Project Documentation

Abstract

Single storey (plus mezzanine) detached holiday home on banks of Ullswater, Lake District, UK

Building data

Year of construction	2021
U-value-wall	0.089 W/m^{2}K
U-value-ground slab	0.100 W/m^{2}K
U-value-roof	0.089 W/m^{2}K
U-value-window (average)	0.84 W/m^{2}K
Heat recovery	90%
Space heating demand	14.2 kWh/m^{2}a
Primary Energy Renewable (PER)	54 kWh/m^{2}a
Generation of renewable energy	25 kWh/m^{2}a
Non-renewable primary energy	108 kWh/m^{2}a
Pressure test n_{50}	0.14 h^{-1} @ 50Pa.

Brief description

Tethera is built as a private holiday home for the architect owners who live and work in Stockport, Greater Manchester. It replaces an existing 1950s bungalow which had reached end of life; the bungalow benefitted from an enviable location and view of Ullswater and was offered for sale on the open market in 2019. Discussions were held with the Lake District National Park planning authority who agreed in principle to replacement of the bungalow with a new dwelling having similar form and materials. During 2020 the design evolved and planning permission obtained without challenge; construction started at the beginning of January 2021.

The passivhaus envelope is a simple rectangular form with a cathedral roof extending for its full 14m length. The open plan lounge, dining and kitchen occupy the southern half of the home. The north half contains bedrooms and bathrooms, with a mezzanine structure above offering reduced height accommodation and the plant room. This additional floor area did improve the form factor but it remains poor at 3.9 owing to the building's relatively small size.

The primary views, and large windows therefore, are to the south-west and west. The south facing gable end looks onto a wooded area. Outriggers extend at each corner to support the hidden gutter and eaves structure on either long side; this structure also provides solar shading to the glazed areas.

Once the groundworks and insulated raft foundation were complete, construction was swift. The prefabricated timber frame panels were installed within three days, with the windows and external doors following soon after providing a fully air and weathertight envelope. The project was completed within six months of clearing the site.

Project participants

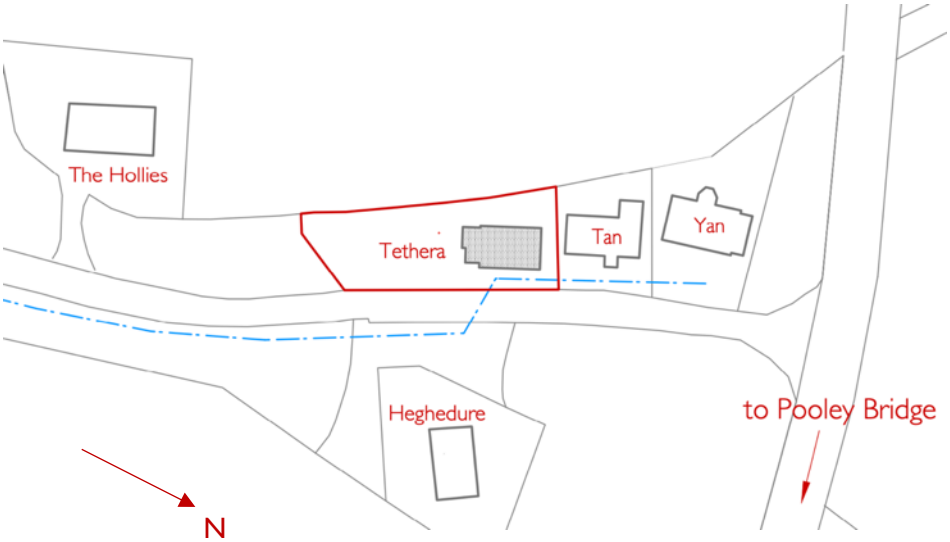
Architect:	Hesketh Hayden www.heskethhayden.co.uk
Project management:	Hesketh Hayden
Energy consultants:	Hesketh Hayden and Humblebee Eco www.humblebee .co.uk
Mechanical services:	Humblebee Eco
Structural engineering:	via Eden Insulation www.edeninsulation.co.uk
Certifier:	Etude www.etude.co.uk

Certification ID **7086**

Author of project documentation

Hesketh Hayden

Date: 01 December 2022 Signature:



