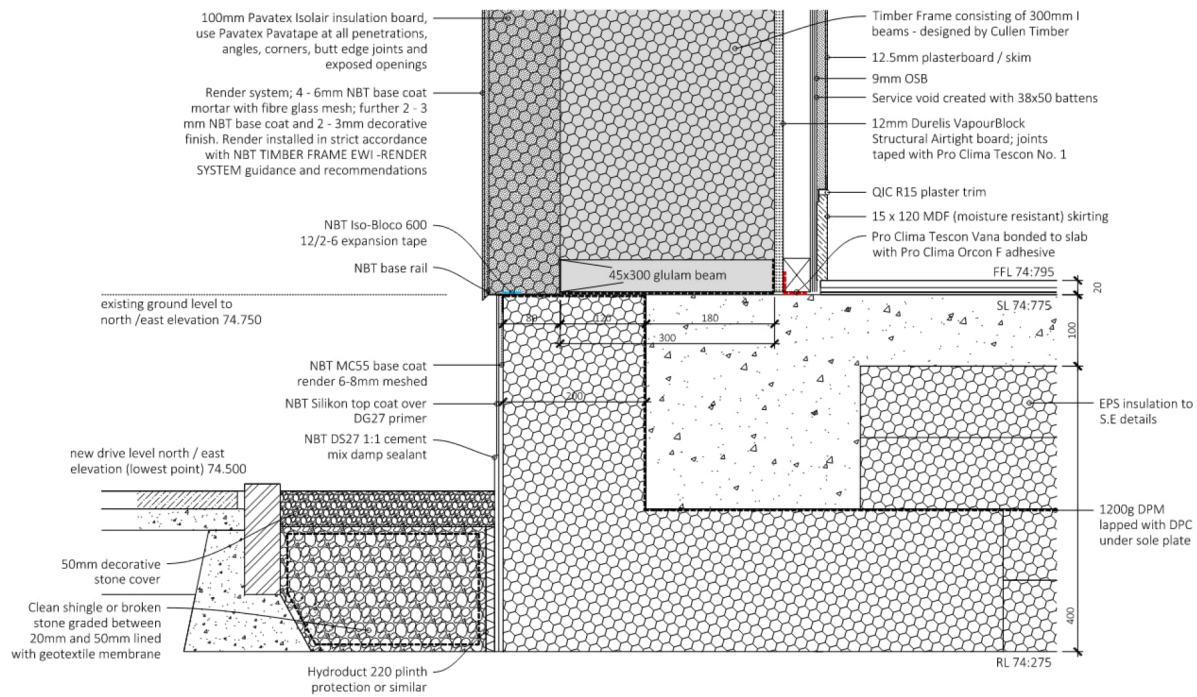
Ground Floor Plan of the Passivhaus in Bishopstone.



First Floor Plan of the Passivhaus in Bishopstone.

5 Construction details of the envelope and Passivhaus technology of the Passivhaus, Bishopstone.

5.1 Construction of the ground floor slab



The ground floor slab is an insulated concrete raft foundation comprising a 100mm reinforced concrete slab insulated beneath with 400mm EPS insulation. The slab depth increases to 300mm (with 200mm insulation beneath) in a ring beam around the perimeter and beneath internal structural walls (Fig. 1). To minimise thermal bridging the external walls over-sail the slab edge to provide insulation continuity at the external wall – ground floor junction. This also enabled door thresholds to sit above the perimeter edge insulation, supported beneath by GRP angle bracket resin-cast into the slab edge. Service penetrations entered via pre-ducted routes in the ground floor slab (Fig. 2).

Floor slab build-up:

Ground Floor Slab	Main slab:	U-value 0.099 W/(m ² K)
	100 mm Reinforced concrete slab 2.0 λ W/mK 400 mm EPS insulation (grey) 0.031 λ W/mK	
	Ringbeam / downstands:	
	300 mm Reinforced concrete slab 2.0 λ W/mK 200 mm EPS insulation (white) 0.032 λ W/mK	

