Submission for renewal of CEPH Designer qualification by

Paul Mallion, BSc(Hons) MSc(Arch) FRICS

Project Documentation

Gebäude-Dokumentation

Top Barn, Sandwell, Kent, UK

1 Abstract / Zusammenfassung

Barn conversion into 3 bed detached house, Maidstone, Kent, England

1.1 Data of building / Gebäudedaten

Year of construction/ Baujahr	2021	**Space heating / Heizwärmebedarf**	**17 kWh/(m²a)**
U-value external wall/ U-Wert Außenwand	0.094 W/(m²K)		
U-value floor U-Wert Kellerdecke	0.149 W/(m²K)	**Primary Energy Renewable (PER) / Erneuerbare Primärenergie (PER)**	35 kWh/(m²a)
U-value roof/ U-Wert Dach	0.089 W/(m²K)	**Generation of renewable energy / Erzeugung erneuerb. Energie**	N/A
U-value window/ U-Wert Fenster	0.85 W/(m²K)	**Non-renewable Primary Energy (PE) / Nicht erneuerbare Primärenergie (PE)**	86 kWh/(m²a)
Heat recovery/ Wärmerückgewinnung	%	Pressure test n_{50} / Drucktest n_{50}	0.53 h-1
Special features/ Besonderheiten	All natural insulation materials used above floor level		

1.2 Brief Description

Top Barn, Sandway, Maidstone, Kent, England

This is the first EnerPHit project completed in the county of Kent, and the first barn conversion in the UK to meet the standard.

The building started life as a modern concrete framed storage barn and was mainly used for housing farm equipment. Permission was granted in 2018 to convert it into residential use under permitted development rights known as Class Q, specifically for former agricultural buildings. The concrete portal frame had to remain in place for planning permission reasons, so the conversion was designed around these elements.

The dwelling has a large double height living area, 3 bedrooms, a study and a combined utility / plant room. New walls and roof are timber framed and insulated with 2 grades of woodfibre and finished externally in coated steel sheet and vertical timber boarding.

The foundations and timber frame were carried out by sub-contractors, the remainder of the other work was done by the owner including external cladding, roof covering, internal fit-out and decoration.

The barn is oriented on its long axis to the east/west and has a shallow pitched roof, so it is not ideal for renewables, however, it has one south facing gable end with reasonable solar access (although there are high trees to the south east that cause some shading). It is located on a very windy ridge with valleys on both sides that cause strong winds all year round. Some shelter is provided by a pair of grain silos to the north and trees to the south east and south.

Retaining the concrete portals was a particular challenge due to cold bridging risks, as well a technical challenge owing to their shallow foundations and being constructed to an 'agricultural' standard i.e., not vertical or level. Balancing the solar gains and overheating risk was also difficult, whilst exploiting the views to the south and west.

The project was managed and partly built by my client, Mark Baker.

1.3 Responsible project participants / Verantwortliche Projektbeteiligte

Architect/ Entwurfsverfasser	Paul Mallion FRICS, Conker Conservation Ltd http://www.conker.cc
Implementation planning/ Ausführungsplanung	Paul Mallion FRICS, Conker Conservation Ltd http://www.conker.cc
Building systems/ Haustechnik	Owenbeg Contracts Ltd https://www.owenbeg-contracts.co.uk
MVHR system design and installation	Built Environment Technology https://www.thebuiltenvironment.co.uk
Structural engineering/ Baustatik	Cason Green Associates https://www.casongreen.co.uk
Building physics/ Bauphysik	Paul Mallion FRICS, Conker Conservation Ltd http://www.conker.cc
Passive House project planning/ Passivhaus-Projektierung	Paul Mallion FRICS, Conker Conservation Ltd http://www.conker.cc
Construction management/ Bauleitung	Mark Baker (owner)

Certifying body/ Zertifizierungsstelle	Warm Low Energy Building Practice www.peterwarm.co.uk	
Certification ID/ Zertifizierungs ID	Project-ID (www.passivehouse-database.org) Projekt-ID (www.passivehouse-database .org)	7100

Author of project documentation / Verfasser der Gebäude-Dokumentation	Paul Mallion paul@conker.cc
Date, Signature/ Datum, Unterschrift	December 2022

2 Views of Top Barn

East elevation: faces the site access but has very limited views and fronts the working farm yard. Small windows were used to reduce risk of overheating and retain privacy, the large first floor window at the south end is into a double height space.

West elevation: faces open fields and has good views, so larger windows are possible although carefully sized to avoid overheating and deeply recessed. The large ground floor window is to the lounge, and the wide slim window provides a panoramic view from the kitchen.

South elevation: faces a secluded area with high trees and overlooking a sloping garden. Overheating was mitigated by recessing the windows and using tall slim windows to create deep reveals. Note the small fresh air inlet below the flue for the stove.

North elevation: during cladding works- there are only two openings on this elevation as there is no view due to the existing grain silos, see photos below.

View from the north of the site before works commenced: two large grain silos located in front of the barn. The trees in the distance to the south and south west cause shading on the south elevation.

View from the north east of the original barn: the barn is clad with asbestos cement sheet and consists of 3 bays.

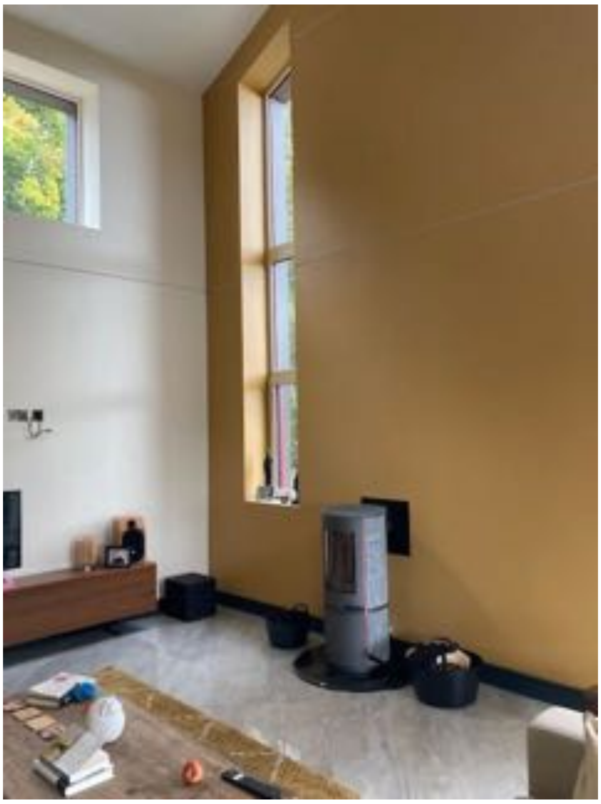
South elevation of the original barn: the site slopes away to the south.

View of the concrete portals: once the cladding was removed the purlins were removed allowing the new timber frame to be inserted around the portals.

Internal view of the double height living space, large windows provide solar gain and views.

Internal view from the double height windows during construction with the crash deck in place, showing the trees on the site boundary in the distance.

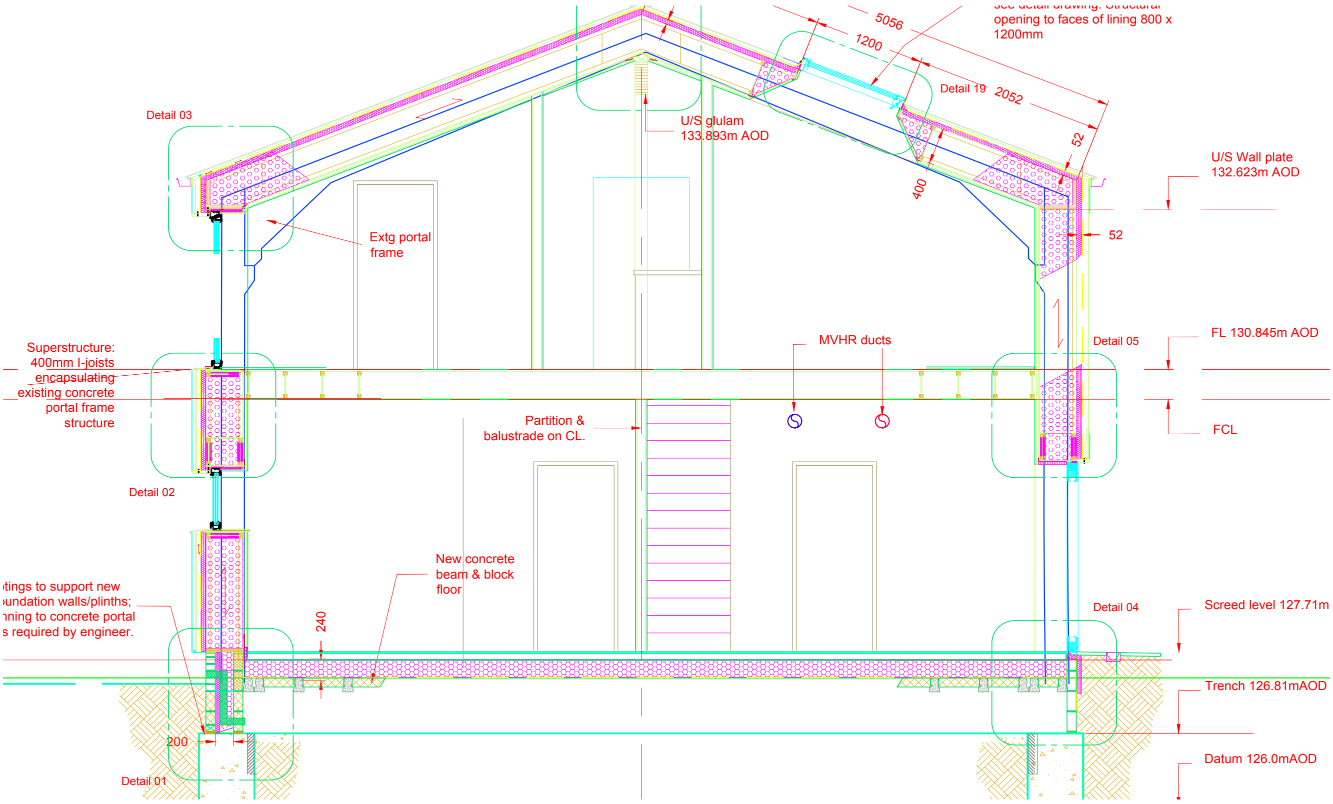
Internal view of the double height space looking back towards the gallery, two bedrooms overlook the space and have large openings so that they can also exploit the views out through the south facing windows. Ventilation return grille can be seen at the top of the yellow wall.



View of the wood stove in the living area.