Location plan

Views of completed building

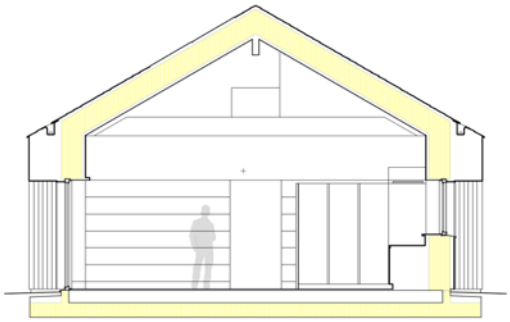
View from north

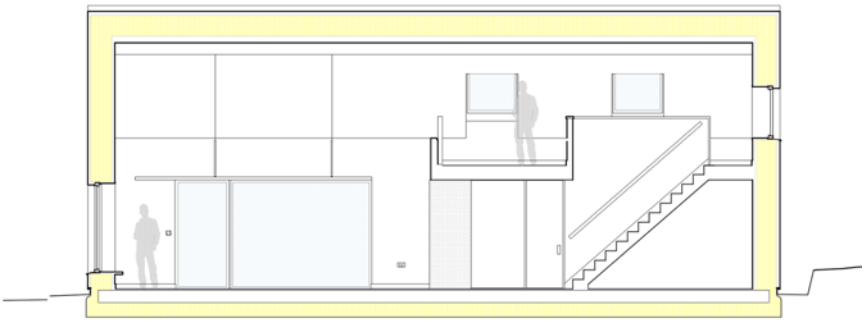
View from north-west

View from south

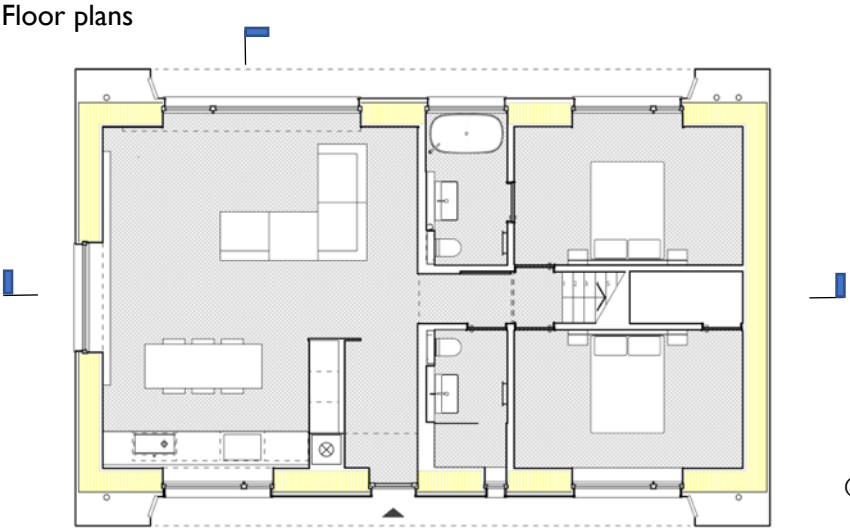
Interior views

Section drawings

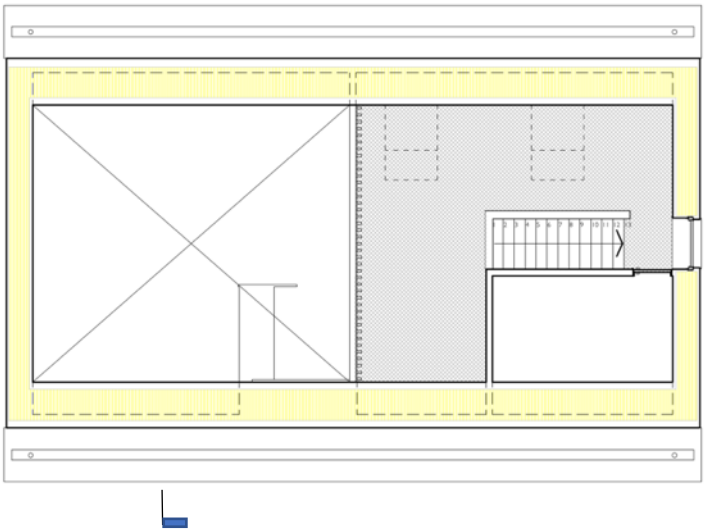




Floor plans



Ground



First

Description of the construction

1. Ground floor slab

The reinforced concrete slab is 260mm thick and sits inside a 300mm thick EPS insulation 'tray'. The concrete has 50% GGBS cement replacement.