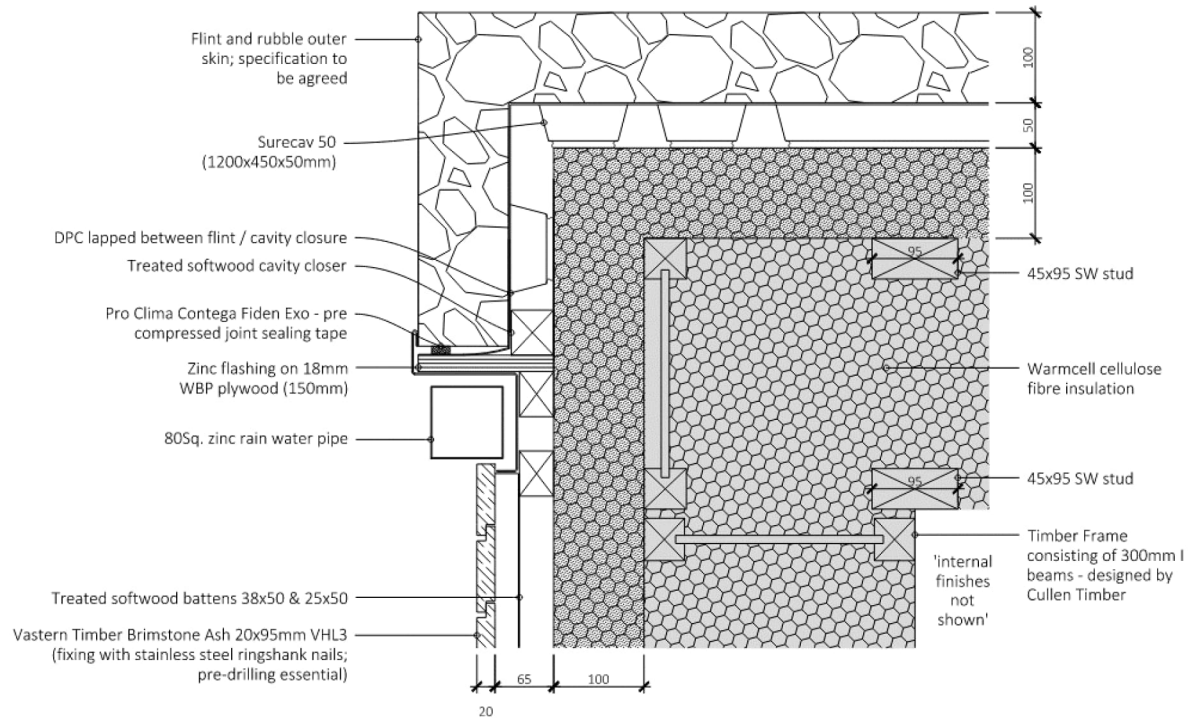


Fig. 1: First 200mm layer of EPS insulation being prepared with DPC before installation of second 200mm EPS layer.



Fig. 2: Plant room service penetrations entering via pre-ducted routes in the ground floor slab.

5.2 Construction including insulation of the external walls



External walls are formed via a timber I-joint frame (300mm), filled with blown cellulose insulation. Walls are lined internally with airtight OSB, followed by a 38mm battened service zone and plasterboard. Externally the walls are covered with 100mm rigid woodfibre insulation. The walls are clad externally with three different rainscreens: render, timber and rubble flint.

External wall build-up:

External Wall	Average:	U-value
	100mm rigid woodfibre board 0.040 λ W/mK	0.095 W/(m ² K)
	300mm cellulose-filled I-Joist timber frame 0.038 λ W/mK	
	12mm Airtight OSB 0.145 λ W/mK	
	38mm battened service void	
	13mm Gypsum plasterboard & skim	