3 Sectional drawings

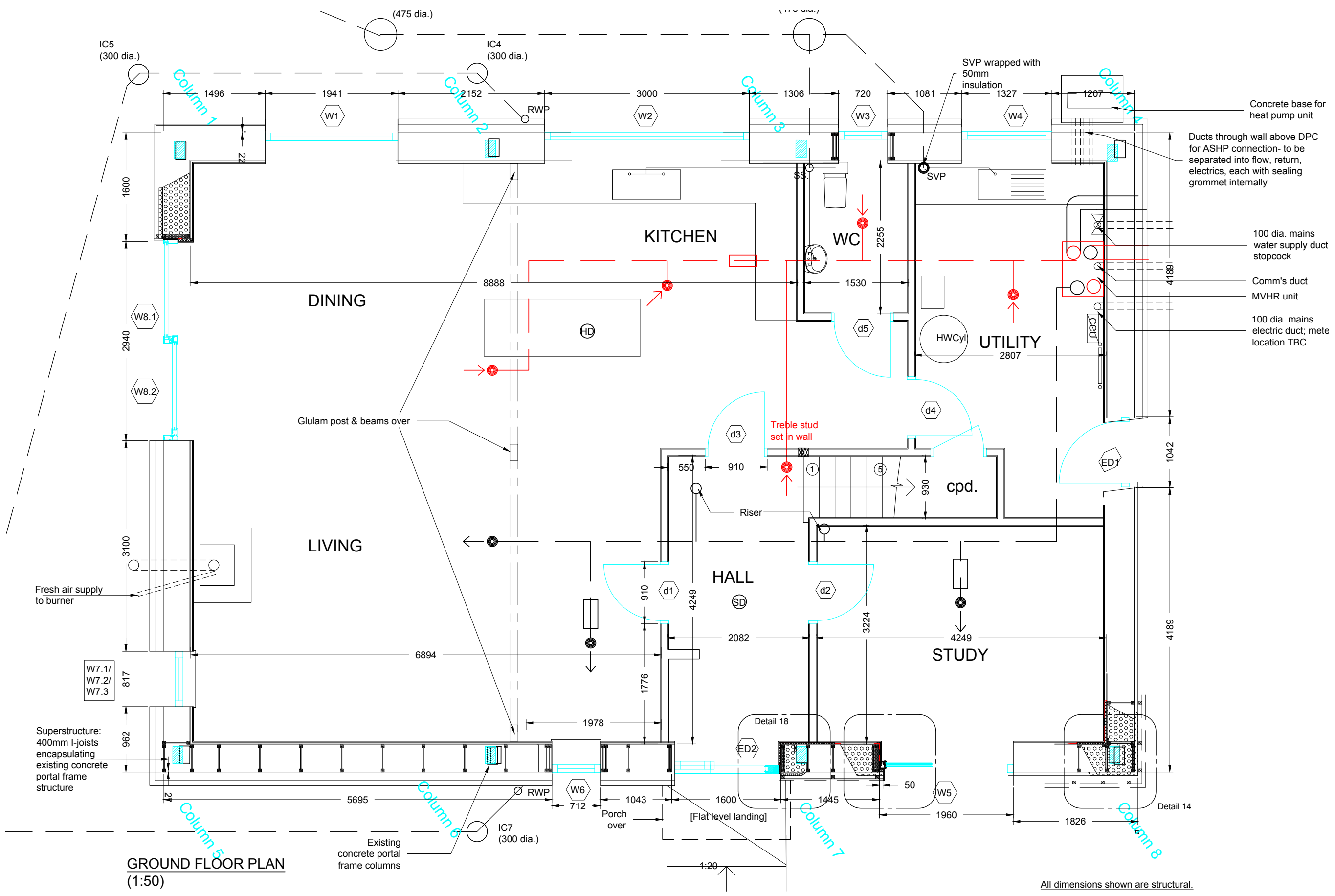
3.1. Cross section BB, extract of drawing 645-BR-04.



Drawing shows the blue outline of the existing concrete portals that had to be retained. Planning law restrictions prevented the building from being fully insulated outside the concrete portal frame, so these had to be partially embedded in the walls and roof. The outer yellow dotted line is the wind barrier. New foundations were laid for the plinth walls to support the new timber framed walls. A suspended concrete beam and block floor was used due to highly shrinkable clay sub-soil. MVHR ducts are exposed on the first floor and concealed on the ground floor. Headroom at the edges of the first floor rooms is 1759mm as the client wanted a 2800mm ground floor ceiling height. This reduced the treated floor area.

4 Floor plans

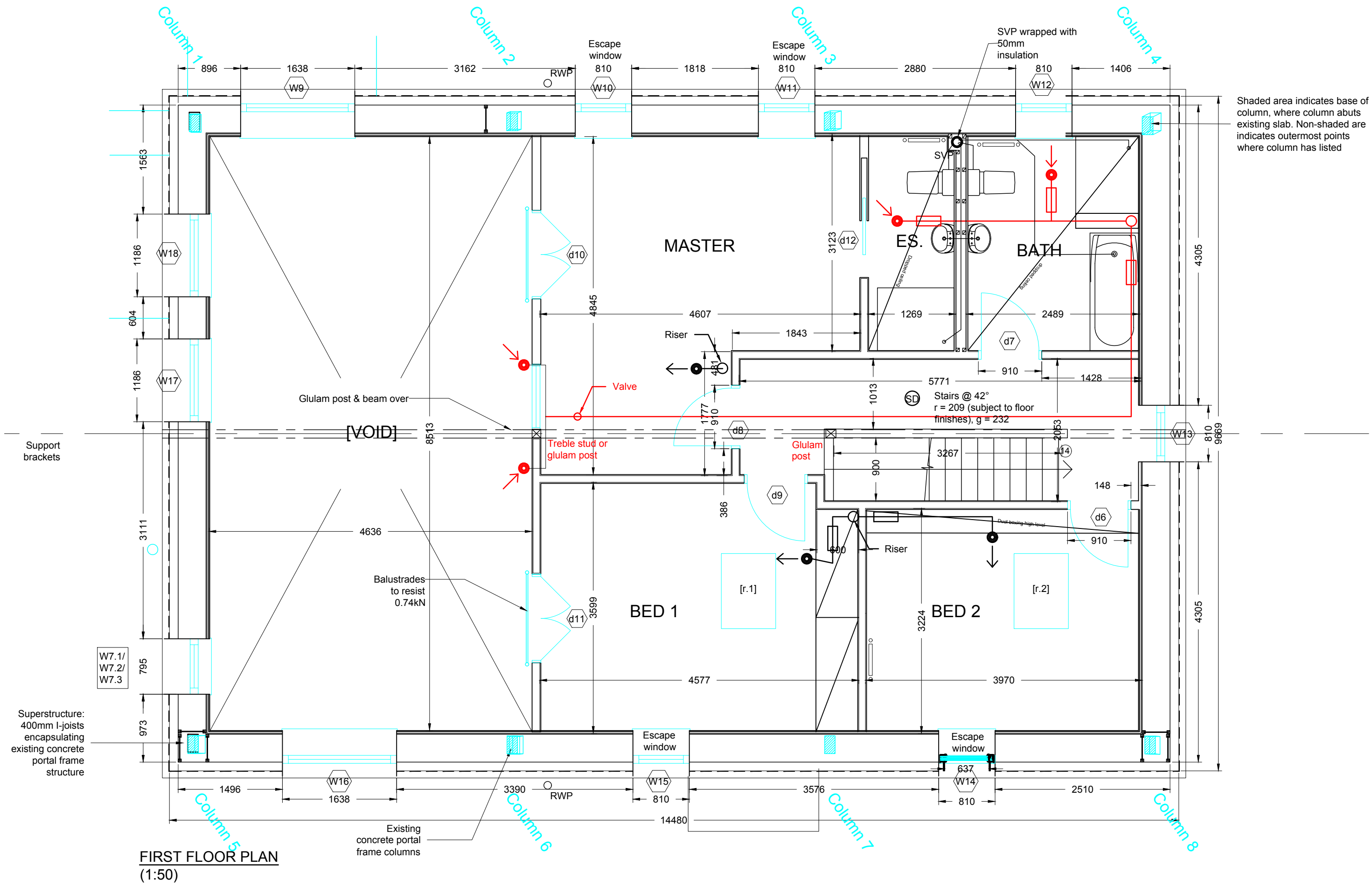
Proposed ground floor plan showing open plan kitchen-dining-living area. The hall and stairs are enclosed and allow the study to be used with privacy from the main house. The utility room houses the plant for the MVHR and ASHP.



The 8no concrete portals can be seen in the walls, the blue hatched outline of each column is the position at ground level, and the black outline is the position at roof level, showing how out of plumb the original frame was, this was measured with a laser scanner at the outset so that the timber frame could be designed around it.

The kitchen and WC are located close to the utility room to reduce pipe runs.

Walls are very thick (400mm I joists), partly to encapsulate the concrete portals which are not perfectly vertical, partly to provide a high level of insulation, and partly to provide strength to resist the very high wind loads of the site.



First floor plan showing double height void over living area, this has a large impact on the TFA but was an important design element for the client. Bed 1 and Bed 2 both have small windows due to privacy, but large enough for means of escape. The two rooms have additional daylight provided by rooflights. The Master bedroom has two reasonable sized windows. The Master bed and Bed 1 also have a view across the double height void through the south windows beyond, via the glazed internal doors, these can be closed to provide acoustic privacy from the living room.

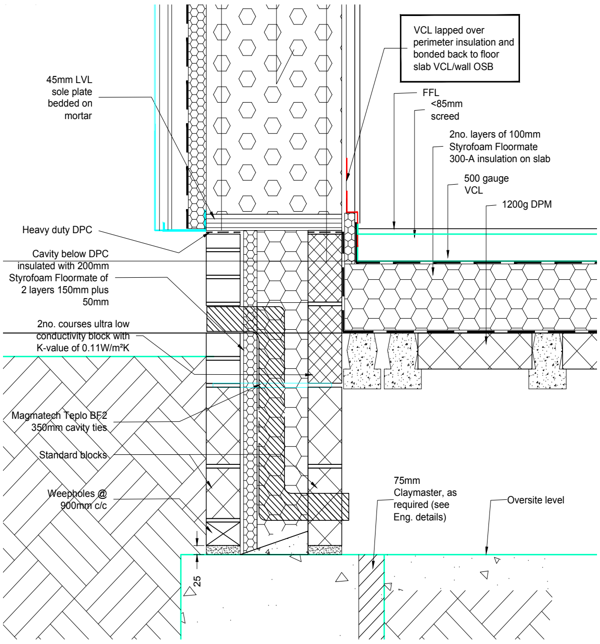
The bathrooms are located directly over the utility room to reduce pipe runs. All the rooms on the first floor have sloping ceilings.

Warm air is collected from the top of the double height space to the MVHR system.

5 Description of construction

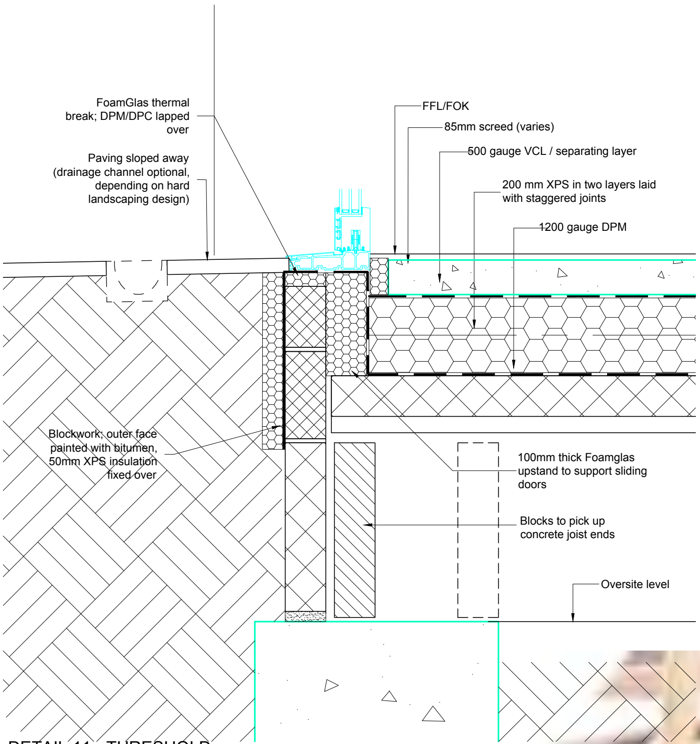
5.1 Floor and floor/wall junction.