Assembly no.	Building assembly description					Interior insulation?
01ud	Floor slab					

Heat transmission resistance [m²K/W]

Orientation of building element: 3-Floor — interior R_{si}: 0.17

Adjacent to: 2-Ground — exterior R_{se}: 0.00

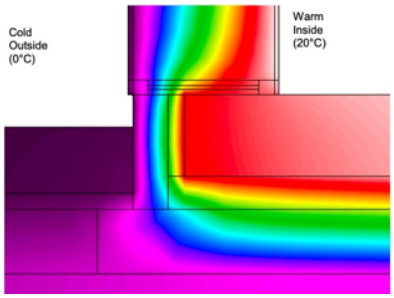
Area section 1	λ [W/(mK)]	Area section 2 (optional)	λ [W/(mK)]	Area section 3 (optional)	λ [W/(mK)]	Thickness [mm]
Porcelain tile	1.500					15
Concrete slab	2.100					260
Insulation-Isoquick	0.031					300

Percentage of sec. 1	Percentage of sec. 2	Percentage of sec. 3	Total
100%			57.5 cm

U-value supplement: W/(m²K)

U-value: 0.100 W/(m²K)

EPS insulation tray being installed



Isotherm diagram of wall/floor junction

2. External walls and roof

The wall and roof superstructure comprises prefabricated panels, assembled locally with 400mm deep engineered timber I-joists, cellulose insulation fill, 22mm woodfibre sarking externally and 12mm Propassiv OSB internally. A single 14m long glulam ridge beam spans the length of the building providing support to the roof panels. After taping and sealing, the frame was fully weathertight within three days of starting.

Assembly no.	Building assembly description					Interior insulation?
04.80952380952381ud	Wall above ground					

Heat transmission resistance [m²K/W]

Orientation of building element: 2-Wall — interior R_{si}: 0.13

Adjacent to: 1-Outdoor air — exterior R_{se}: 0.04

Area section 1	λ [W/(mK)]	Area section 2 (optional)	λ [W/(mK)]	Area section 3 (optional)	λ [W/(mK)]	Thickness [mm]
Plasterboard	0.250					15
Service void-Th'fleece	0.039					45
Chipboard-VapourBlock	0.130					13
Insulation-Isofloc blown	0.038	timber battens	0.130	timber battens	0.130	40
Insulation-Isofloc blown	0.038			timber battens	0.130	320
Insulation-Isofloc blown	0.038	timber battens	0.130	timber battens	0.130	40
Insulation-Multiplex Top	0.044					22

Percentage of sec. 1	Percentage of sec. 2	Percentage of sec. 3	Total
79%	16.5%	4.5%	49.5 cm

U-value supplement: W/(m²K)

U-value: 0.089 W/(m²K)

Prefabricated wall panels being craned into position

Installation of prefabricated first floor panels towards end of Day 1

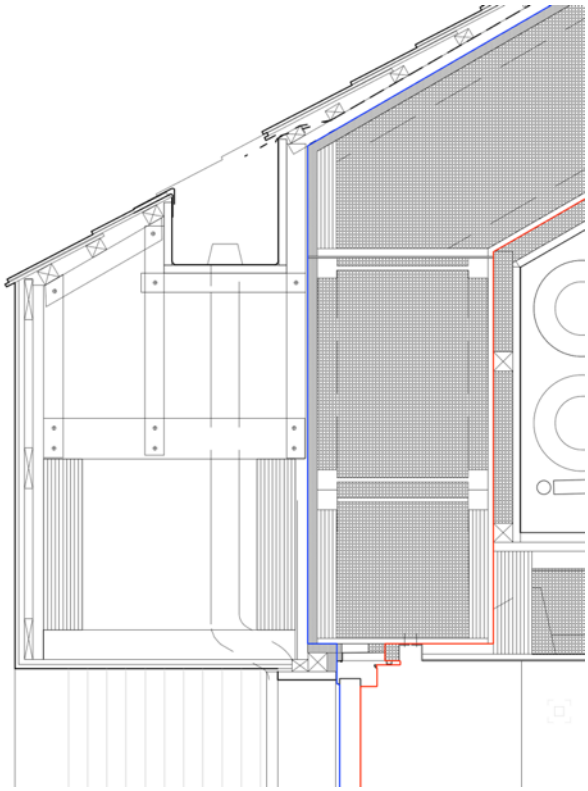
View of completed frame from mezzanine

The outrigger structure on each long side is outside and structurally independent from the passivhaus thermal envelope. Deep LVL beams span between the external storage volumes at each corner.

