Passive House Documentation - ID 4426

Passive House Designer: Martin Marshall - Marshall McCann Architects - MMcCarchitects.com

This is a 4 occupant detached farm house located outside Dunloy, Co. Antrim Northern Ireland, completed June 2014. It is a compact design with a Southeast orientation optimizing the use of the free heat from the sun with solar shading and cross ventilation for passive cooling. It is of timber frame construction with cavity and outer skin of rendered block, zinc and timber cladding.

U-value floor 0.141 W/(m²K)	PHPP Annual heating demand **15** kWh/(m²a)
U-value exterior wall 0.144 W/(m²K)	PHPP primary energy demand 105kWh/(m²a)
U-value roof 0.104 W/(m²K)	Pressure test n50 0.46h-1
U-value window 0.78 W/(m²K)	Heat recovery 80%

2.2 Brief project description

This Passive House is an 189sqm 2 storey, detached, single family home designed by Marshall McCann Architects. It was built on a green field and due to Planning NI issues the site selection was restricted so it had to be built on site looking onto to the farm yard. The clients brief was to design a contemporary building that fits into it surroundings, to minimize the views of the midden, and have a family home with no energy bill with a budget of £175,000 (excluding studio and landscaping).

Like all Marshall McCann Architects designs, the starting point for this design was around the sun path and the views, by highlighting and enhancing the good views and shielding the bad views. Marshall McCann Architects final design was based around a courtyard, so they are looking out to their own ‘attractive farm building’ in the form of a contemporary take of an outbuilding for their studio, shielding the view of the farm, with a wall linking back to the house acting as a wind break and privacy wall.

The house itself was designed with large amounts of southern facing glazing to maximize the winter sun, with solar shading to minimize the summer sun. All the spaces that had the potential of overheating in the summer were also designed to passively cool with cross ventilation; with the main open plan, having 2 large sliding doors, one to the southern patio and one opening on the west elevation on the evening patio and BBQ area. The house’s living spaces was designed around a centralized, double sided wood burning stove to maximize the heat output around the house. The stove was encased in a high density brick to act as a storage heater so it continues to output heat after the fire is out. Due to a cut in their mortgage some areas of the project hand to be temporarily cut back, and where the client choose to do this was with their air source heat pump and PV’s but still leaving provision to easily install them at a later date. They now have the PV’s install (after PHPP sign off) and are due to install their air source heat pump within the next few months. When both these are installed they are predicted to make over one hundred of pound from the energy demands. Whilst waiting to get these installed they use Economy 7 electricity to heat their hot water, and in the winter months they used the wood burning stove as their primary heating with a few 1KW heater on timers to heat the house in the morning before they got up.

This house was designed very compactly, with each room designed down to the smallest acceptable size and minimizing the circulation space.

All junction in the house we analyzed using 'Therm' to ensure all junctions were free of thermal bridging.

Ground Floor Construction:	100mm concrete screed on 150mm PIR on 100mm concrete sub floor on DPC lapped and taped to airtighness membrane.
Wall Construction:	Render 100mm block, 50mm cavity, breather paper, 10mm OSB, 140x38mm studs @ 400mm centers with fibreglass between, airtightness membrane tacked to studs tape and jointed, 80mm PIR, 38mm service void, 12.5mm plasterboard drylined.
Roof Construction:	150x38mm truss sections @ 400mm centers with 200mm fibreglass insulation between and 200mm fibreglass insulation laid over the top, airtightness membrane fixed to the underside of trusses jointed to membrane on walls, 100mm service void with 100mm PIR along the perimeters on minimize cold bridging.
Doors & Windows:	Triple glazed Passive House Certified Window by Munster Joinery.
Front Door:	Bespoke timber door with 40mm PIR in the core 0.8 W/(m^2K)

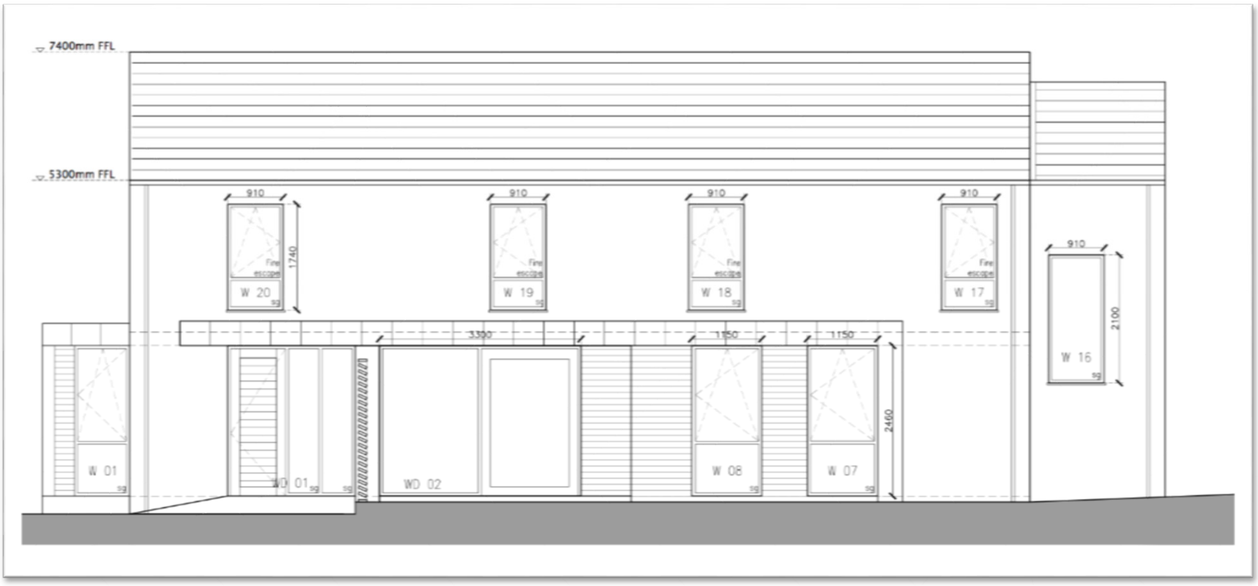
2.3 Elevations

Southern facing elevation with large glazed areas with zinc shading, and the large glazed doors to open plan area recessed further back to reduce summer solar gain. 4kw of PV panels on the roof.