5.1.1. A cavity wall plinth was constructed between the concrete portal legs, but as the legs were not constructed accurately the plinth wall had to be very carefully set out to avoid clashing with the legs. A small amount of insulation was wrapped around each. Blocks with very low conductivity were used, and the insulation was laid in two layers to ensure overlap of joints.



DETAIL 01
(1:10)

5.1.2. Thresholds to the external doors are located over a strip of foamed glass insulation on the outer leaf and have an external insulation board placed against the brickwork (not visible in the image) to reduce thermal bridging. The image below shows the laminated sole plate across the cavity wall.



DETAIL 11 - THRESHOLD
(1:10)

5.1.3. The ground floor consists of a suspended concrete beam and block system spanning across sleeper walls running from side to side. Insulation is two layers of 120mm extruded polystyrene insulation, topped with a 75mm sand cement screed with underfloor heating pipework, and porcelain tile finish.

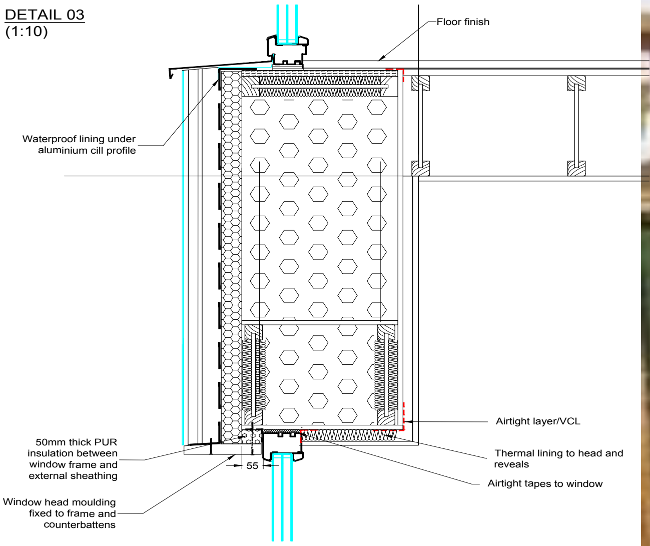
5.1.4. The engineer required the ground floor partitions to sit on the structural floor to carry the loads from above, therefore they penetrate the insulation and vapour barrier. This was a difficult detail to execute as the VCL had to be carefully lapped up the face of the partitions and taped to the studwork. The studs extending below the screed were also a minor repeating thermal bridge and were accounted for within the U value. In the future I would design out this detail.

5.1.5. Three posts penetrate the floor to support the gallery above, each post sits on a block of Foamglas to avoid a direct thermal bridge.

5.1.6. **Ground floor** showing VCL rising at internal partitions in the background before being sealed to the studwork, prior to screeding.

Ground floor	Beam and block floor; DPM; 240mm XPS insulation; VCL;75mm screed.	U-Value 0.149 W/m^{2}K

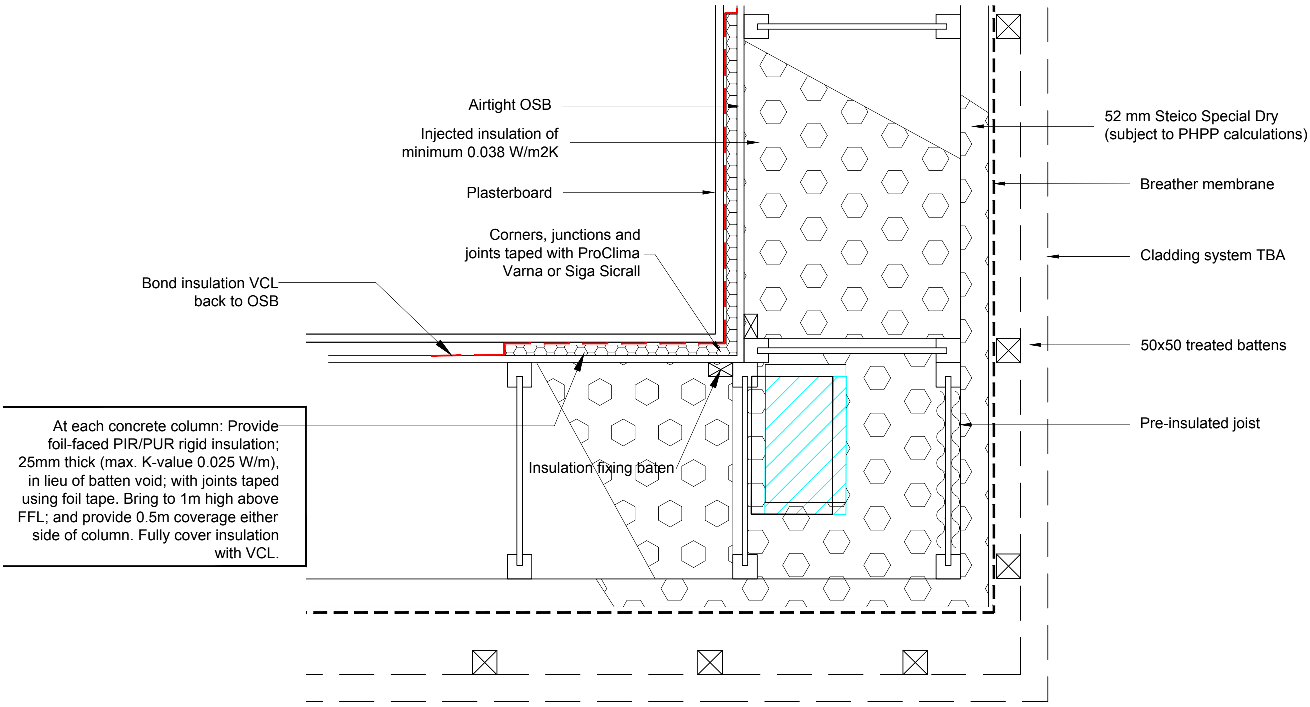
5.2 External walls.



5.2.1 The detail above shows the 400mm wide ‘I’ joist (Steico SJ45 x 400) fully filled with insulation, and 60mm thick woodfibre sheathing board to the outside. The interior was lined with airtight sheathing board ‘Vapourblock’ by Unilin. Lintols were formed using the same sized joists. The photograph above shows the concrete portal being enclosed by the wall system. Interstitial condensation checks were made to ensure the concrete was not a risk.

5.2.2 Photographs showing woodfibre insulation being injected through holes cut into the sheathing board, and the injection machine located on a truck with the insulation material in bags waiting to be loaded into the hopper. Each hole in the sheathing is taped over with a square patch.

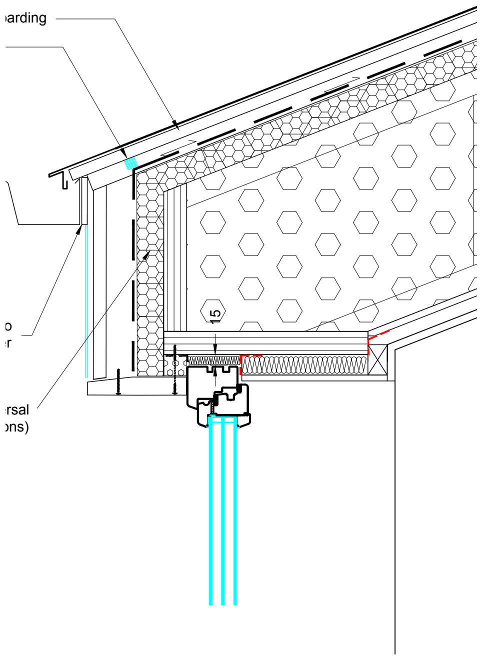
5.2.3 At the locations of the concrete columns an additional layer of insulation was added between the service void battens, to mitigate the thermal bridge.



DETAIL 14 - TYPICAL CORNER POST
(1:10)

External wall	Steel cladding on boards over a ventilation layer; 60mm dense woodfibre insulation boards; 400mm I joists at 600mm centres fully filled with woodfibre insulation; airtight OSB board 13mm thick with joints fully taped; batten void, 12 mm plywood and plasterboard. Timber fraction is cautiously accounted for at 20% for chord and 5% for web.	U-Value 0.094 W/m²K

5.3 Roof



5.3.1 The roof is constructed from 400mm I joists at 600mm centres, sitting on a plate at the eaves and a ridge beam, with plywood reinforcing gussets at the ends and to join them at the ridge. The ridge beam is below the rafters to ensure continuity of insulation. The exterior of the roof is enclosed with a 60mm insulation board.

5.3.2 **View of roof** showing external woodfibre board laid over rafters, with tongued and grooved joints it forms a windtight layer.

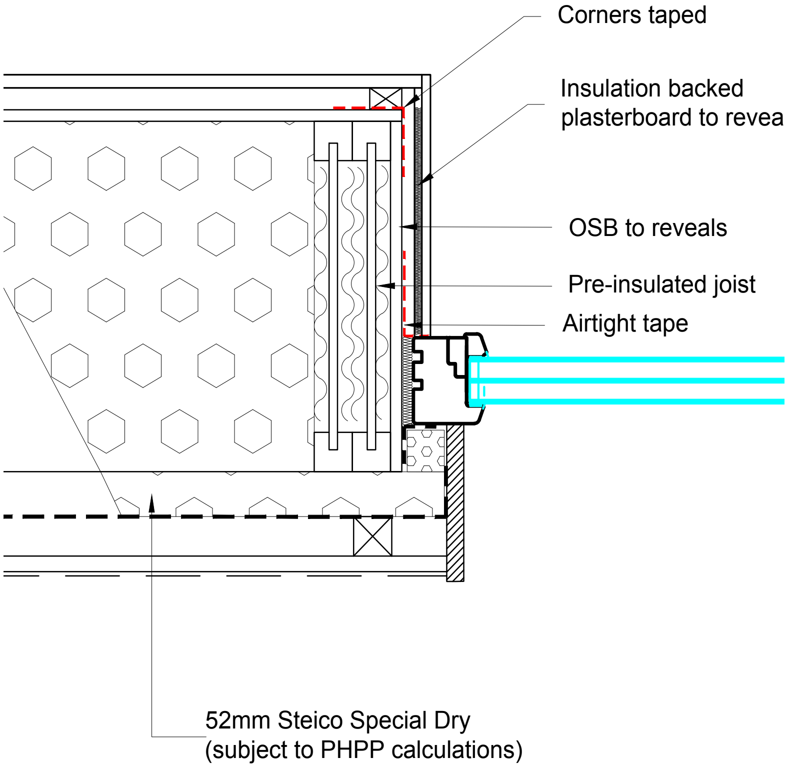
Roof	Steel cladding on boards over a ventilation layer; 60mm dense woodfibre insulation boards; 400mm I joists at 600mm centres fully filled with woodfibre insulation; airtight OSB board 13mm thick with joints fully taped; batten void and plasterboard. Timber fraction is 12% for chords and 3% for webs.	U-Value 0.089 W/m^2K

5.4 Windows

5.4.1 Various window systems were evaluated for the project before Internorm system was selected, as this was assessed as the highest quality and with best thermal properties, as well as the easiest to form thermal-bridge free installation as the outer face can be partially covered with insulation. There is a local window agent in Kent, Passivlux, with considerable experience of specifying triple glazed windows with whom we have worked since 2005. Their specialist knowledge is highly valuable, especially when dealing such a costly element of the project. Units were ordered in June 2020 and delivered in August.