External walls are boarded and finished with render. Solid wall surfaces below the overhangs are clad with narrow vertical larch boards, pre-finished with SiOOX weather treatment to maintain an even appearance.

The roof re-uses the Westmoreland slates from the previous dwelling, falling to deep hidden gutters that drain at each end to outlets and downpipes within the corner outriggers. The south-west facing roof has photovoltaic panels, detailed to sit flush with the adjacent slates, and two quadruple glazed rooflights providing daylight at mezzanine level.

View of hidden gutter



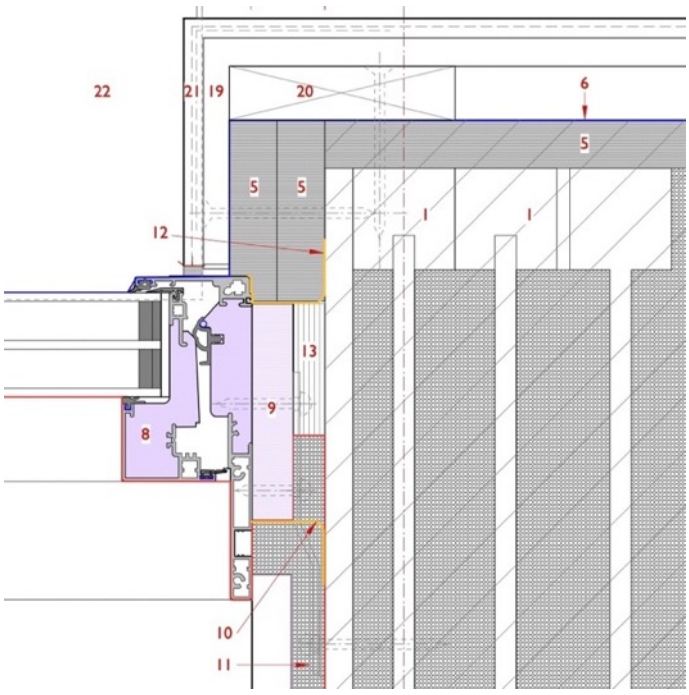
Detail section at eaves through hidden gutter and outrigger

3. Windows

Window openings are formed within the prefabricated structural wall panels with double or triple I-joists at the jambs and LVL lintels above.

Airtightness is achieved with internal and external tape, expanding foam tape was applied to the perimeter just before windows were positioned. Heat was applied at some corners to ensure the expanding tape fully filled the gaps.

1	Engineered I-joists full filled with cellulose insulation
5	22mm woodfibre sarking insulation
8	*Idealcombi Futura+i* inward opening window frame
9	site fixed timber packer
10	*Tescon Profil* internal airtightness tape
11	galv. steel window fixing strap
12	*Tescon Vana* external airtightness tape
13	expanding foam tape
19	12mm render carrier board
20	25mm treated battens
21	render system with mesh reinforcement
22	window cill below.



Typical window jamb detail in rendered wall

4. Airtight envelope

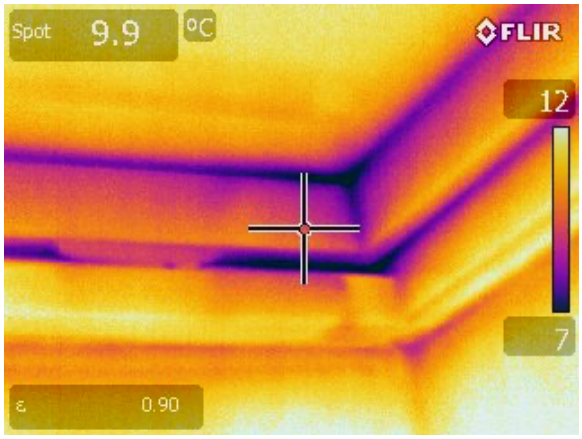
The prefabricated wall and roof panels arrived on site fully sealed and airtight. All panels are lined internally with 12mm *Propassiv* structural OSB boards, simply butt jointed, then taped internally and externally with *Tescon Vana No.1 tape*. The junction between panels and concrete floor slab are sealed with brush applied *Aerosana Visconn* liquid membrane. Airtightness at ground level relies on the concrete raft.