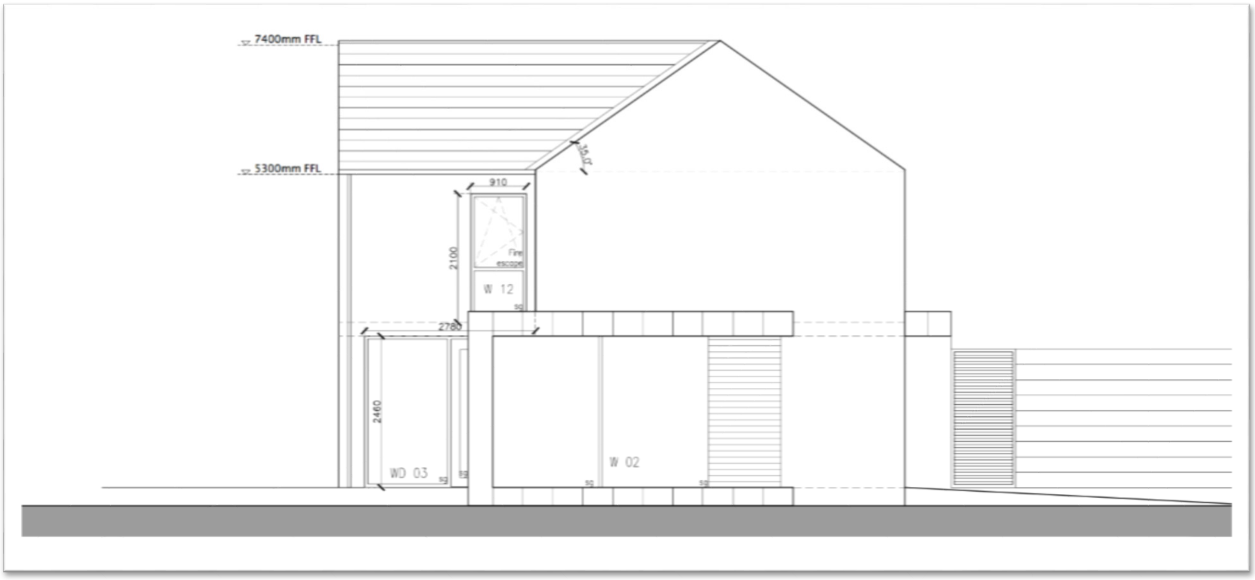
West elevation with projection zinc box, with openable windows in either corner to provide cross ventilation.

Northern & West elevation, with large doors to the open plan area to provide cross ventilation.