5.4.2 Windows and side hinged doors are Internorm HF410 tilt and turn units. The main entrance door is an HT-400 unit. The lift and slide unit to the living area is an HS-330 unit.

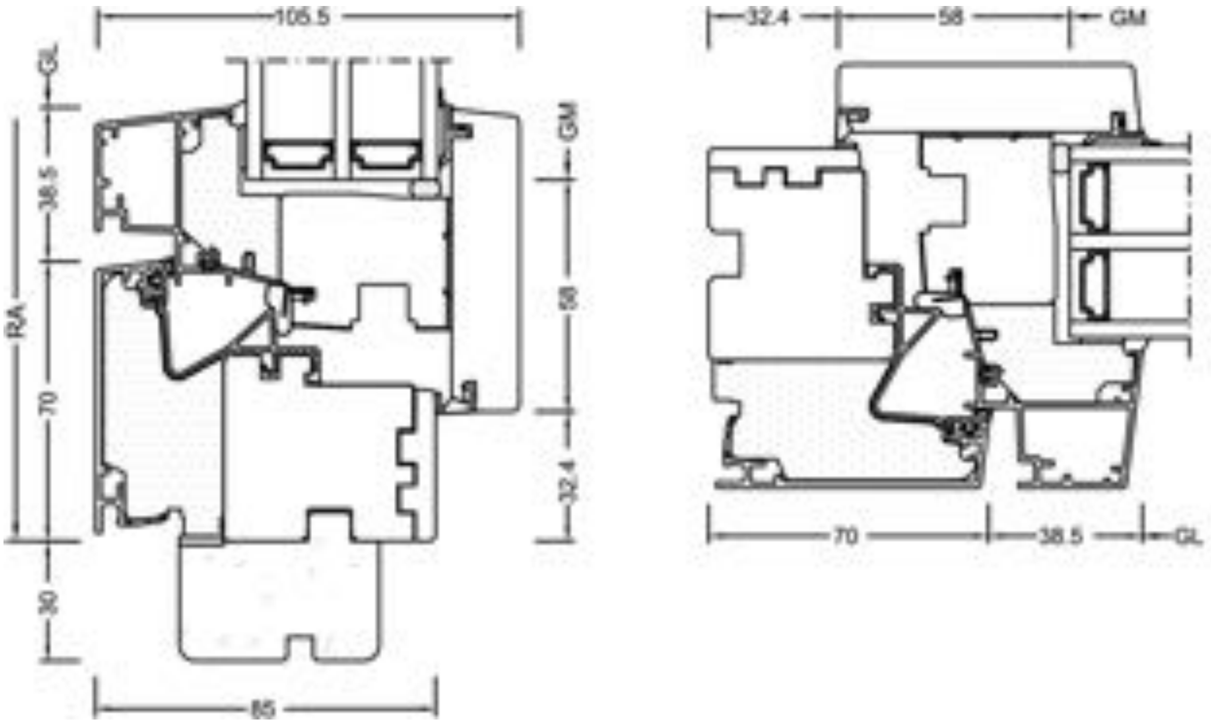
5.4.3 Windows are located 200mm inboard of the external structure face, this allows a 50mm insulation board to be fitted externally to the window face. The gaps around the windows and doors has been designed at 11mm wide, which is ideal for injection with low expansion foam, this is trimmed flush before sealing inside and out.



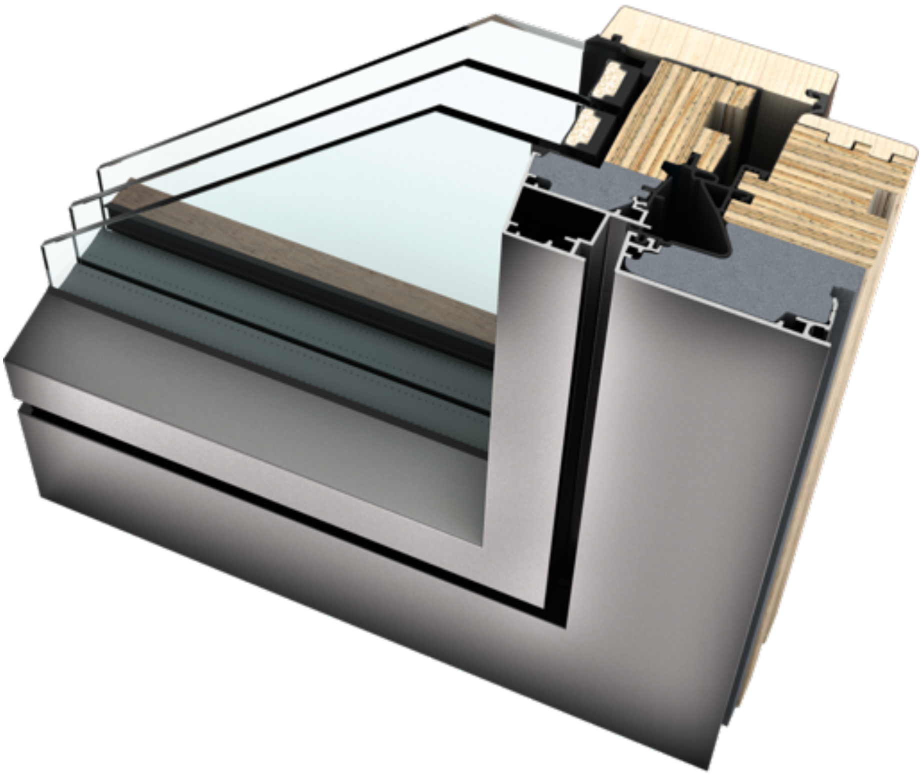
5.4.4 Four types of glass were used mainly to suit the safety or security of the window location. All types included 2 low E coatings and argon gas fill with ISO spacer.

5.4.5 Windows were taped internally onto the airtight lining board to the reveals/head/cill for airtightness then insulated with a plasterboard/insulation laminate. Externally a waterproof tape is used between frame and opening.

5.4.6 Obtaining the details necessary for certification from the local agent was very difficult and caused a delay of several months. The manufacturer was refusing to provide the calculations for the glass as their contractual relationship with the agent was troubled. I had to carry out the Calumen calculations myself, my results varied very slightly from the factory figures provided, and the certifier downgraded them by 5% as a precaution.



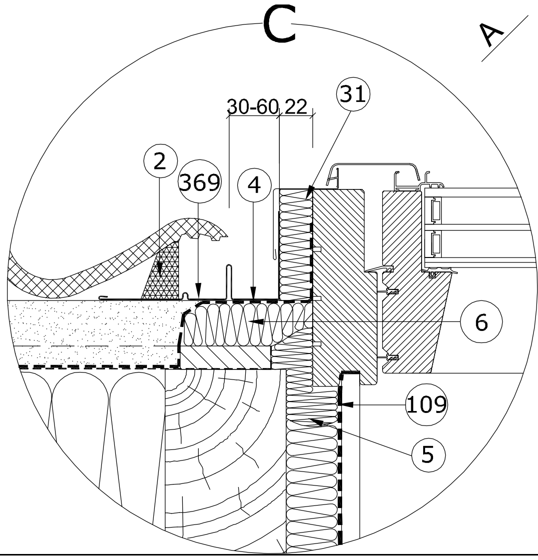
5.4.7 Detail of HF410 tilt and turn window profile. The aluminium profile is backed with high density foam insulation whilst the cill section sits on a strip of 'Purenit' recycled PU insulation which is waterproof and insulating, to which the aluminium cill profile can be screwed.



5.4.8 Image of the HF-410 system.

5.4.9 Two rooflights from Fakro were used, from the FTT range using the EHV-AT Thermo flashing kit and U6 triple glazing. This consists of an insulated flashing around the timber frame on 3 sides and partial insulation on the cill, in conjunction with insulation to pack around the frame/structure gap, wind collar and airtight internal collar. The units have 3 draught seals.

5.4.10 **Fakro rooflight** insulated flashing detail, taken from installation instructions.



Windows	Triple glazed with two layers of low-e glass and two gas fillings, low-conductivity spacers; set in an insulated wooden frame with aluminium facing; 3 no draught seals. Average g value 0.57.	Average U-Value 0.86 W/m^2K

The Airtight envelope

6.1 The main airtight layer is the internal OSB sheathing board which has a phenolic coating. Joints in the boards are taped using ProClima Tescon Vana. A balloon timber frame was adopted. With a conventional design the intermediate floor rests on the ground floor walls and the upper walls are built on top of the floor joist ends. This causes the air tight layer to snake around the plates and joists ends, with risk of air leakage and condensation as the VCL gets very close to the exterior surface. I designed the walls to extend directly from sole plate to the eaves plate with the sheathing applied to the walls before a ledger plate (or rim board) was fixed through the sheathing to the studs, from which the first floor joists are hung.

6.2 **Internal image** of ‘rim board’ to which first floor joists are hung.

6.3 **Internal image** of airtight board to underside of roof with taped joints.

6.4 A continuity membrane was provided over the ridge beam to link to the boards each side, rather than relying just on tape along the edge of the beam.

6.5 At ground level the vapour barrier laid over the rigid floor insulation acts as the airtight layer and is taped at the perimeters to the sheathing board. Joints in the VCL are double taped. The membrane is protected by the floor screed.

6.6 All ductwork and services were kept fully inside the airtight layer. Incoming services were carefully separated to allow them to be made airtight. Each service was brought in through a duct and concreted around, before insulation was laid.

6.7 **View of incoming** services through floor, spaced to allow them to be individually taped to the VCL.

6.8 Results of air leakage test by Airsmart, ATTMA registration number 0008 on 22/07/2021. The average of the pressurisation and depressurisation was 0.49 air changes per hour.

Top Barn - Popes Hall

Depressurise Test	
Building Volume m3	648.95
Q50	314
APR	0.68
ACH	0.48

Pressurise Test	
Building Volume m3	648.95
Q50	325
APR	0.70
ACH	0.50

Average APR	**0.69**
Average ACH	**0.49**

6.9 The results of both tests are attached at the end.

Mechanical system

7.1 Ventilation ductwork

7.1.1 The MVHR unit is located in the utility room at the north end of the building, the intake and exhaust are on the north elevation in an area relatively sheltered. Acoustic attenuators are fitted to both to prevent noise reverberating off the adjacent silo and back into the dwelling.