Construction view of prefabricated external wall and floor panels

Testing in progress

Air leakage was measured by Green Footsteps by blower door test based on the building volume of 363m^2. The interim and final tests achieved an average air change per hour (n_{50}) of 0.14 h^{-1} @ 50Pa.

The quadruple glazed *Fakro* rooflights were seen to be the most problematic in not achieving better airtightness, with air leakage evident between frames using infrared imagery and smoke during depressurisation. *Fakro* were invited to comment on the poor performance but they considered them to be within the specified parameters and offered no further assistance.



Infrared image of rooflight during airtest

Smoke testing during airtest

5. Ventilation system

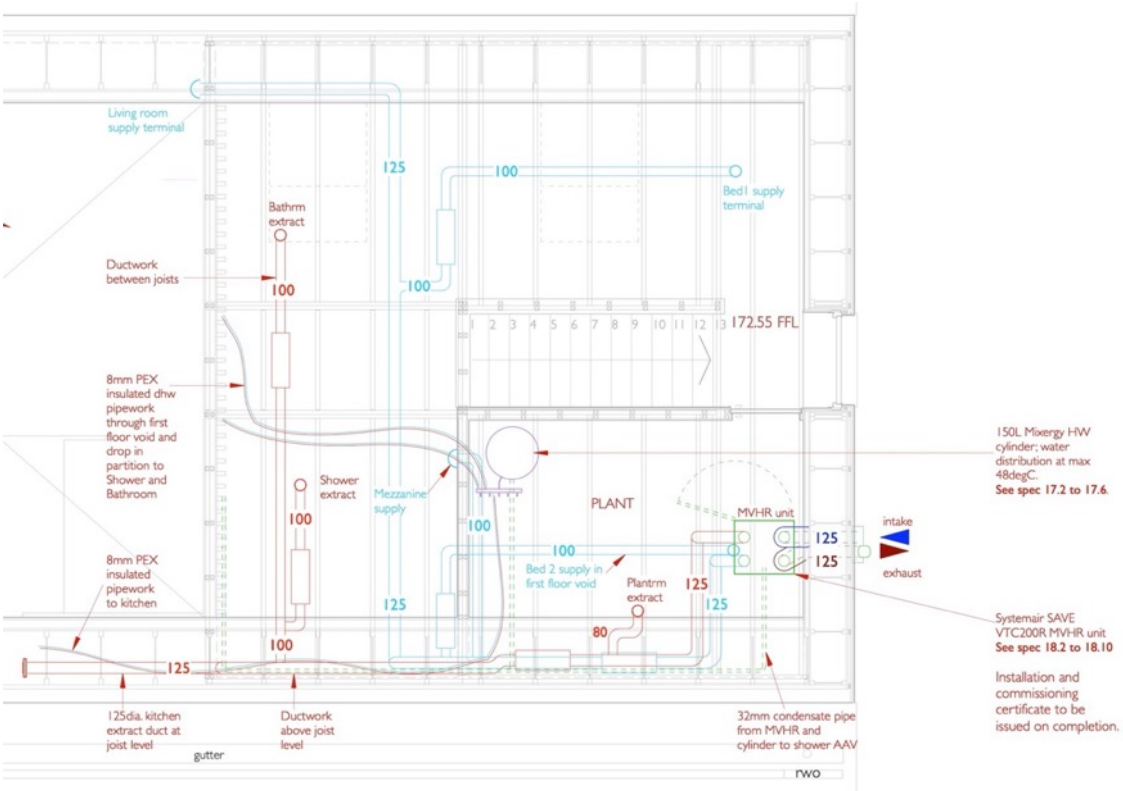
The unit chosen for the mechanical ventilation system is Systemair's SAVE VTC 200R. It is located at mezzanine level within the dedicated plantroom space, entirely within the thermal envelope. The unit is certified to provide an air recovery rate of 90%.