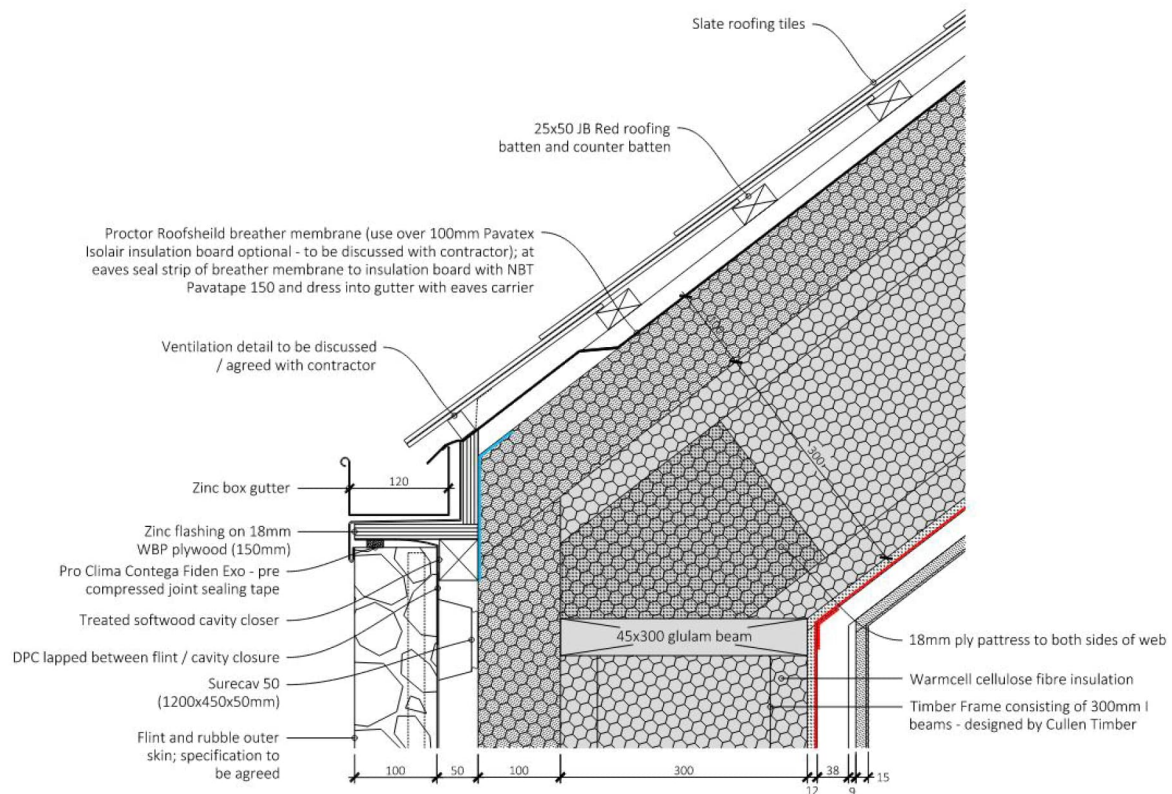


Fig. 3: Timber I-Joist frame in construction. The airtightness membrane wrapped around the mid-floor joists can be clearly seen.



Fig. 4: Rigid woodfibre board applied externally before installation of rainscreen.

5.3 Construction including insulation of the roof



The roof was formed of the same timber construction as the walls, i.e. 300mm cellulose-filled timber I-joist (spanning to a glulam ridge beam), lined externally with 100mm rigid woodfibre board, and internally with airtight OSB and a battened service void. Thermal bridging was minimised by using the same profile I-joist and insulated sarking board as the external walls to create insulation continuity at the eaves.

Roof build-up:

Roof	100mm rigid woodfibre board 0.040 λ W/mK 300mm cellulose-filled I-Joist timber frame 0.038 λ W/mK 12mm Airtight OSB 0.145 λ W/mK 38mm battened service void 13mm Gypsum plasterboard & skim	U-value 0.097 W/(m ² K)
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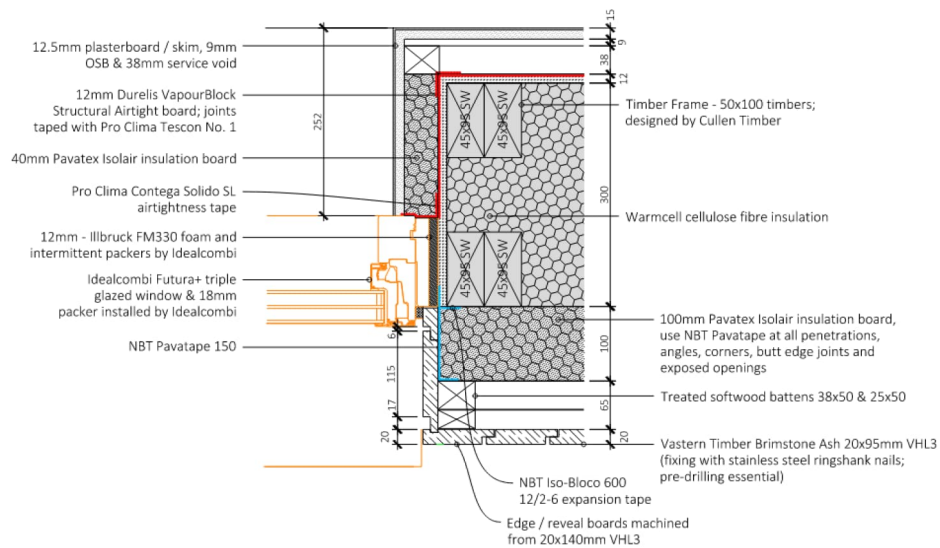


Fig. 5: Timber frame roof in construction.