7.1.2 The MVHR unit has 160mm ductwork connections. The intake and exhaust are enlarged to 200mm which makes them fit a 250 x 250mm plenum and louvre on the external wall. Slightly over-sizing the intake and exhaust avoids any restrictions in air flow. These ducts are insulated with 2 layers of 25mm Armaflex closed cell foam (50mm in one layer being too difficult to work with) and are taped to the VCL at the external wall, and on to the top of the MVHR unit.

7.1.3 Supply and extract ductwork is 160mm diameter galvanised steel spiral, although plastic pipework is available I have found that workmanship often falls short. Steel ductworks needs a little extra skill to install but repeatedly proves to yield better quality installations. Ducts reduce to 125mm to run to each room.

7.1.4 The MVHR duct layout was designed in conjunction with local specialist, BET Ltd, we worked out a routing that could be harmonised with the timber frame, so joist directions were designed to suit the main routing of the ducts, and drilling of joists or beams minimised. 6 iterations of the design were created before the final version was approved.

7.1.5 A high level extract was located at the top of the double height space where heat may accumulate.

7.1.6 The owner/client installed the ductwork himself, being an engineer. Rubber mounted brackets were used to support ducts.

7.1.7 Air circulates from supply areas to extract via undercuts in the room doors.

7.1.8 BET inspected the work at several stages, then commissioned the system.

7.2 Ventilation unit

7.2.1 The unit is a certified Zehnder ComfoAir Q350 which is located at a convenient height for easy inspection and replacement of the filters. The unit can operate from 70 to 270m^3/h so it can suit a wide range of projects.

7.2.2 The unit has a heat recovery rate of 90%, and a SFP of 0.24W/m^3h.

7.2.3 A 1.7kW pre-heater is built in for frost protection. A humidity sensor automatically raises the air flow rates if RH rises above a set level.

7.2.4 **Ventilation unit** in utility room

7.2.5 **Insulated ductwork** to exterior. Galvanised steel ductwork secured with rubber mounted brackets.

Ventilation system	Zehnder ComfoAir Q350, certified component ID 0956vs03. Heat recovery efficiency 90%, Specific fan power 0.24Wh/m³.	Heat recovery efficiency 81.4%

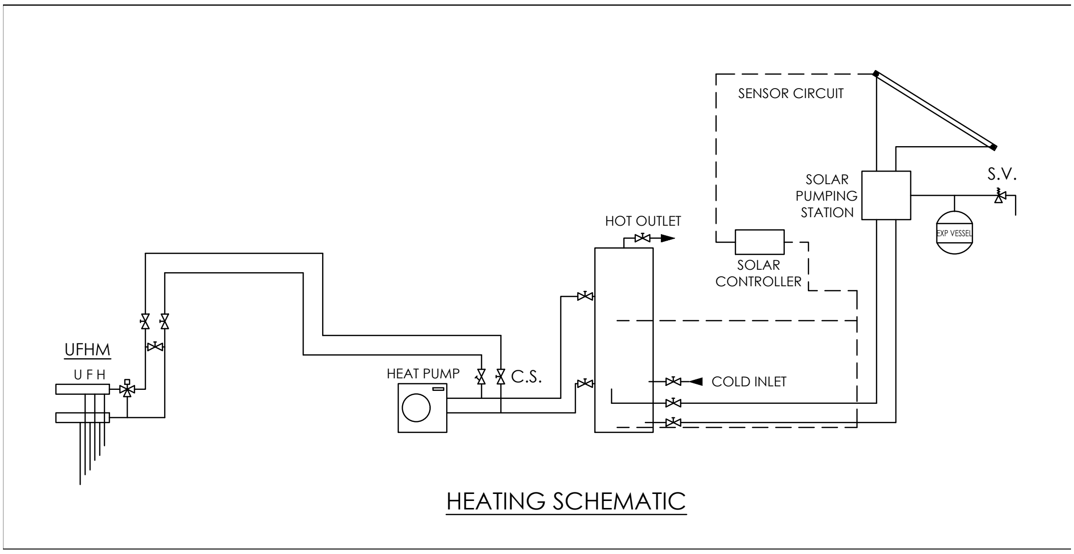
8 Heating and Hot Water

8.1 Various heating options were considered. As with most rural houses there was no mains gas supply, leaving wood, electricity, or bottled gas as options. Ground source and air sourced heat pumps were considered, heating load is only 2.2kW so the system needed to be cost effective. Small air sourced heat pumps have become far more cost effective in recent years, with lots of options for small output units. Ground sourced heating was much more expensive and considered overkill.

8.2 A NIBE F2040 6kW ASHP was selected to provide heating and hot water, in conjunction with a wood burning stove for the living room. Although the heat pump is larger than necessary it allows quick recovering of water temperature in the cylinder and quick heat up of the underfloor heating if the property has been empty for a while.

8.3 Obtaining the certification data from the manufacturer was very difficult, their UK technical department is not familiar with providing this level of detail. After numerous enquiries I realised that the data needed for the HP sheet was published on their data sheet, although only 5 test points were listed. By contrast Vaillant have the data and are familiar with providing this level of detail to designers.

8.4 The external unit is mounted at ground level on the north side of the house, the client reports that the unit is almost silent in operation. A buried duct transfers the pipework to the house via the floor to avoid a hole in the external wall.



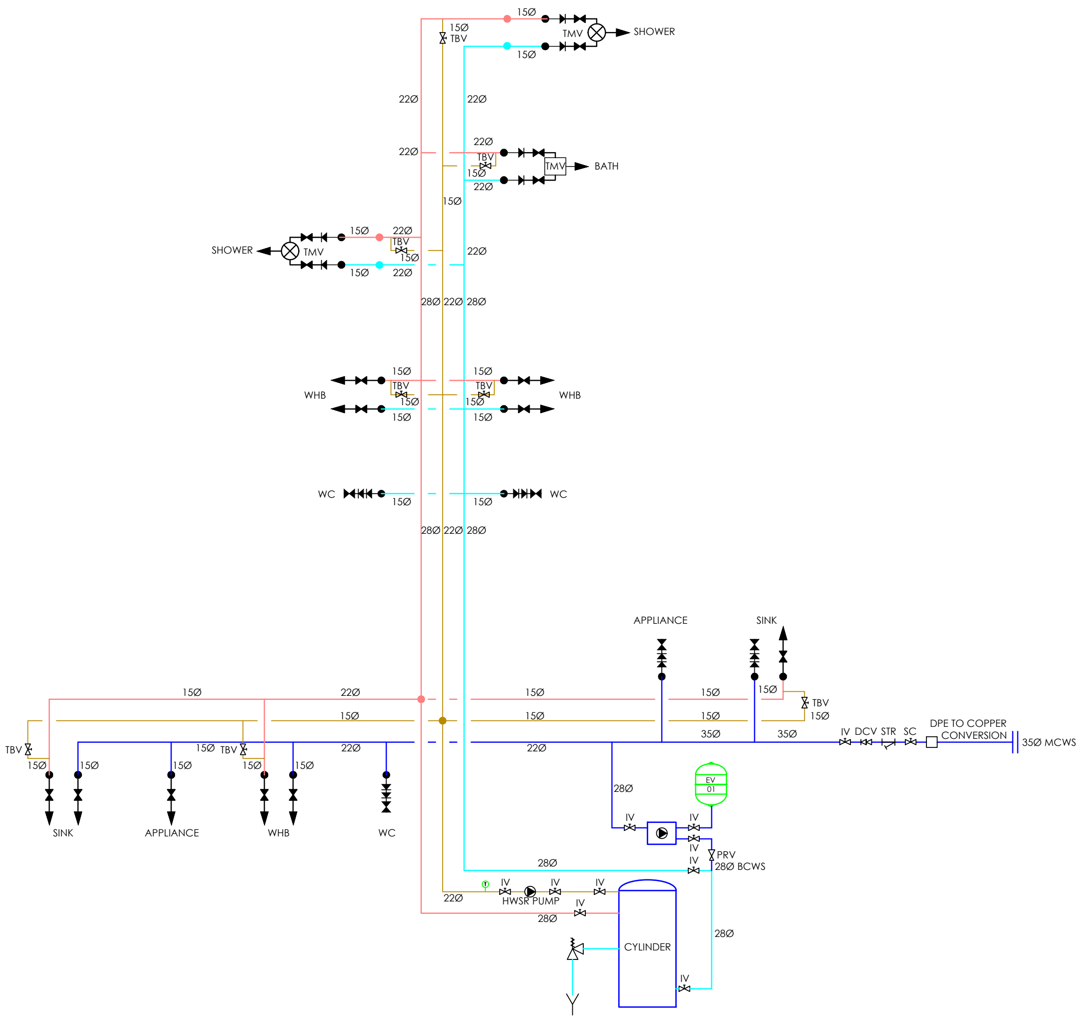
8.5 **Heating Schematic**- the solar system is not installed yet.

8.6 The stove selected was a Heta Scanline with soapstone to absorb heat and distribute evenly. The flue exits through the external wall, this can cause problems with water draining down the exterior of the flue pipe and entering the building, so a stove was chosen which could have a horizontal section of flue up to 1m long, before turning 90 degrees to run vertically. I carefully detailed the flue penetration through the wall to ensure that there was a fire proof lining which was also draughtproof and insulated, by using vermiculite rigid boards to form a sleeve. Fresh air is brought in through a direct connection to the exterior.

8.7 Underfloor heating is used on the ground floor, split into 5 zones. On the first floor there is no heating, but the two bathrooms are provided with towel rails.

8.8 Hot water is provided by a Newark stainless steel cylinder of 231 litres with 100mm insulation, heat loss 39W/h. A secondary return was designed but not installed owing to low water use requirements.