The unit is against the external wall with short duct lengths (approx. 300mm) to the external wall, insulated with Armaflex insulation. Galvanised spiral metal ductwork extends from the unit within the first floor void to the bedrooms and wet rooms below and to the main living space. In-line silencers are concealed within the floor void and within the plantroom.

Systemair SAVE VTC 200R unit installed in plant room

Ductwork and silencers located in first floor void

The Systemair unit has a large hinged front panel for maintenance and filter change. The panel is, however, secured with eight specialist head screws, making access time consuming and fiddly.



First floor plan with MVHR system located in plant room and first floor void

6. Heat supply system and hot water

The strategy for space heating at Tethera is simple. It relies on good solar gains through the substantial glazed areas to the south and west, gains from human activity, and output from two electric towel rails, one in the Bathroom and one in the Shower. These are Rointe D-Series 600W units with built-in WiFi for remote control. There are no other dedicated heat sources.

Domestic hot water is provided by a Mixergy electric immersion hot water storage tank located in the plantroom. The 150L Direct Smart Cylinder links to the 12-panel photovoltaic array via a diverter and has primary and backup electric immersion heaters.

The cylinder's hot water draw pipe is connected to a 32mm steel manifold with six connections. The hot water temperature in the distribution pipework is maintained by ensuring short runs from the distribution manifold in 8mm PEX pipework direct to fittings.

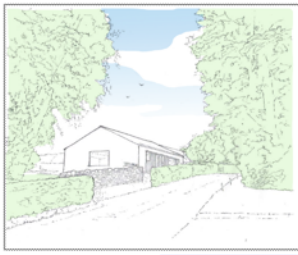
A GivEnergy battery is installed with a capacity of 8.2kWh, allowing greater use of on-site generated electricity. The solar PV system is set up to meet in-house electricity demands first, followed by water heating and then battery storage.

Hot water manifold system

Insulated 8mm PEX pipework

PHPP calculations

Passive House Verification



Building:	Tethera		
Street:	Watermillock		
Postcode/City:	CA110JN	Penrith	
Province/Country:	Cumbria		GB-United Kingdom/ Britain
Building type:	Single family home		
Climate data set:	GB0009a-Carlise		
Climate zone:	3: Cool-temperate	Altitude of location:	170 m
Home owner / Client:	Russel Hayden		
Street:	2 Churwell Avenue		
Postcode/City:	SK4 3QE	Stockport	
Province/Country:	Greater Manchester		

Architecture:	Hesketh Hayden		
Street:	2 Churwell Avenue		
Postcode/City:	SK4 3QE	Stockport	
Province/Country:	Greater Manchester	UK	
Energy consultancy:	Humblebee Eco		
Street:	Hawthorn Walk		
Postcode/City:	SK9 5BS		
Province/Country:	Cheshire		

Mechanical system:	Humblebee Eco		
Street:	Hawthorn Walk		
Postcode/City:	SK9 5BS		
Province/Country:	Cheshire		
Certification:			
Street:			
Postcode/City:			
Province/Country:			

Year of construction:	2021	Interior temperature winter [°C]:	20.0	Interior temp. summer [°C]:	25.0
No. of dwelling units:	1	Internal heat gains (IHG) heating case [W/m²]:	2.6	IHG cooling case [W/m²]:	2.6
No. of occupants:	2.5	Specific capacity [Wh/K per m² TFA]:	84	Mechanical cooling:	