Fig. 6: Timber I-Joists spanning to glulam ridge beam (left) and installation of blown cellulose insulation (right).

5.4 Window sections including installation drawing



The windows used on the Blackthorn House project were from the Ideal Combi Futura+ range with U_f 0.98 $W/(m^2K)$. Glazed bifold doors were selected from the Solarlux Highline range (U_f 1.65 – 2.15 W/m^2K). Triple glazing was installed throughout with U_g varying from 0.60 – 0.71 W/m^2K , and g-value 0.50 – 0.54. Airtightness around window frames was delivered via flexible airtight expanding foam. Thermal bridging was minimised by positioning window frames within the insulation layer and partially covering the frames with woodfibre board internally and externally.



Fig. 7: Ideal Combi aluminum composite windows before (left) and after (right) installation of external woodfibre insulation.

Window data:

Windows	Triple low-e, argon filled with TGI warm edge spacer. Aluminium composite window frames.	0.98 $W/(m^2K)$
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6 Description of the airtight envelope; documentation of the pressure test result

Airtight OSB was used to provide the airtightness layer on external walls and roofs, with the solid concrete slab forming the ground floor airtightness layer. Airtightness tape was used at junctions to maintain the airtightness barrier and prevent future air leakage from differential movement of building components with time. Continuity around the mid-floor joists and ridge beam was maintained by using an airtight membrane taped internally to the OSB layer. Window and door frames were made airtight using flexible airtight expanding foam.



Fig. 8: Airtightness membrane taped and lapped over mid-floor joists, and window frames installed within airtight layer using flexible airtight expanding foam.

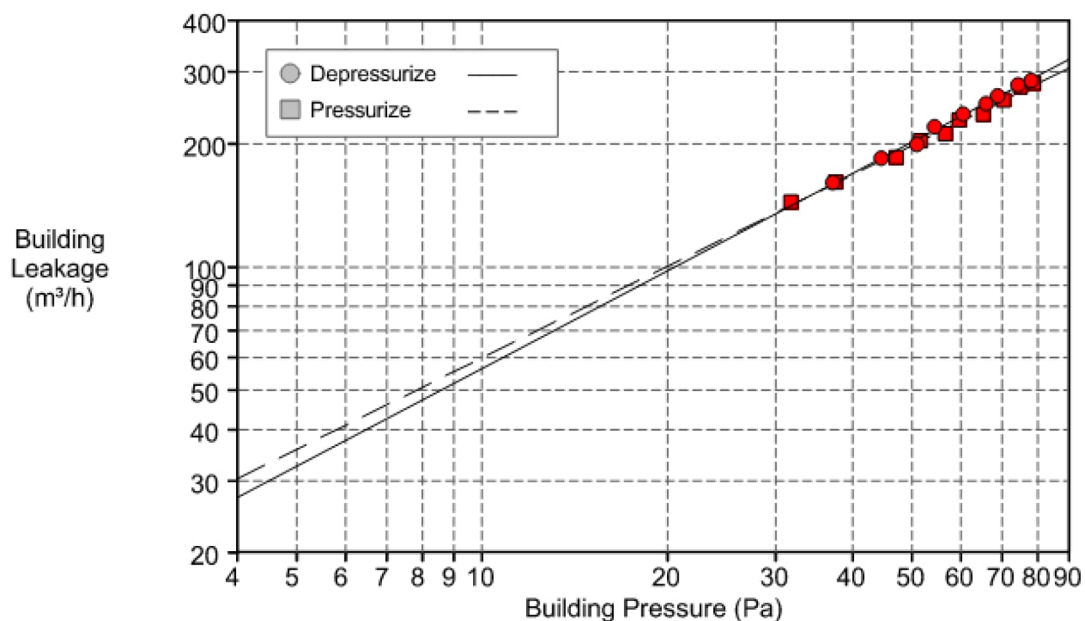
The air pressure test was carried out by Waxwing Energy and the air leakage achieved was $0.33 \text{ h}^{-1}@50\text{Pa}$ on pressurisation and depressurisation.