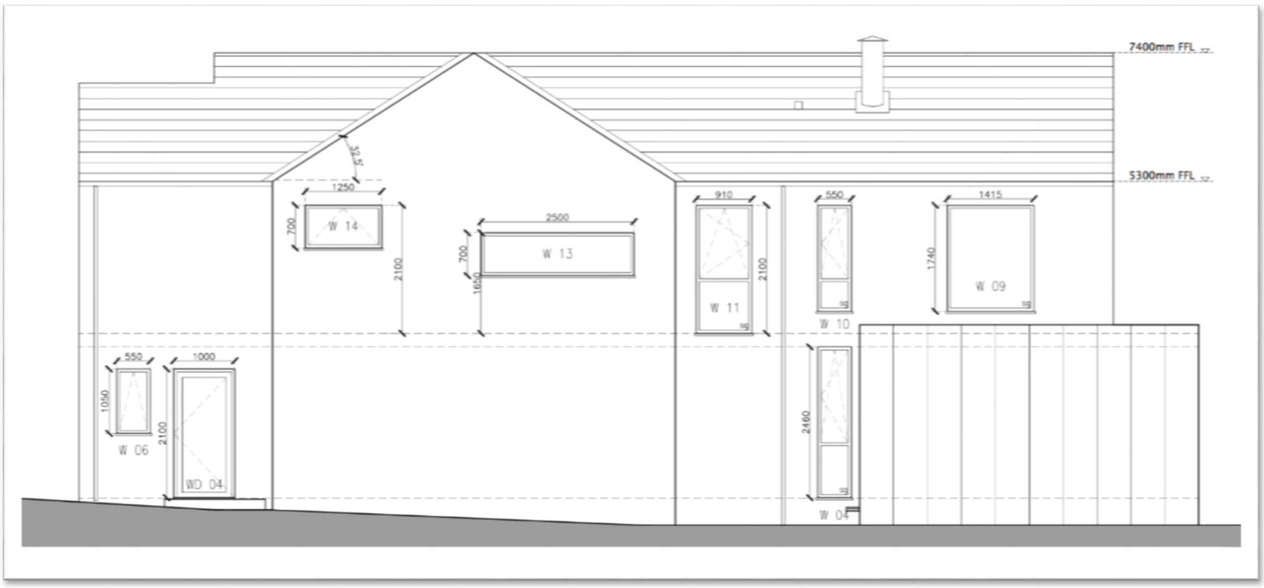
East and North elevation



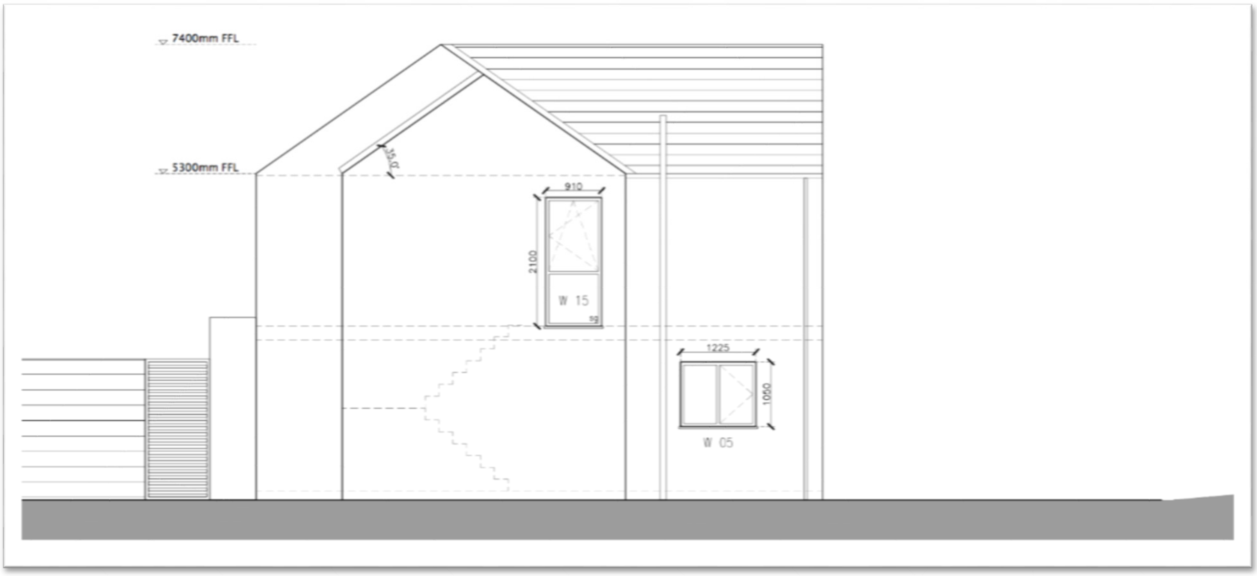
South Elevation above and West Elevation below