Specific building characteristics with reference to the treated floor area

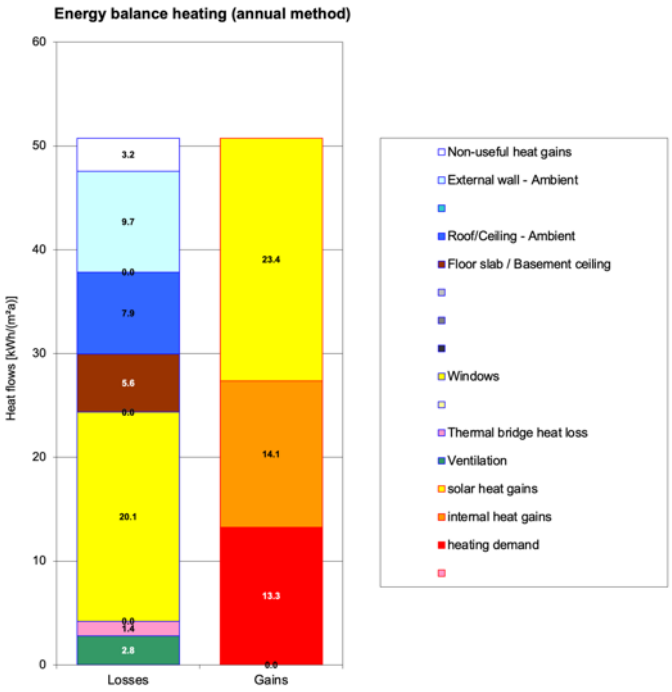
					Criteria	Alternative criteria	Fullfilled?[2]
	Treated floor area	m²	110.0				
Space heating	Heating demand	kWh/(m²a)	14.2	≤	15	-	yes
	Heating load	W/m²	10	≤	-	10	
Space cooling	Cooling & dehum. demand	kWh/(m²a)	-	≤	-	-	-
	Cooling load	W/m²	-	≤	-	-	
	Frequency of overheating (> 25 °C)	%	0	≤	10		yes
	Frequency excessively high humidity (> 12 g/kg)	%	0	≤	20		yes
Airtightness	Pressurization test result n_{50}	1/h	0.1	≤	0.6		yes
Non-renewable Primary Energy (PE)	PE demand	kWh/(m²a)	108	≤	-		-
Primary Energy Renewable (PER)	PER demand	kWh/(m²a)	54	≤	60	60	yes
	Generation of renewable energy	kWh/(m²a)	25	≥	-	-	

[2] Empty field: Data missing; '-': No requirement

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? yes

Task:	First name:	Surname:	Signature:
	russel	hayden	
	Issued on:	City:	

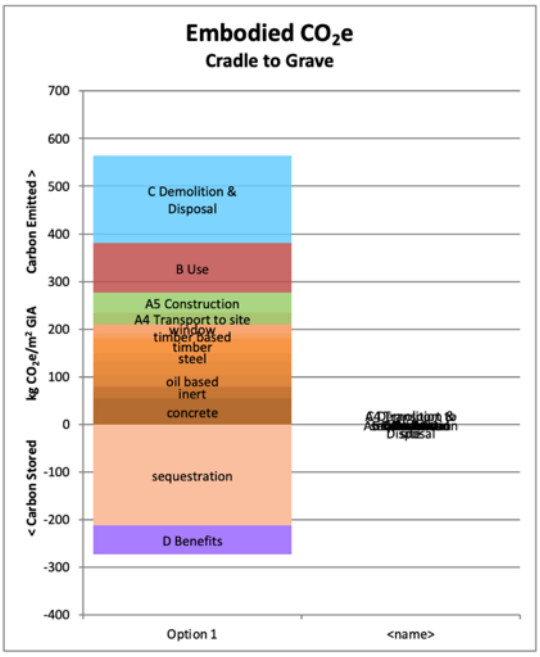


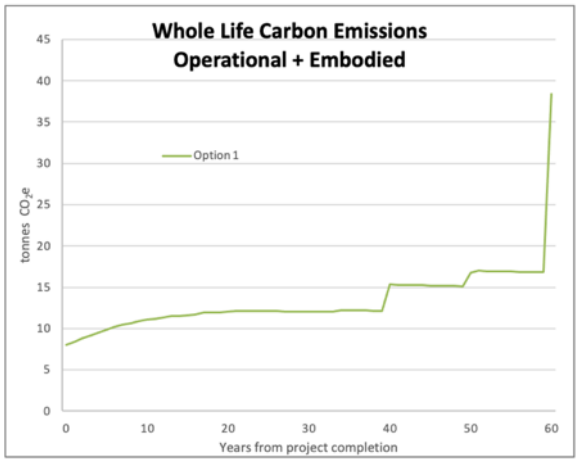
Extracts taken from PHPP spreadsheet

Embodied carbon and operational energy

Calculations have been carried out by Tim Martel to assess the embodied carbon for the proposals. The as-built home scored a cradle-to-grave embodied carbon figure of **351kg CO_2e/m²** GIA, satisfying the RIBA 2030 Climate Challenge target. The concrete slab is a major limiting factor to a better result, despite adopting 50% GGBS as cement replacement.