BUILDING LEAKAGE TEST

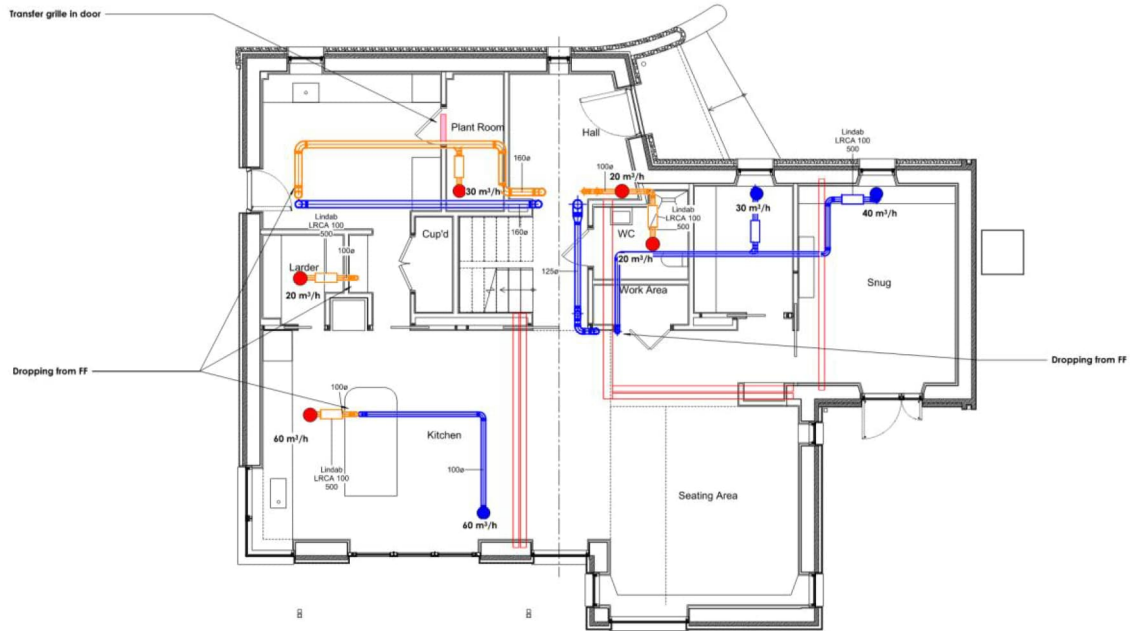
Waxwing Energy
 Reform Cottage
 Little Birch
 Hereford, Herefordshire HR2 8AT

	<u>Depressurization</u>	<u>Pressurization</u>	<u>Average</u>
Test Results at 50 Pascals:			
V50: m ³ /h50 (Airflow)	202 (+/- 1.3 %)	198 (+/- 1.6 %)	200
n50: 1/h (Air Change Rate)	0.33	0.32	0.33
w50: m ³ /(h·m ² Floor Area)	1.41	1.39	1.40
q50: m ³ /(h·m ² Envelope Area)	0.36	0.35	0.35
Leakage Areas:			
Canadian EqLA @ 10 Pa (cm ²)	63.0 (+/- 8.4 %)	66.9 (+/- 9.1 %)	64.9
cm ² /m ² Surface Area	0.11	0.12	0.11
LBL ELA @ 4 Pa (cm ²)	29.5 (+/- 12.7 %)	32.7 (+/- 13.9 %)	31.1
cm ² /m ² Surface Area	0.05	0.06	0.05
Building Leakage Curve:			
Air Flow Coefficient (C _{env}) m ³ /(h·Pa ⁿ)	9.1 (+/- 19.2 %)	10.9 (+/- 21.2 %)	
Air Leakage Coefficient (CL) m ³ /(h·Pa ⁿ)	9.1 (+/- 19.2 %)	10.8 (+/- 21.2 %)	
Exponent (n)	0.793 (+/- 0.047)	0.743 (+/- 0.053)	
Correlation Coefficient	0.99778	0.99623	
Test Standard:	EN 13829		
Test Mode:	Depressurization and Pressurization		
Type of Test Method:	B		
Regulation complied with:	Passivhaus n50 ≤ 0.6 1/h		