North Elevation below

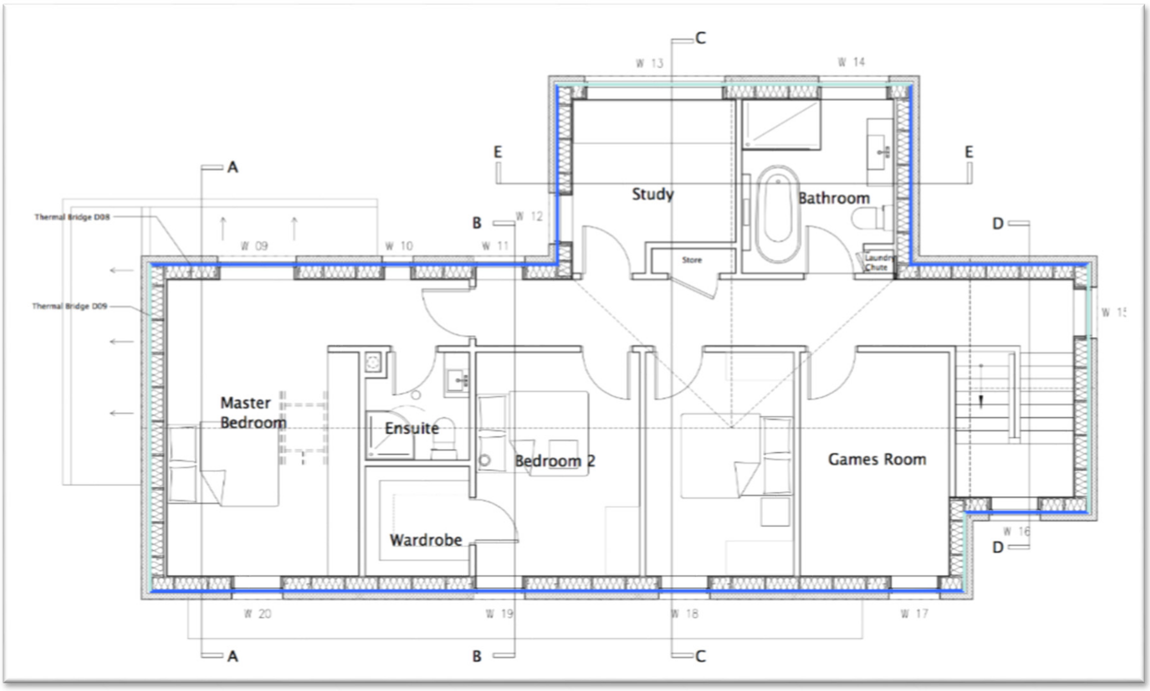


East Elevation below



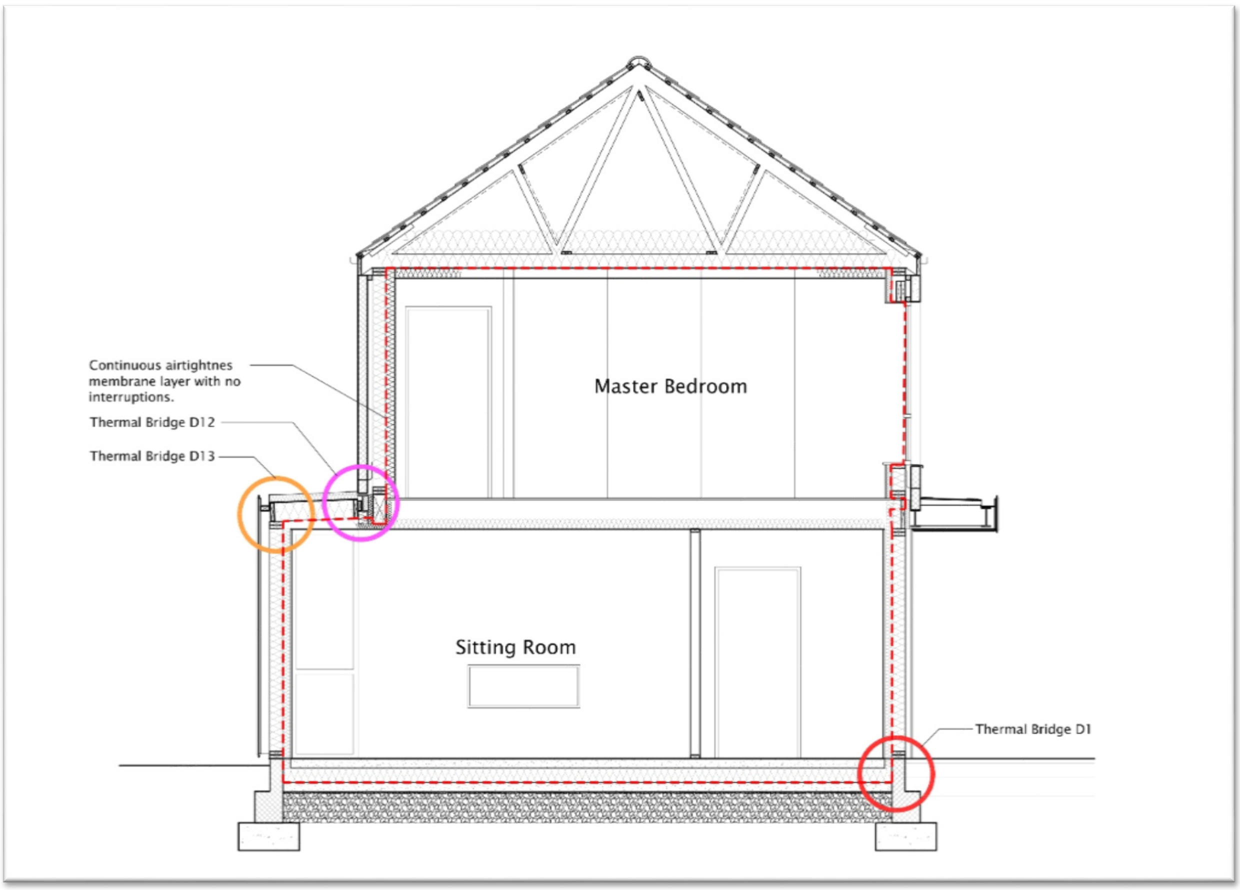
2.4 Plans

Ground Floor Plan

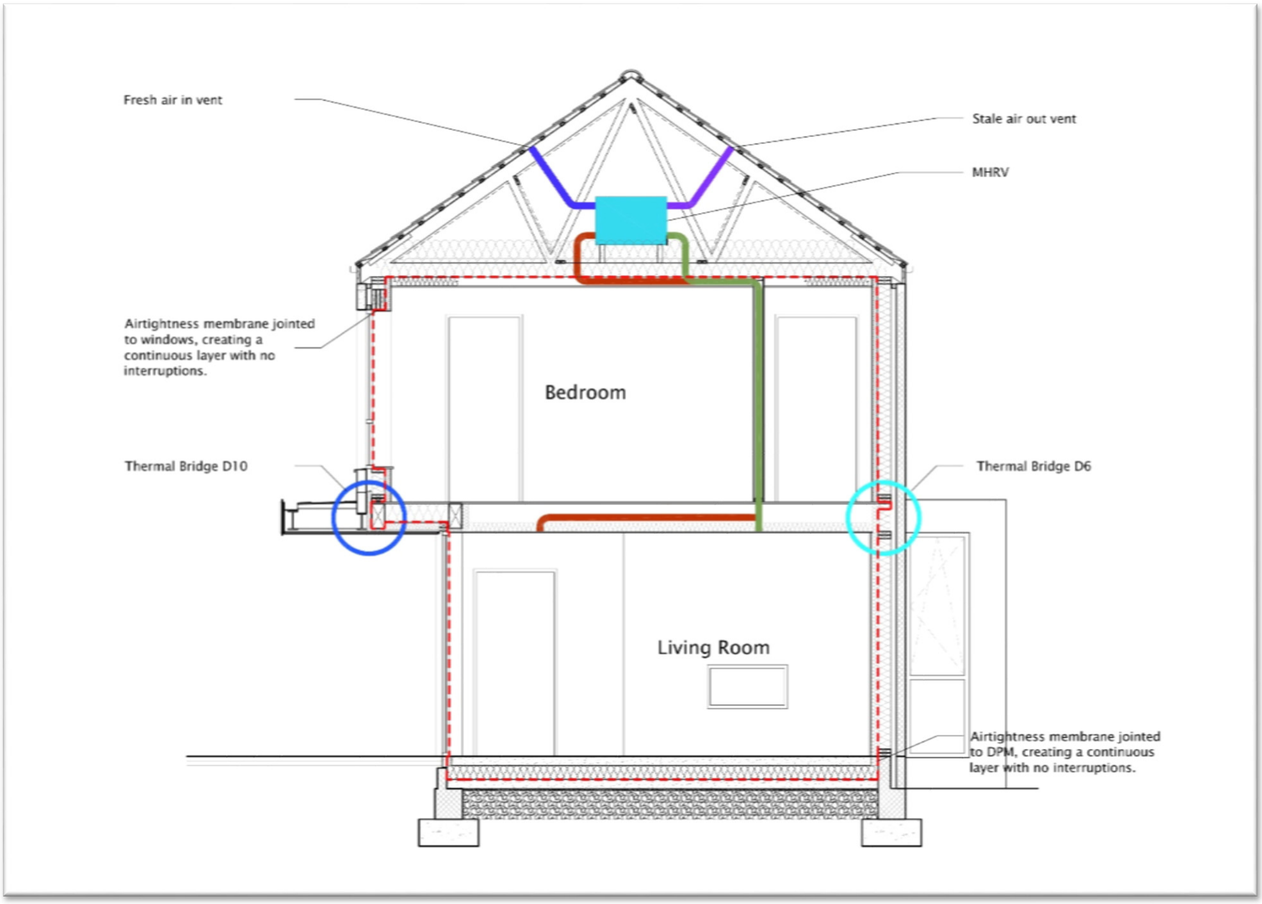


First Floor Plan

2.5 Sections



Section A-A with some of callouts of the areas calculated in Therm.