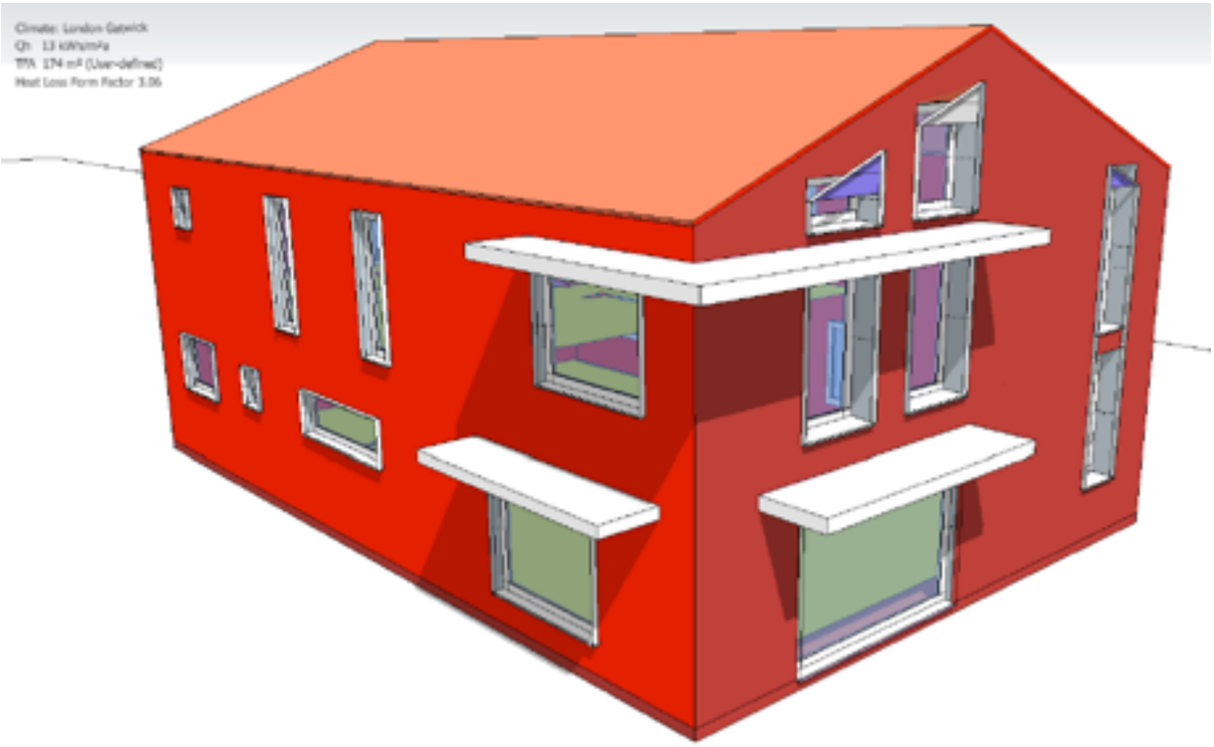
8.9 **Hot water schematic.**



9 PHPP results

9.1 Copy of Verification page. My client, Mark Baker has consented to publication of these details.

9.2 Initial assessment was done on DesignPH, this showed that overheating could be an issue and led to the design of solar shading overhangs to the south west corner. As the design evolved in more detail some of the windows reduced in size, and all windows were set slightly further inboard.



9.3 Overheating assessment was carried out using the Passivhaus Trust Summer Comfort Protocol in 2018/2019. The client was involved with this process, and confirmed that opening windows could be used most of the summer owing to the secluded nature of the site and low security risk. Noise from farm vehicles could be a problem either on the yard side (east) or on the field to the west, but opening windows are present on opposite sides to allow flexibility. Openable rooflights are particularly effective at evacuating heat.

9.4 I used the standard shading sheet to assess adjacent structures and trees, Warm used their Additional Shading sheet 210, this resulted in a difference in solar load, my figures being more pessimistic at 759kWh/m^2a versus 813kWh/m^2a on Warm's assessment. Warm's figure is more accurate and I now use their add-on sheet for most projects.

9.5 It was clear that achieving the EnerPHit standard was possible from the early calculations, although the client hoped that the building could achieve the full

Passivhaus standard. The poor form factor was against it, and the low headroom along the east and west sides reducing the TFA.

9.6 Initial calculations were done using 300mm I joists for wall and roof with U values of around 0.14, but the engineer required 400mm rafters due to the long span, and recommended 400mm wide wall studs to resist wind loads and to stiff the structure. Once these size timbers were input into PHPP the result came to just over 15kWh/m^{2}a.

9.7 The next critical element to assess was the windows. Rationel, Green Building Store (GBS), Ecomerchant and Internorm systems were evaluated. Rationel were ruled out early on as the client preferred tilt and turn. GBS were the most cost effective, Ecomerchant were untried so we were cautious about them. Internorm were the best quality but the most expensive. Calculations were progressed through design phase on the assumption of GBS Ultra tilt and turn windows.

9.8 During assessment by Warm the thermal bridge values used for the concrete columns was reviewed. I had used a linear thermal bridge value, Warm favoured assessing the columns as a separate heat loss area, this was more accurate and PHPP was updated.

9.9 A thermal bridge value was used for the column where it enters the plinth wall and dissects the cavity insulation. We agreed with Warm on a very safe value of 0.5W/mK. At this point in time 3 dimensional thermal bridge evaluations were costing around £1500 each, it was deemed acceptable to use cautious figures rather than the expense of a calculation.

9.10 A thermal bridge value of 0.01W/mK was used for the sole plate over the plinth wall which runs around the perimeter of the whole building. The ridge, eaves and verge were considered to be negative thermal bridges but were ignored at the design stage.

9.11 During construction stage the client decided to opt for the higher specification Internorm windows, this brought the specific heating demand to just below 15kWh/m^{2}a. After completion of the project Internorm refused to co-operate and provide detailed calculations for the glazing. My Calumen calculations were downrated by 5% by the certifier, this in conjunction with other minor corrections raised the heating demand to 17.3kWh/m^{2}a.

9.12 The property was occupied in late 2021, but the finishes were still being completed throughout 2022. The solar shading was not installed as per design, but remains a solution should the client decide overheating is an issue. The property was in occupation during the exceptionally hot summer of 2022 and was comfortable. I reassessed the overheating risk using stack ventilation from the two rooflights and two ground floor windows, and omitted the solar shades. This showed that overheating could be controlled adequately through night ventilation and stack ventilation, at 3% of the year above 25C, Warm's figure was 5%, reflecting their slightly higher solar load from the shading calculation.

9.13 The elongated construction period and the unprecedented demand on the construction industry during this time made it harder to gather evidence for the certification. All the collaborators were over-stretched and took time to provide copies of evidence for my records. As a result it has taken around 6 months to compile the information and obtain certification.

9.14 Copy of the certification verification page:

EnerPHit Verification

Photo or Drawing

Building:	Top Barn, Popes Hall Farm
Street:	Sandway
Postcode/City:	ME172BH Kent
Province/Country:	Kent GB-United Kingdom/ Britain
Building type:	Detached dwelling
Climate data set:	GB0003a-London Gatwick
Climate zone:	3: Cool-temperate — Altitude of location: 124 m
Home owner / Client:	Mark Baker
Street:	As above
Postcode/City:	
Province/Country:	Kent UK

Architecture:	Conker Conservation Ltd	Mechanical system:	Built Environment Technology Ltd
Street:	22-24 Stour Street	Street:	15 The Glenmore Centre, Honeywood Parkway
Postcode/City:	CT12NZ Canterbury	Postcode/City:	CT16 3FH Dover
Province/Country:	UK UK	Province/Country:	Kent UK
Energy consultancy:	WARM: Low Energy Building Practice	Certification:	WARM: Low Energy Building Practice
Street:	3 Admirals Hard	Street:	3 Admirals Hard
Postcode/City:	PL1 3RJ PLYMOUTH	Postcode/City:	PL1 3RJ PLYMOUTH
Province/Country:	DEVON GB-United Kingdom/ Britain	Province/Country:	DEVON GB-United Kingdom/ Britain

Year of construction:		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]:	2.4	IHG cooling case [W/m²]:	3.1
No. of occupants:	3.0	Specific capacity [Wh/K per m² TFA]:	72	Mechanical cooling:	

Specific building characteristics with reference to the treated floor area

		Unit	Value		Criteria	Alternative criteria	Fullfilled?[2]
	Treated floor area	m²	176.0				
Space heating	Heating demand	kWh/(m²a)	16	≤	25	-	yes
	Heating load	W/m²	12	≤	-	-	
Space cooling	Cooling & dehum. demand	kWh/(m²a)	-	≤	-	-	-
	Cooling load	W/m²	-	≤	-	-	
	Frequency of overheating (> 25 °C)	%	5	≤	10		yes
	Frequency excessively high humidity (> 12 g/kg)	%	0	≤	20		yes
Airtightness	Pressurization test result n_{50}	1/h	0.5	≤	1.0		yes
Non-renewable Primary Energy (PE)	PE demand	kWh/(m²a)	76	≤	122		yes
Primary Energy Renewable (PER)	PER demand	kWh/(m²a)	35	≤	-	-	-
	Generation of renewable energy	kWh/(m²a)		≥	-	-	

[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.

EnerPHit Classic? yes

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

PHPP, Verification — 2018 11 13 Certification PHPP Top Barn LM1.xlsm

10 Construction costs

10.1 Building construction cost based on treated floor area £2,306/m^2, exclusive of professional and design fees and preliminaries (scaffolding, electricity connections, water supply, waste disposal, scaffolding, hire charges, WC and insurance). The cost being £405,800.

10.2 Construction costs including all preliminaries £2,488.07/m^2. Preliminaries cost a total of £32,100.

10.3 Professional fees including topographical survey, structural engineer, architecture, planning application, building regulations application, timber frame design, and Passivhaus design and certification totals £35,300.00.

10.4 Total project costs including preliminaries and professional fees total £2.689/m^2, or £473,200. VAT is not included in any of the above costs.

10.5 The property was built during a time of relatively high costs, but was completed before the sudden inflation that occurred after COVID and BREXIT in 2021-2022. Costs were saved (estimated at £75k) by my client carrying much of the intricate detailed work himself, although that extended the completion period.

10.6 My client lived in a caravan next to the site during the construction, and was able to manage each stage of the works by employing direct labour, using specialist sub-contractors, and also carrying out work himself.

10.7 Costs have increased dramatically in some areas since completion, for example an MVHR system is now costing twice as much as Mr Baker paid, and windows have also increased by nearly 50%. This may stabilise as the current economic and energy crisis will hopefully abate over the next 12-24 months.

10.8 There are increasing numbers of competent installers of windows and ventilation systems, giving rise to more choice and competition, albeit a slow process. When this project was tendered there was only one competent installer of ventilation in Kent with PH experience, now there are two! I have been actively encouraging contractors to undertake PH tradesperson training, and hope that several will book on the course this spring.

10.9 The table below lists the building costs, preliminaries and professional costs:

Indicative cost data extrapolated from invoices and receipts

Package	Material	labour	VAT	Total	Cost per TFA m2
					176
Foundations / inc groundwork	22000	5000		£ 27,000.00	£ 153.41
Super structure inc roof & internal walls	43000	30000		£ 73,000.00	£ 414.77
Roof covering (metal)	9500			£ 9,500.00	£ 53.98
Guttering inc downpipes	2300			£ 2,300.00	£ 13.07
External wall cladding (timber & metal)	19500	2500		£ 22,000.00	£ 125.00
Windows	32000	6000		£ 38,000.00	£ 215.91
Air tightness products	1800			£ 1,800.00	£ 10.23
Blown insulation	11000			£ 11,000.00	£ 62.50
Insulation - excluding blown insulation	4300			£ 4,300.00	£ 24.43
Internal battens, sheathing boards, plasterboard,	5600			£ 5,600.00	£ 31.82
Electrical	4300			£ 4,300.00	£ 24.43
Lighting including controls	7000			£ 7,000.00	£ 39.77
ASHP & Cylinder	11000			£ 11,000.00	£ 62.50
Plumbing Inc waste	5100			£ 5,100.00	£ 28.98
Plastering	10000			£ 10,000.00	£ 56.82
MVHR & Ventilation	7500			£ 7,500.00	£ 42.61
Under floor heating	4500			£ 4,500.00	£ 25.57
Internal doors inc iron mongery	2800	1000		£ 3,800.00	£ 21.59
Internal door frames, shadow gap beads ready for plastering	7000			£ 7,000.00	£ 39.77
Sanitary / brassware / shower glass	8200			£ 8,200.00	£ 46.59
Screeding	1700			£ 1,700.00	£ 9.66
Porcelain floor finishes	9000	6800		£ 15,800.00	£ 89.77
Bathroom wall tiling	3500	1600		£ 5,100.00	£ 28.98
LVT floor finishes	2800	1500		£ 4,300.00	£ 24.43
Kitchen including cabinetry, appliances, stone worktops	18000			£ 18,000.00	£ 102.27
External drainage in klargester	8000	5000		£ 13,000.00	£ 73.86
Joinery	3500	500		£ 4,000.00	£ 22.73
Specialist tools to enable self build	6000			£ 6,000.00	£ 34.09
MB Estimated labour for self build works		75000		£ 75,000.00	£ 426.14
		134900		**£ 405,800.00**	**£ 2,305.68**