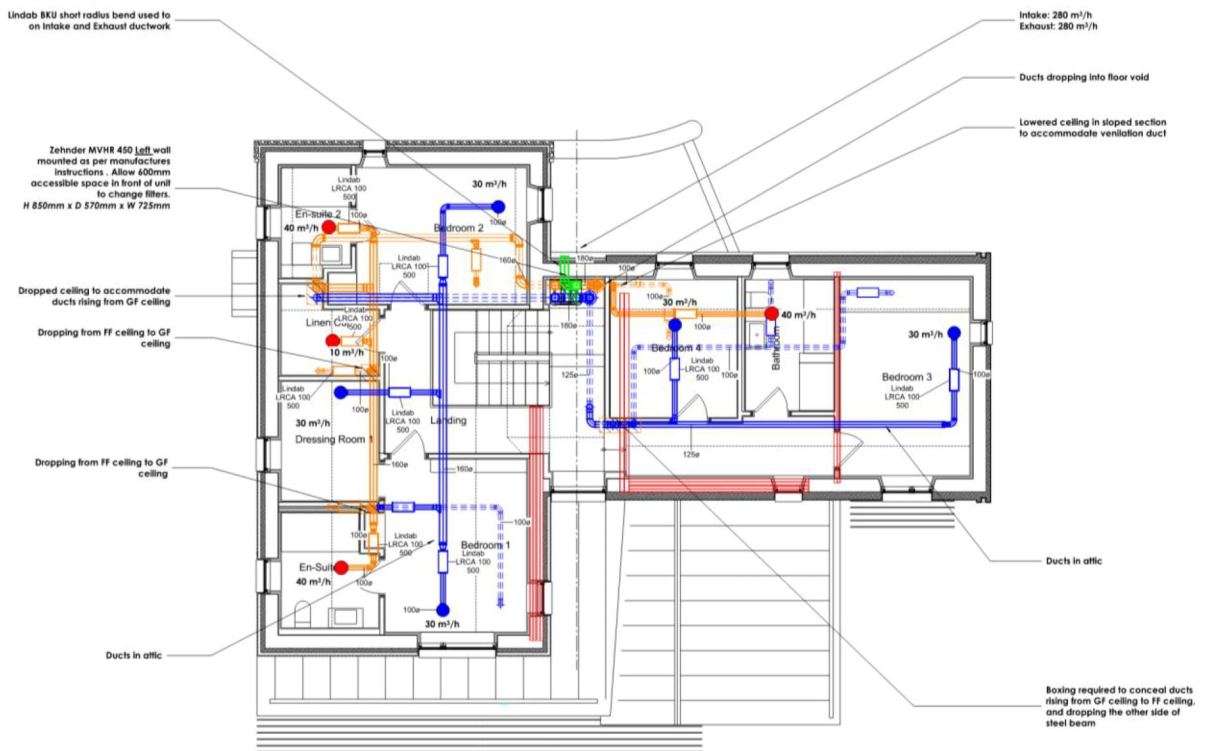


7 Description of the ventilation system

7.1 Planning of the ventilation ductwork



Ground Floor ventilation layout



First floor ventilation layout

The ventilation unit was installed inside the thermal envelope in a utility cupboard at first floor level. This allowed intake and exhaust duct lengths to be kept to a minimum by terminating directly out through the external wall upon which the MVHR unit was mounted. Rigid steel spiral wound ductwork was used throughout with sound attenuators where necessary. Ductwork was concealed within the mid-floor joist zone and above suspended ceilings at first floor level. A recirculating cookertop extractor was installed in the kitchen to remove grease and particulates. Supply ducts (blue) were routed to bedrooms, living areas the kitchen, with extract ducts (orange) routed to bathrooms, ensuites, plant room, utility and store cupboards. Air transfer paths were provided via door undercuts and air transfer grilles where required to balance ventilation volumes across the dwelling.



Fig. 9: Installation of rigid steel spiral wound ventilation ductwork in mid-floor joists for distribution of supply and extract air to ground and first floor rooms.