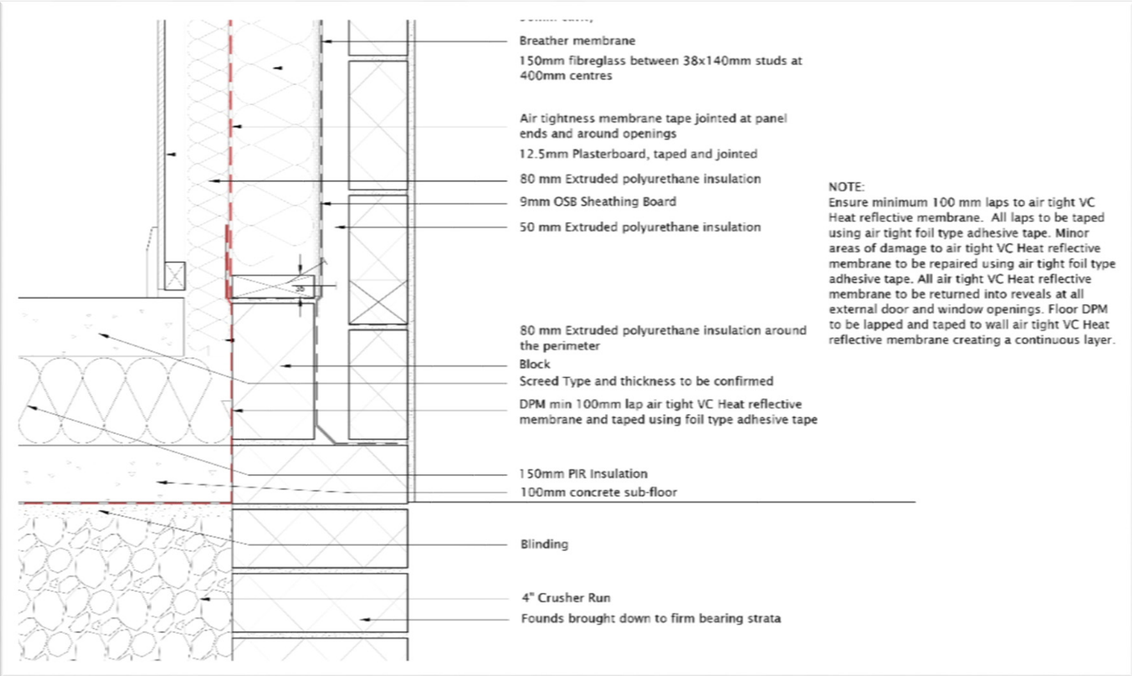


Section B-B with some of callouts of the areas calculated in Therm. MVHR unit in roof space venting through inline roof tiles. Continuous airtightness membrane dashed in red tape around all external windows & doors and DPC, creating a layer with no interruptions.

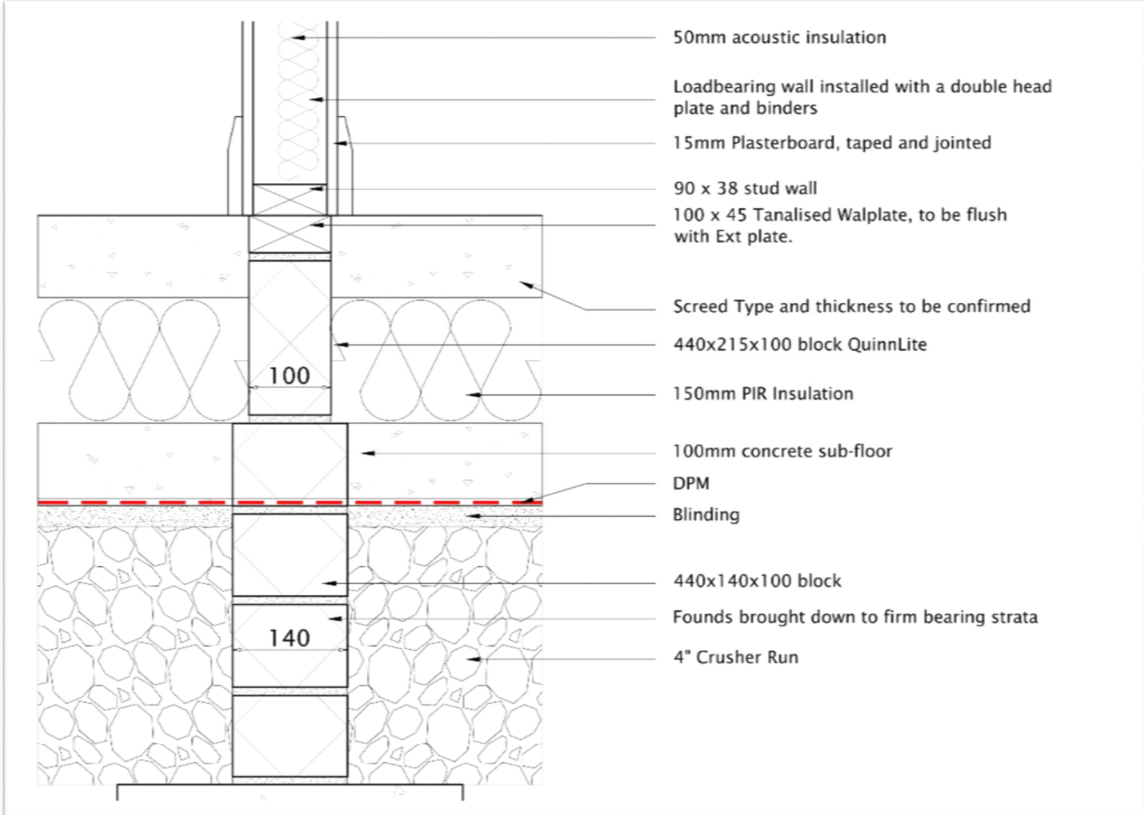
2.6 Internal view

Open plan area with double sided wood burning stove also serving the Sitting Room.