Prelims					
Site Toilet (inc waste disposal)	4000		inc	£ 4,000.00	
Utility connection (electric)	9000		inc	£ 9,000.00	
Utility connection (water)		500	inc	£ 500.00	
Scaffold inc internal crash deck(s) and mods	6500		inc	£ 6,500.00	
Skips	4300		inc	£ 4,300.00	
Hired-in plant	5800		inc	£ 5,800.00	
Self build insurance	2000		inc	£ 2,000.00	
				£ 32,100.00	
Construction cost				£ 405,800.00	
Total construction and preliminary costs				**£ 437,900.00**	£ 2,488.07

Professional fees					
Architecture and Passivhaus design	25000		inc	£ 25,000.00	
Structural Engineer	1800		inc	£ 1,800.00	
Timber frame design	3000		inc	£ 3,000.00	
Passivhaus certifier	2500		inc	£ 2,500.00	
Topo + As measured survey	3000		inc	£ 3,000.00	
				£ 35,300.00	
Total construction and preliminary costs				**£ 437,900.00**	
Total project costs				**£ 473,200.00**	£ 2,688.64

11 Measured performance

11.1 Figures are only available for 12 months so far, starting Jan 2022. Sub meters have not been fitted, so electricity is for all usage in the house.

11.2 Internal temperatures are set at 22C internally from 7am to 10pm, and 21C during the night. The wood stove was only used occasionally in evenings from October.

11.3 Based on PHI evidence the consumption in the first year is always higher, due to the energy needed to raise the building to comfort temperature and to complete the drying out process. Electricity consumption for the period Jan 2022 to December 2022 was 5101kW. Using an average PER factor of 1.3 this equates to 37.67kWh/m^{2}a.

11.4 According to Warm's certification PHPP the PER value is 34.9 kWh/m^{2}a. My figures vary slightly at 37.1 kWh/m^{2}a, the difference is due to very small differences in the calculation of space heating demand; DHW and Distribution; calculation of the ventilation volume (due to sloping ceilings and double height areas); and design air flow rate (warm use a higher design air flow rate). The recorded energy use is very close to my calculated figures although I would have expected them to be a little higher owing to the observation made in 11.3 above. It is possible that due to the slow completion of the project, much of the drying out took place during 2021, so that the 2022 figures are more like year 2 figures rather than year 1.

11.5 The table below charts the electricity consumption for the first twelve months since occupation:

Heating Set Points	7.00am to 10.00pm 22^0 C	10.00pm to 7.00am 21^0 C
Hot water set point	45^0 C	

Log burner supplmentary use from october 2022 (occasional evenings)

Bedroom windows opened nightly during summer

Unit rate changeable during period

Raw cost (excluding standing charges and taxes)

Month	Lowest daily		Average daily		Highest daily		Total monthly	
	kWh	cost	kWh	cost	kWh	cost	kWh	cost
Jan-22	11	£ 2.24	19	£ 3.86	23	£ 4.77	590	£ 121.17
Feb-22	14	£ 2.96	17	£ 3.59	21	£ 4.21	512	£ 105.07
Mar-22	13	£ 2.72	18	£ 3.67	24	£ 4.96	554	£ 113.67
Apr-22	13	£ 3.56	14	£ 3.83	15	£ 4.13	478	£ 134.10
May-22	8	£ 2.33	13	£ 3.77	23	£ 6.43	416	£ 116.90
Jun-22	10	£ 2.82	13	£ 3.65	17	£ 4.78	364	£ 102.16
Jul-22	9	£ 2.66	13	£ 3.57	17	£ 4.88	394	£ 110.73
Aug-22	10	£ 2.77	13	£ 3.58	16	£ 4.36	393	£ 110.49
Sep-22	10	£ 2.91	12	£ 3.44	13	£ 3.77	251	£ 70.58
Oct-22	12	£ 6.25	16	£ 7.92	18	£ 9.33	327	£ 165.64
Nov-22	13	£ 6.33	17	£ 8.83	22	£ 11.22	384	£ 194.28
Dec-22	17	£ 8.74	23	£ 11.62	35	£ 17.69	438	£ 221.55
							Total kWh	Total cost
							5101	£ 1,344.79
							Average monthly	
							kWh	Cost
							425	£ 112.07

TFA 176

Unit rate @ January 2023	.354p/kWh		28.983	
		PER factor for electricity	1.3	
			37.6778	kWh/m2a

12 User satisfaction-

12.1 Client comments are very succinct as follows:

"Remarkably warm comfortable home during colder months (with significant heat retention) as well as fabulously cool, well ventilated (by opening windows) during hotter months" Mark Baker 2.1.2023.

12.2 Summer overheating has not been reported as a concern, despite 2022 being the hottest summer on record in England. The location of the site is unique and known to be windy all year round, allowing good use of natural cross ventilation in warm weather.

12.3 Air quality reported as good.

12.4 Noise from plant or MVHR outlets has not been reported as an issue.

13 Conclusion

13.1 This has been a very interesting and challenging project undertaken during a difficult economic and political period of time, with issues such as COVID and BREXIT affecting suppliers and deliveries.

13.2 Working with a client who was knowledgeable on the services (Mr Baker is an electrical engineer) was a great help, and using a timber frame contractor with considerable Passivhaus experience also helped to ensure a good quality structure and airtightness, despite some difficult detailing around the existing concrete portal frame.

13.3 The client undoubtedly paid exceptional attention to detail and should be complemented on the quality of finishing. His inexperience in working to Passivhaus levels of detail did result in some early mistakes co-ordinating the air tightness continuity between different stages of the work, but these were overcome. Some elements were over-engineered on site adding cost and time.

13.4 The project overran on time by 12 months due to multiple reasons, including shortage of funds, delays in delivering components, shortage of labour, and the client having to stop work in order to work abroad for several months.

13.5 Although I was the building designer and the PH designer I was not engaged to carry out regular site inspections as a contract administrator, only to undertake specific inspections at certain stages of work. This was the clients decision. Fortunately the client kept very good records of the invoices, delivery notes, and photographic record so that the evidence was available to present to the certifier. The extended project timescale meant it was difficult obtaining some details 12 or more months after a specialist had completed an element of work, particularly the window suppliers.

13.6 The project was due for completion in early to mid 2021, which would have allowed me to complete this documentation in time for my Passivhaus Designer qualification renewal date in April 2022. For the reasons described above I was not able to collate the initial certification details until May 2022. At this time Warm were exceptionally busy so the checking of details took until the end of November 2022, followed by lodgement with PHI in December.

13.7 I passed the Certified Passivhaus Designer examination on 11.06.2011; the qualification was first renewed on 10th April 2017 through the certification of The Den, ID 2343. I hope that this submission will allow me to renew again.

Building Airtightness Test Report

Date of Issue:	**22/07/2021**	Issued by:	**Andrew Turner**
Date of Test:	**22/07/2021**	Test Engineer:	**Andrew Turner**
CPS Scheme:	**ATTMA**	Registration No.:	**0008**

Airsmart
Grenham House Lodge
29 Grenham Road
Birchington, Kent CT7 9JH
Phone: 07814 940519

Email: info@airsmart.co.uk

Report Number	**21.481 Top Barn Mark Baker dp**

Client: **Mark Baker**

Region:

Address: **Top Barn**
Popes Hall
Maidstone
Kent

Plot Number:

Developers Type: **Mark Baker**

Development Name:

Development Address: **Top Barn**
Popes Hall
Maidstone
Kent
UK

Test Results		Q_{50}: Airflow ($m^3.h^{-1}$):	**314**
Measured Air Permeability ($m^3.h^{-1}.m^{-2}$)@50Pa	**0.68**	Design Air Permeability ($m^3.h^{-1}.m^{-2}$)@50Pa	**0.00**

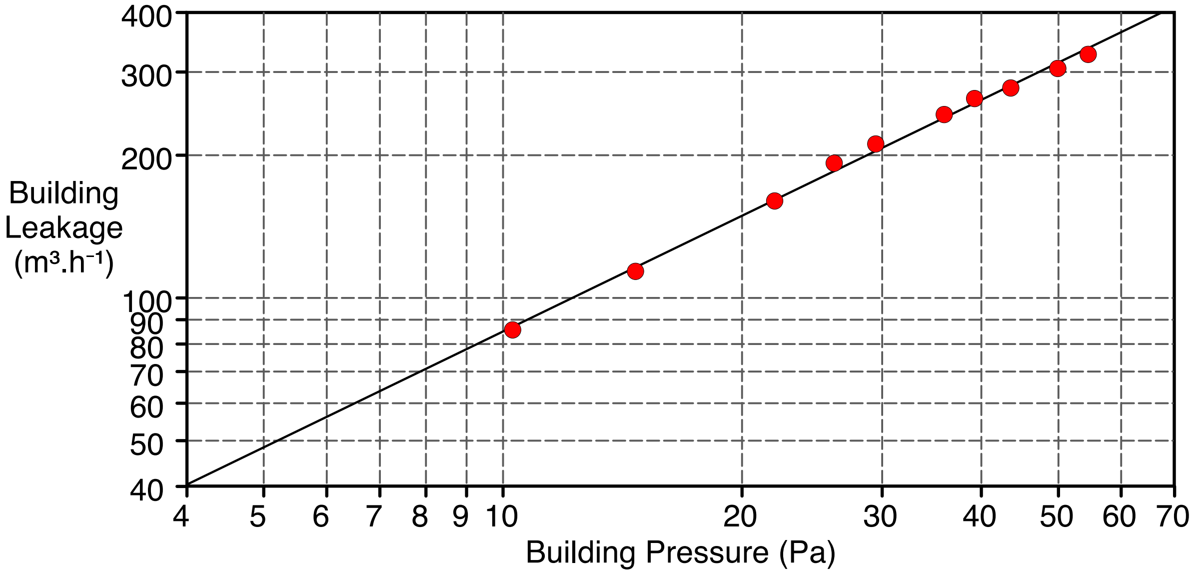
Test Information		Regulation complied with:	**ADL1A-2010**
Test Method:	**B**	Test Standard:	**TSL1**
ATTMA TS1 Leakage Area (m^2):	**0.016**	Type of Test:	**Depressurisation**

Building Leakage Curve			
Air Flow Coefficient (C_{env}) ($m^3.h^{-1}.Pa^{-n}$):	**13.1**	Air Leakage Coefficient (C_L) ($m^3.h^{-1}.Pa^{-n}$):	**13.1**
Exponent(n):	**0.812**	Coefficient of Determination (r^2):	**0.9966**