7.2 Planning of the central unit



Passivhaus certified MVHR Brink Flair 400. This model included a built-in electric frost protection pre-heater with summer bypass mode. Aerfoam insulated ductwork (16mm insulation thickness) was used to convey the cold air flow masses (intake and exhaust) to the outside. Lindab sound attenuators were installed on the supply and extract ducts directly next to the unit to mitigate noise from the MVHR unit propagating via the ventilation system. The effective heat recovery of the system (including heat loss from the external ducts) was 86.4% with a specific power input of 0.20 Wh/m^3 . The system was supplied and installed by CVC systems.

8 Heat Supply


Heat was provided via a Vaillant Arotherm Plus 7 kW air source heat pump. The monobloc ASHP was located externally and delivered hot water to an indoor plant room where it was directed to the heating and hot water systems via a wall-mounted hydraulic module. Hot water storage was stored in a 300 litre storage cylinder, and space heating was delivered via underfloor heating manifolds to ground and first floor levels. A 45 litre buffer vessel was provided on the heating circuit to increase the effective water volume of heating circuit to minimise ASHP short-cycling and increase the seasonal coefficient of performance. Additionally the flow temperature of the air source heat pump is weather-compensated to operate in the range 30°C – 48°C to maximise heat pump efficiency. The heat pump contains 0.9kg of hermetically sealed R290 (propane) refrigerant with a global warming potential of 3 (0.0027 TCO₂ equivalent).



Fig. 10: Vaillant Arotherm monobloc ASHP (left) and plant room (right) containing Vaillant indoor hydraulic module, DHW store and 45 litre buffer vessel.

9 PHPP Calculations

The verification sheet from PHPP.

Passive House Verification																																																																																																																		
		Building: Blackthorn House Street: Crouchston Postcode/City: SP5 4BU Province/Country: Wiltshire GB-United Kingdom/ Britain Building type: Residential Climate data set: GB0006a-Lyneham Climate zone: 3: Cool-temperate Altitude of location: 75 m																																																																																																																
		Home owner / Client: Mr and Mrs Castle Street: Crouchston Postcode/City: SP5 4BU Province/Country: Wiltshire GB-United Kingdom/ Britain																																																																																																																
Architecture: Inkbox Architecture Street: Oak Tree Cottage, Brislands Lane Postcode/City: GU34 5AE Province/Country: Hampshire GB-United Kingdom/ Britain		Mechanical engineer: Greengauge Building Energy Consultants Street: The Old Brewery Postcode/City: BA15 1NF Bradford On Avon Province/Country: Wiltshire GB-United Kingdom/ Britain																																																																																																																
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No. of dwelling units: 1	Internal heat gains (IHG) heating case [W/m²]: 2.3	IHG cooling case [W/m²]: 2.3																																																																																																																
No. of occupants: 3.1	Specific capacity [Wh/K per m² TFA]: 84	Mechanical cooling:																																																																																																																
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I confirm that the values given herein have been determined following the PHPP methodology and based on the characteristic values of the building. The PHPP calculations are attached to this verification.			Passive House Classic? <input checked="" type="checkbox"/> yes Signature:																																																																																																															
Task: 2-Certifier	First name: Naomi	Surname: Grint																																																																																																																
Certificate ID: 41506_ETUDE_PH_20240202_NG	Issued on: 02/02/24	City: London																																																																																																																

10 Construction costs

The following cost information was provided by the client:

Cost figures are imprecise but excluding VAT, the garage (which is not part of the house and is not passive), excluding landscaping, external works and furnishing but including the kitchen, professional costs and a new sewage treatment plant the total cost is of the order of £1,031,000 which based on 227 square meters represents £4,541 per sq meter or £422 per sq foot.

In building Blackthorn House minimum cost was not our prime objective but there are many examples from all over the country of housing built to passive house standards that cost little or no more than the equivalent housing built to meet the current building code. The very material reduction in the cost of heating, cooking and power in a passive house is itself a large contributor to a reduction in the cost of living in such a house which can easily compensate for increased construction costs, before any consideration is given to the enhanced year round living environment.