2.7 Construction Details

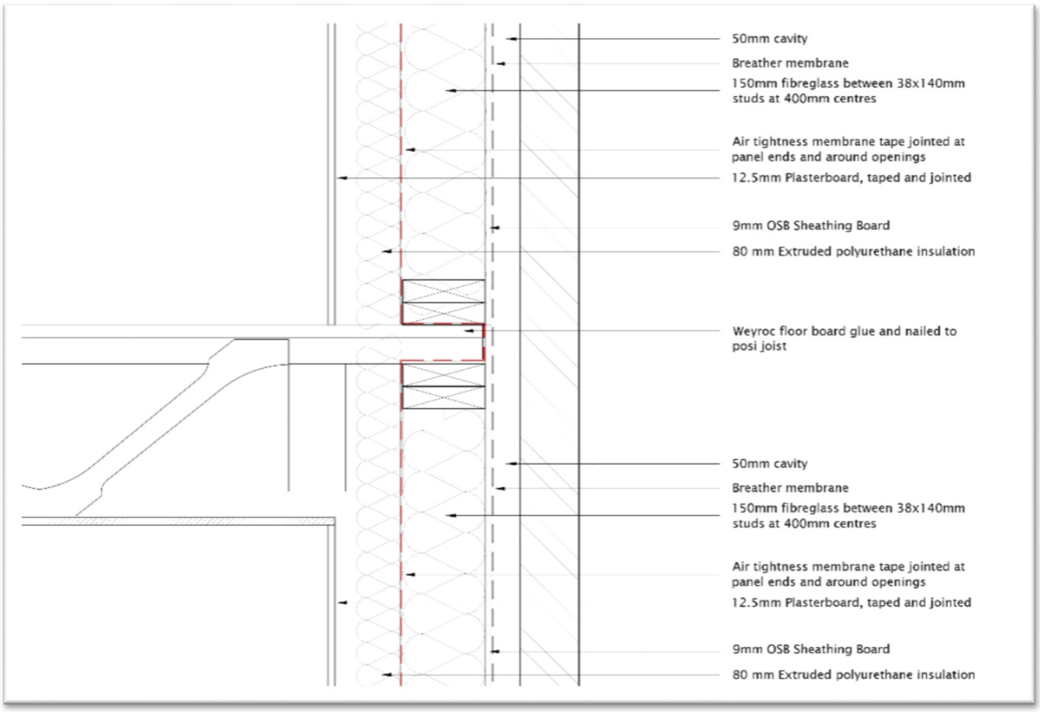


External wall foundation detail with 150mm PIR insulation (0.022 w/mK) in the floor, lapping with 80mm PIR insulation (0.022 w/mK) to the internal face of the external stub wall which is filled with 150mm fibreglass insulation (0.040 w/mK). Airtightness membrane jointed to DPM, creating a continuous layer with no interruptions.



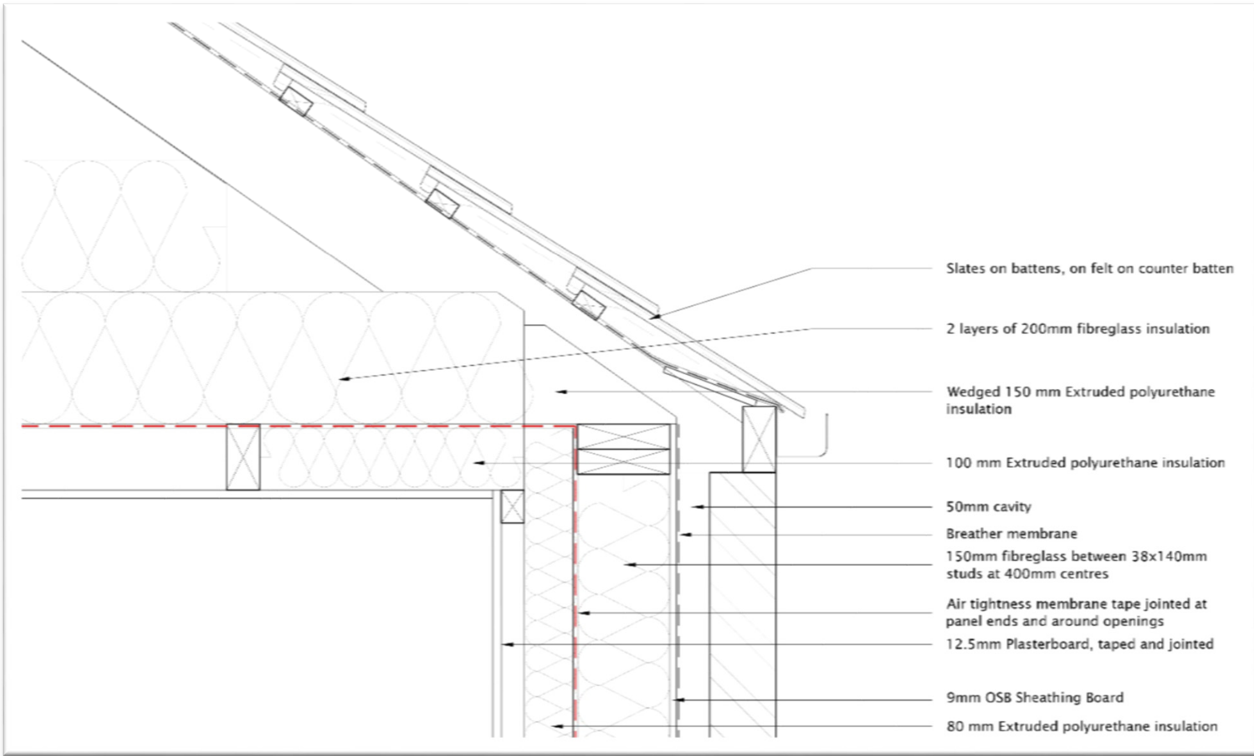
Internal load-bearing walls; QuinnLite blocks used at all penetrations through floor insulation to reduce cold bridging.

Internal load-bearing walls; QuinnLite blocks used at all penetrations through floor insulation to reduce cold bridging.