Testing Deviations	
Have any deviations from the 'measurement and equipment' protocol been recorded?	**YES**
Have any deviations from the 'building preparation' protocol been recorded?	**NO**

DEVIATIONS MUST BE CONSIDERED WHEN DETERMINING COMPLIANCE

Air Leakage Graph



Building Information

Building Type	**House - Detached**	Building Classification	**Dwelling**
Envelope Area	**463.45**	Primary Construction	**Timber Frame**
Footprint	**113.43**	Primary Heating	**Electric**
No. Storeys	**2**	Primary Air Conditioning	**None**
Adjacency to Unheated Space	**None**	Envelope Area Verified	**Yes**
Warm Roof Construction	**No**	Year of Construction	**2021**
No. Significant Penetrations	**Not Required**	Area Under Test	**Whole Building**

Primary Ventilation	**System 4 - Continuous Mechanical Ventilation with Heat Recovery**
Mastic Sealing Status	**No Air Paths Specifically Sealed**

Building Preparation

Temp seal to mechanical vents

Deviation From Standard - Building Preparation

None

Environmental Data

Time	Internal Temperature (°C)	External Temperature (°C)	Barometric Pressure (mbar)	Wind Speed (m.s^{-1})
Pre-Test	**16.9**	**21.4**	**1008.8**	**0.0**
Post-Test	**16.9**	**21.6**	**1008.7**	**0.0**
Average	**16.90**	**21.50**	**1008.75**	**0.0**

Zero Flow Pressure Data

Pre-Test			Post-Test		
$\Delta p_{0,1-}$	$\Delta p_{0,1+}$	$\Delta p_{0,1}$	$\Delta p_{0,2-}$	$\Delta p_{0,2+}$	$\Delta p_{0,2}$
-0.3	**0.1**	**-0.2**	**-0.8**	**0.0**	**-0.8**

Measurement Data

Building Pressure (Pa)	Fan Pressure (Pa)	Uncorrected Flow (m^3.h^{-1})	Corrected Flow (m^3.h^{-1})	Error (%)	Fan Configuration
-55.0	**69.8**	**323**	**327**	**-3.0**	**Ring C**
-50.4	**60.9**	**302**	**305**	**-2.7**	**Ring C**
-44.1	**50.4**	**274**	**277**	**-1.2**	**Ring C**
-39.7	**45.6**	**261**	**264**	**2.3**	**Ring C**
-36.4	**39.0**	**241**	**244**	**1.6**	**Ring C**
-30.0	**29.4**	**209**	**211**	**3.5**	**Ring C**
-26.6	**24.4**	**190**	**192**	**3.8**	**Ring C**
-22.5	**177.2**	**158**	**160**	**-0.6**	**Ring D**
-15.2	**88.9**	**113**	**114**	**-1.9**	**Ring D**
-10.8	**49.9**	**85**	**86**	**-1.6**	**Ring D**

Equipment Information

Instrument	Manufacturer	Model	Identifier	UKAS Calibration Identifier	UKAS Calibration Expiry
Fan	**Energy Conservatory**	**Model 3 (110V)**	**Kit 1 Fan**	**113245**	**15/09/2021**
Micromanometer	**Energy Conservatory**	**DG-700**	**Kit 1 PG**	**112624**	**15/09/2021**
Barometer	**Druck**	**DP1705**	**Kit 1 Bao**	**113242**	**15/09/2021**
Thermometer	**Testo**	**110**	**Kit 1 Temp**	**113243**	**15/09/2021**
Anemometer	**Anemo**	**Deuta**	**Kit 1 Ane**	For Indication Only	For Indication Only

Deviation From Standard - Measurement Data & Equipment

- Equipment specific calibration coefficients have not been used.

Measurement Calculations as Specified in the Test Standard

The test calculation method can be found in the ATTMA test standards, which can be downloaded from www.attma.org.

Report Information

This report has been generated using TECTITE Express UK Version 4.0.60.2

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Building Airtightness Test Report

Date of Issue:	**22/07/2021**	Issued by:	**Andrew Turner**
Date of Test:	**22/07/2021**	Test Engineer:	**Andrew Turner**
CPS Scheme:	**ATTMA**	Registration No.:	**0008**

Airsmart
Grenham House Lodge
29 Grenham Road
Birchington, Kent CT7 9JH
Phone: 07814 940519

Email: info@airsmart.co.uk

Report Number	**21.481 Top Barn Mark Baker p**

Client:	**Mark Baker**	Plot Number:	
Region:		Developers Type:	**Mark Baker**
Address:	**Top Barn Popes Hall Maidstone Kent**	Development Name:	
		Development Address:	**Top Barn Popes Hall Maidstone Kent UK**

Test Results		Q_{50}: Airflow (m³.h⁻¹):	**325**
Measured Air Permeability (m³.h⁻¹.m⁻²)@50Pa	**0.70**	Design Air Permeability (m³.h⁻¹.m⁻²)@50Pa	**0.00**

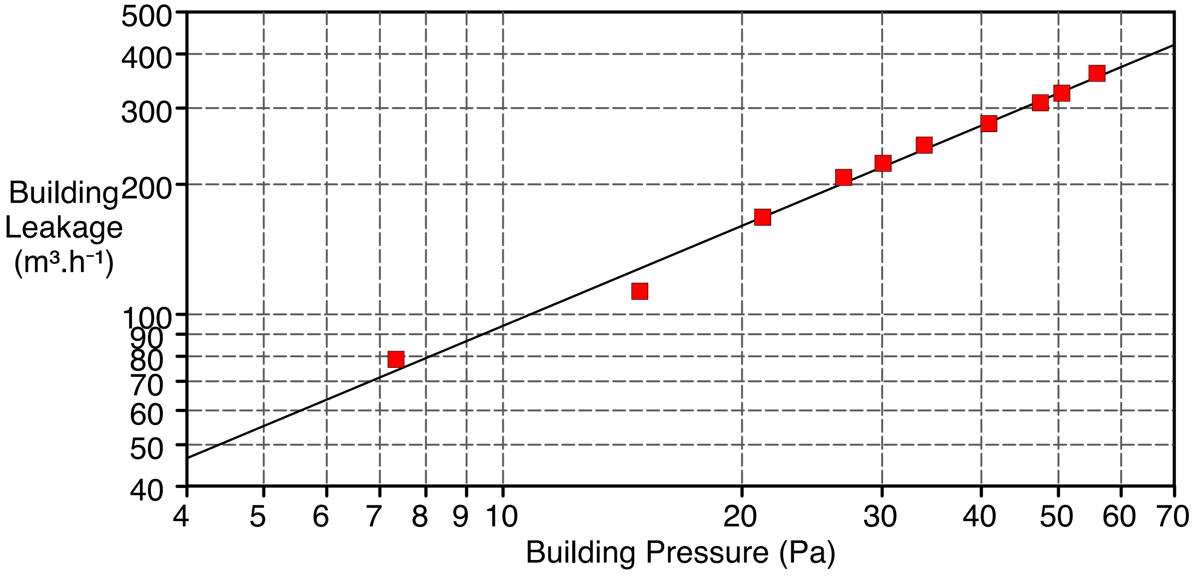
Test Information		Regulation complied with:	**ADL1A-2010**
Test Method:	**B**	Test Standard:	**TSL1**
ATTMA TS1 Leakage Area (m²):	**0.016**	Type of Test:	**Pressurisation**

Building Leakage Curve			
Air Flow Coefficient (C_{env}) ($m^3.h^{-1}.Pa^{-n}$):	**16.0**	Air Leakage Coefficient (C_L) ($m^3.h^{-1}.Pa^{-n}$):	**16.0**
Exponent(n):	**0.770**	Coefficient of Determination (r^2):	**0.9904**

Testing Deviations	
Have any deviations from the 'measurement and equipment' protocol been recorded?	**YES**
Have any deviations from the 'building preparation' protocol been recorded?	**NO**

DEVIATIONS MUST BE CONSIDERED WHEN DETERMINING COMPLIANCE

Air Leakage Graph



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No. Storeys	**2**	Primary Air Conditioning	**None**
Adjacency to Unheated Space	**None**	Envelope Area Verified	**Yes**
Warm Roof Construction	**No**	Year of Construction	**2021**
No. Significant Penetrations	**Not Required**	Area Under Test	**Whole Building**

Primary Ventilation	**System 4 - Continuous Mechanical Ventilation with Heat Recovery**
Mastic Sealing Status	**No Air Paths Specifically Sealed**

Building Preparation

Temp seal to mechanical vents

Deviation From Standard - Building Preparation

None

Environmental Data

Time	Internal Temperature (°C)	External Temperature (°C)	Barometric Pressure (mbar)	Wind Speed ($m.s^{-1}$)
Pre-Test	**16.9**	**21.6**	**1008.7**	**0.0**
Post-Test	**16.8**	**21.7**	**1008.8**	**0.0**
Average	**16.85**	**21.65**	**1008.75**	**0.0**

Zero Flow Pressure Data

Pre-Test			Post-Test		
$\Delta p_{0,1-}$	$\Delta p_{0,1+}$	$\Delta p_{0,1}$	$\Delta p_{0,2-}$	$\Delta p_{0,2+}$	$\Delta p_{0,2}$
-0.8	**0.3**	**-0.7**	**-1.2**	**0.6**	**-0.8**

Measurement Data

Building Pressure (Pa)	Fan Pressure (Pa)	Uncorrected Flow ($m^3.h^{-1}$)	Corrected Flow ($m^3.h^{-1}$)	Error (%)	Fan Configuration
55.2	**88.5**	**364**	**361**	**2.0**	**Ring C**
49.8	**71.7**	**328**	**325**	**-0.8**	**Ring C**
46.7	**64.7**	**311**	**308**	**-1.2**	**Ring C**
40.1	**51.9**	**279**	**276**	**-0.8**	**Ring C**
33.2	**41.4**	**249**	**246**	**2.2**	**Ring C**
29.3	**34.2**	**226**	**224**	**1.8**	**Ring C**
26.1	**29.4**	**209**	**207**	**3.0**	**Ring C**
20.5	**19.4**	**170**	**168**	**-0.0**	**Ring C**
14.1	**91.6**	**114**	**113**	**-11.4**	**Ring D**
6.6	**43.9**	**79**	**79**	**6.2**	**Ring D**

Equipment Information

Instrument	Manufacturer	Model	Identifier	UKAS Calibration Identifier	UKAS Calibration Expiry
Fan	**Energy Conservatory**	**Model 3 (110V)**	**Kit 1 Fan**	**113245**	**15/09/2021**
Micromanometer	**Energy Conservatory**	**DG-700**	**Kit 1 PG**	**112624**	**15/09/2021**
Barometer	**Druck**	**DP1705**	**Kit 1 Bao**	**113242**	**15/09/2021**
Thermometer	**Testo**	**110**	**Kit 1 Temp**	**113243**	**15/09/2021**
Anemometer	**Anemo**	**Deuta**	**Kit 1 Ane**	For Indication Only	For Indication Only

Deviation From Standard - Measurement Data & Equipment

- Equipment specific calibration coefficients have not been used.

Measurement Calculations as Specified in the Test Standard

The test calculation method can be found in the ATTMA test standards, which can be downloaded from www.attma.org.

Report Information

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