Our high costs can be attributed to various items;

1 *We chose to clad the north side of the house in free laid flint and much of the rest of the house in Brimstone heated ash cladding. This helped blend the contemporary structure with the local vernacular.*

2 *Where economy is paramount the least costly format for a passive house is a rectangular block over two floors with four corners and a straightforward pitched roof. Our house has a complicated external design with numerous corners which of themselves add to the cost as that is where a lot of time is spent achieving airtightness and avoiding thermal bridging. There are also seven different roof slopes and single storey areas where the roof is almost flat, necessitating extensive hand crafted zinc work – and an efficiency loss.*

3 *The house is built to a fairly high quality finish including, externally, partially concealed zinc rainwater goods and internally pocket doors, shadow gaps rather than skirting and high ceilings that extend into the roof space. In addition, the internal walls are all insulated and in addition to plaster board have a layer of OSB board underneath to make all walls load bearing for pictures etc and also to ensure sound proofing.*

4 *If economy was the first consideration we should probably have adopted SIP panels for the external walls. We had a timber consultant to convert the architects' timber design for the house into digital cutting instructions for a timber yard. This resulted in the house frame being delivered from the timber yard on three trucks in stick form with every piece of timber coded to enable simple erection of what was*

effectively a huge timber jigsaw puzzle. This was achieved very satisfactorily but it was time consuming. Arguably the end result is more thermally efficient as there are no joins in the external structure and insulation was pumped into the walls under pressure to make the walls seamless.

5 For reasons that are now not immediately clear in addition to the 300mm of insulation that were pumped into the external walls an additional 100mm of wood fibre board insulation was added to the outside of the timber frame of the house. Erecting this along with the Brimstone ash cladding proved a very time consuming operation and duplicated work that had already been done by insulating the walls by injection.

6 Although described as a selfbuild we were not involved in the day to day construction of the house; our builders, Maidment and Carter, were fully in charge on site. They were perfectionists and every step of the way the highest quality work was undertaken. The other side of that coin was that quality took time and it was therefore more costly; that said we suffered none of the tales one hears of nightmare builders. A passive house is a rare beast in this part of the world and no builder we spoke to had ever built to the required standard. As a result financially we were very largely flying by the seat of our pants and the final cost was much higher than we had planned for at the outset. No builder we came across would give us anything like a fixed price. We commenced work on site in March 2021 by which time we were well into the inflationary spiral caused by Covid/Ukraine and other disasters but by that time we had already bought many long lead time items such as the timber frame, insulation, windows, doors etc so whilst there were a lot of costs incurred by the builder, the major factor in our extra cost was that there was far more labour on site.

11 Measured results of the inhabited Passivhaus in Bishopstone

11.1 Measured energy consumption values

Electricity meter readings have been taken since June 2022, however due to problems with the incumbent energy supplier solar export readings have only been available since March 2024. Total electricity import for the most recent year to date (August 2023 – August 2024) was 4,800 kWh/yr (21.1 kWh/m²_{TFA}), with a total solar PV electricity generation of 7,300 kWh/yr (16.5 kWh/m²_{TFA}). Based on the export meter readings since March 2024 it is estimated that around 40% of the PV generation is consumed on-site, with the remaining 60% exported to the grid. From this a total Energy Use Intensity (electricity used by the home) of 7,700 kWh/yr (34 kWh/m²_{TFA}) is inferred.

Space heating demand has also been measured via the built-in metering within the ASHP controls system and suggests an average space heating demand of 11 kWh/m²_{TFA}/year in operation.

11.2 Year of construction

March 2021 – June 2022

11.3 User satisfaction

Prue and Allan Castle, Blackthorn House

„If we were going to build an Eco house why not try and achieve the highest efficiency possible - it would have been frustrating to live in ‘nearly a passivhaus’. Our architect carefully explained all the other options available through the AECB but Passivhaus is a more recognisable concept. At the end of the day it was our decision as the client.

The house is undoubtably lovely to live in. Not only in terms of warmth and comfort but also light and aspect. Each room is evenly warm with small variations between rooms facing North and those facing South. The house is not too hot - we still wear jumpers! It is also super quiet - both within the house and keeping out external noise.

The builders - who had never built a Passivhaus before - really got the hang of it. The site foreman embraced the concept and the detailing and was rigorous in making sure that the subcontractors understood it too and didn't try and cut corners. From

our point of view as the client the challenge therefore was less to do with the quality of the site work which was excellent but more to do with keeping the costs down. The extra costs were not just related to the Passivhaus details such as taping all the joints, routing the services through the slab etc but also labour costs re fixing the cladding and other items which we would have had whether Passiv or not.“