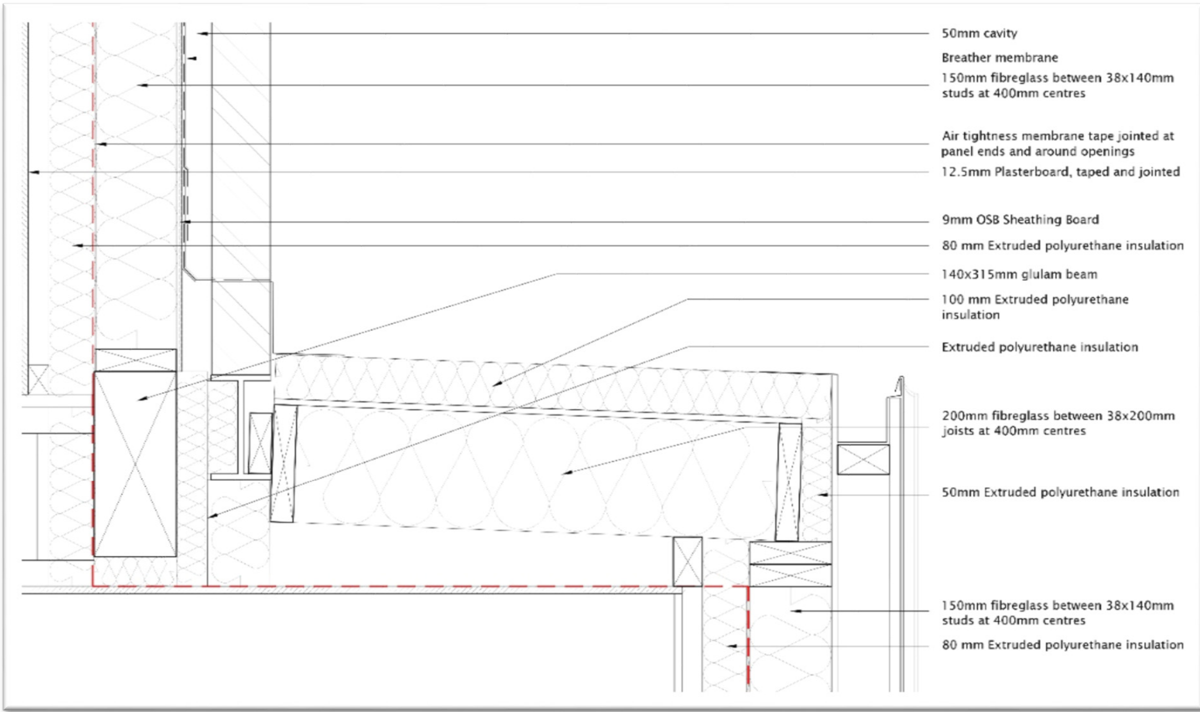
First floor joist hung from wall

First floor joist hung from wall reducing penetration through insulation in wall, consisting of 80mm PIR insulation (0.022 w/mK) to the internal face of the external stub wall which is filled with 150mm fibreglass insulation (0.040 w/mK). Airtightness membrane lapped around end of joists to create a continuous layer with no interruptions.



Eaves Detail

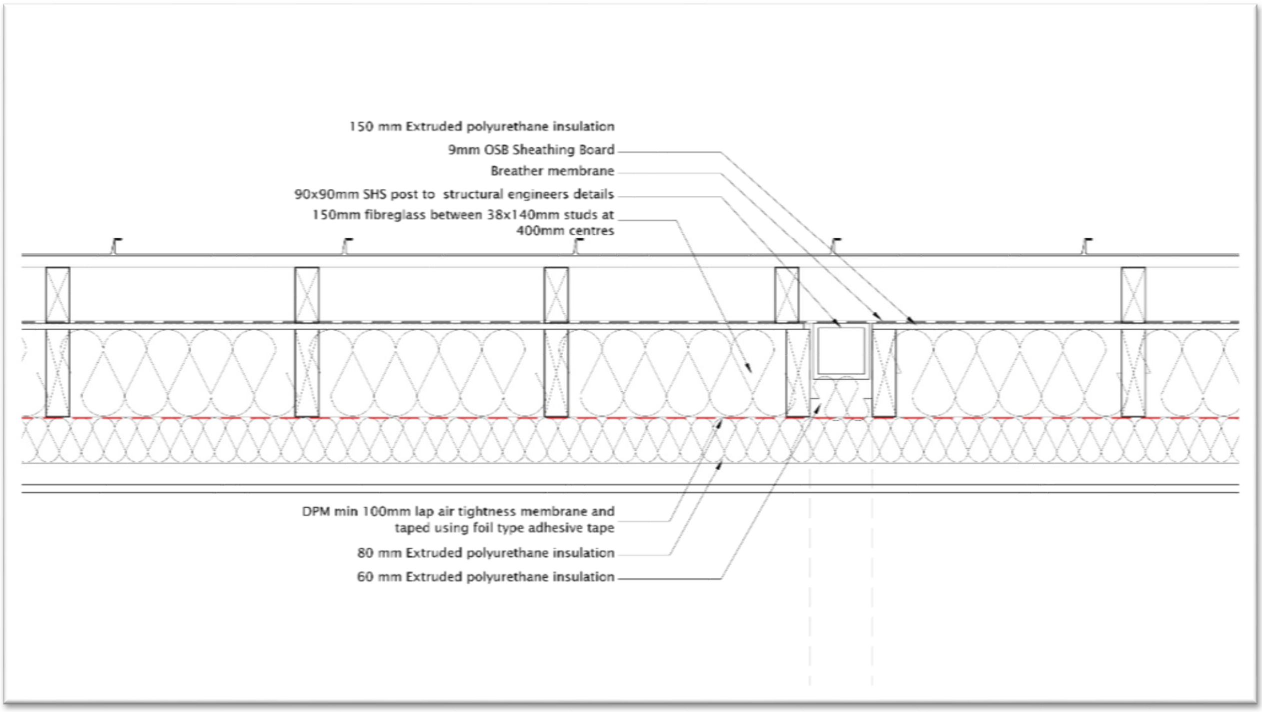
1st floor roof with 2 layers of 200mm fibreglass insulation (0.040 w/mK), one between joists and the other on top running at 90deg from the 1st. there is 100mm PIR insulation (0.022 w/mK) in the service void to reduce thermal bridging. Airtightness membranes between wall and ceiling is jointed to create a continuous layer with no interruptions.



Flat roof to zinc box in sitting room; 200mm fibreglass insulation (0.040 w/mK) between roof joists with 80mm PIR insulation (0.022 w/mK) above. Extra PIR insulation (0.022 w/mK) in cavity and under beams to reduce thermal bridging. Airtightness membranes between walls and ceiling is jointed to create a continuous layer with no interruptions.