The operational energy figure is **39kWh/m².a** GIA, satisfying the RIBA 2025 Climate Challenge target.





if Operational varies then adjust these cells

Operational	Option 1	Option 2	Option 3	Option 4
Space Heating kWh/m2.a	14.2	14.2	14.2	14.2
Final Energy kWh/m2.a (excl PV)	41.6	41.6	41.6	41.6
Tonnes CO2e over 60yrs (incl PV)	3.5	0.0	0.0	0.0
kgCO2e/m² GIA over 60yrs (incl PV)	29.4			

Embodied	Option 1	Option 2	Option 3	Option 4
tonnes CO2e A-C over 60yrs	41.4	0.0	0.0	0.0
RIBA kgCO2e/m² GIA over 60yrs	351.2			
LETI kgCO2e/m² GIA over 60yrs	268.7			

Option 1
Embodied CO2 kgCO2e/M2, GIA

	Building element category	A1-A3 Manufac	A1-A3 Sequestered	A4 Transp to site	A5 Construc	B1, B2, B3	B4, B5	C1-4	D
Facilitating works	Toxic Material Treatment							0	0
	Major Demolition Works							0	0
	Temporary Enabling Works	0	0	0	Estimated using RICS as a total only (C1 is also only given as a total, so is in the 3 totals but not the table)	0	0	0	0
	Specialist Ground works	0	0	0		0	0	0	0
Substruc	Substructure	90	0	11		0	6	11	5
Superstructure	Frame	0	0	0		0	0	0	0
	Upper floors incl. balconies	5	-14	0		0	0	15	0
	Roof	20	-76	4		0	0	56	-19
	Stairs and ramps	0	0	0		0	0	0	0
	External Walls	34	-118	7		0	6	85	-36
	Windows and External Doors	19	0	2		0	27	6	-7
	Internal Walls and Partitions	6	-5	1		0	0	6	-3
	Internal Doors	0	0	0		0	0	0	0
Finishes	Wall Finishes	0	0	0		0	0	0	0
	Floor Finishes	0	0	0		0	0	0	0
	Ceiling Finishes	0	0	0		0	0	0	0
FF&E	FF&E (fixed)	0	0	0		0	0	0	0
	FF&E (non-fixed)	0	0	0		0	0	0	0
Building Services	Building services	9	0	0		0	9	0	0
	Refrigerant Leakage	0	0	0		0	0	0	0
	Renewable Electricity Generation	27	0	0		0	55	0	0
Prefab	Prefab Building Units	0	0	0		0	0	0	0
Existing	Minor Demolition and Alterations	0	0	0		0	0	0	0
External	External Works	0	0	0		0	0	0	0
	LETI Total for Option 1	183	-213	25	42	0	49	183	-60
	RIBA Total for Option 1	210	-213	25	42	0	104	183	-60
	All, Option 1	210	-213	25	42	0	104	183	-60

RIBA CHALLENGE (includes ●)
Building Type: Domestic

Operational Energy	39 kWh/m².a GIA
RIBA level met	2025 Target
Embodied Carbon	351 kg CO_2e/m² GIA
RIBA level met	2030 Target

User experience

The building has been occupied during holiday times and then, on average, on alternate weekends. It is difficult therefore to provide an accurate energy usage comparison with other similar sized projects that are more frequently occupied. The following has been recorded between October 2021 and October 2022.
Solar PV generated: 2840kWh. (620kg saved)
Total energy consumed: 3020kWh.

The primary take-away is that Passivhaus is proving to be an ideal approach for properties that are not constantly occupied. On arrival, after a couple of weeks away, the internal environment is not 'stale', thanks largely to the MVHR and careful use of zero VOC coatings and materials.

After one heating season the internal temperature could be best described as adequate first thing on a winter morning, but the temperature soon rises to a comfortable level as activities start. Provision has been made for an additional radiator to be installed in the living space should the towel rails prove insufficient, but there are no plans for this at the moment. A further fall back option is installation of an electric heater installed in the MVHR supply air duct.

Although Cumbria is renowned more for rain than sun, the southwest facing glazing does has result in some overheating particularly in Bedroom 1 and the bathroom. Experience has shown this is most simply dissipated or avoided with cross and stack ventilation, particularly when the rooflights are opened.

Overall the internal environmental is supremely comfortable and confirms Passivhaus as the only approach that guarantees comfort and low energy bills.