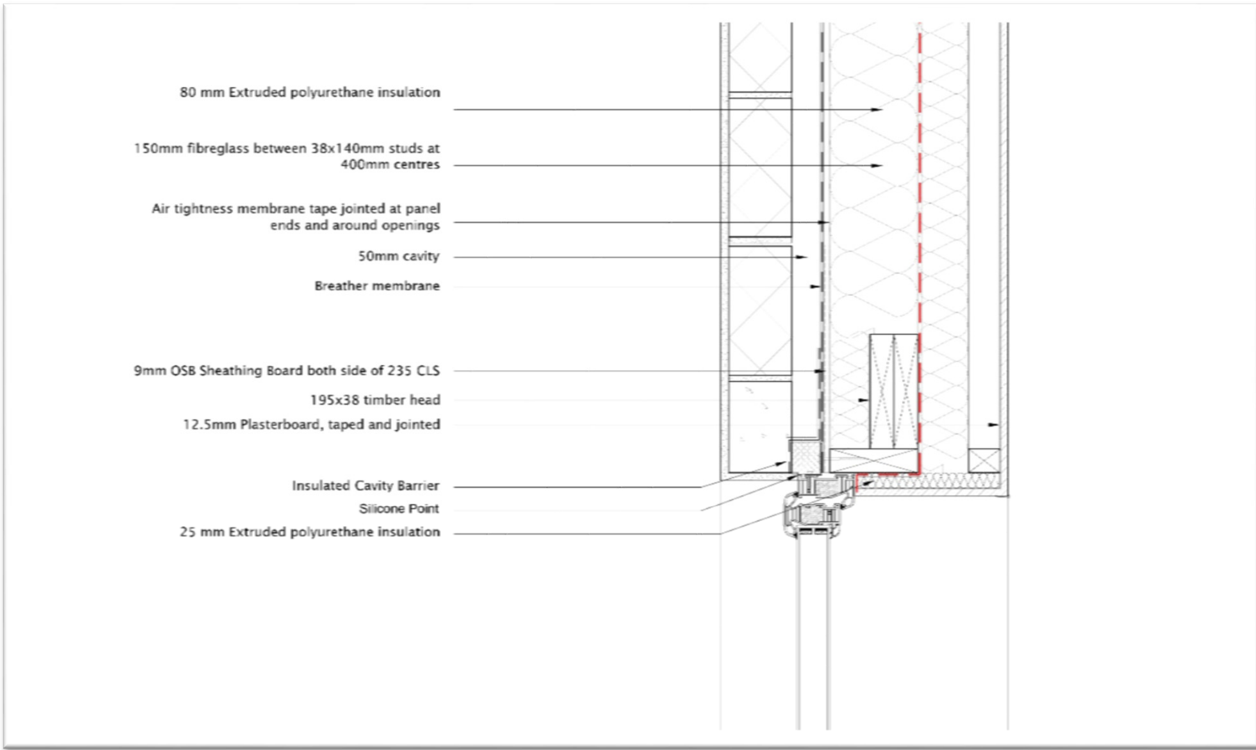
PIR (0.022 w/mK) inside web of the steel beam and around the exterior, in the Sitting Room reducing thermal bridging.

PIR (0.022 w/mK) enclosing steel beam in the Sitting Room, effectively moving it outside the thermal fabric.



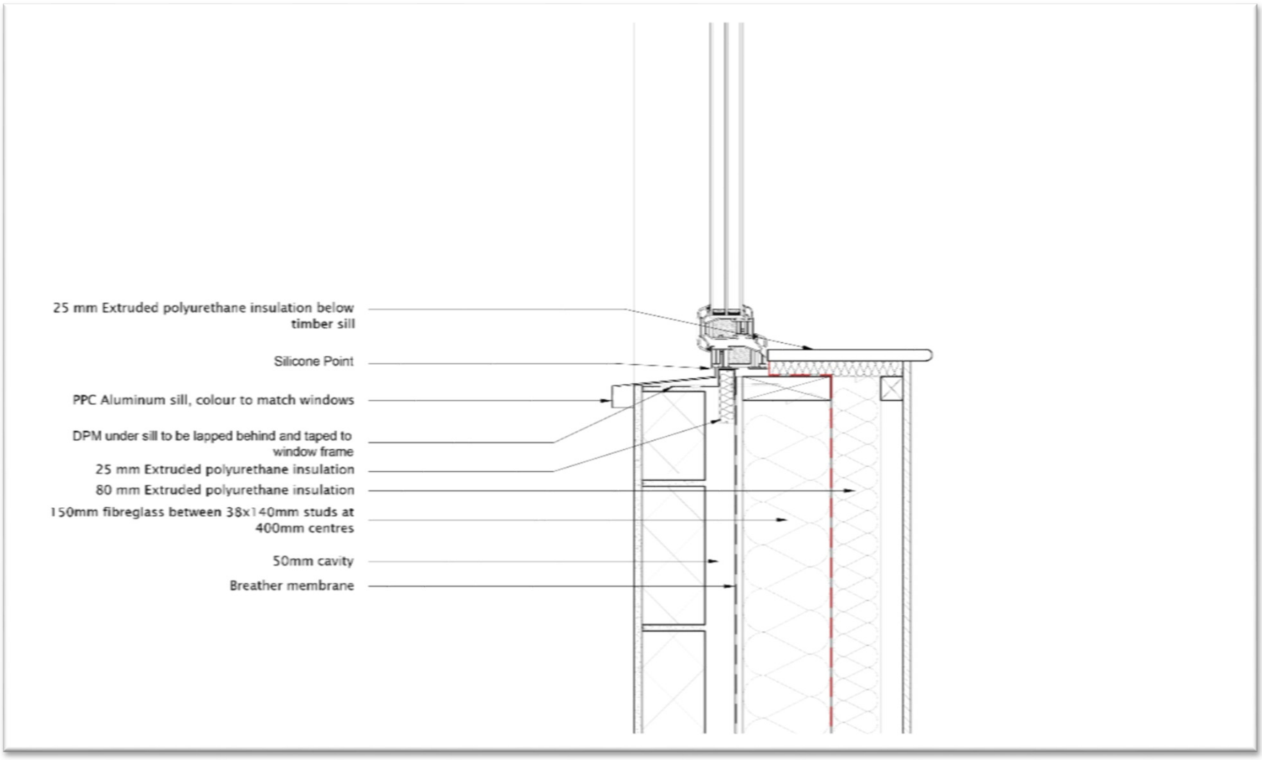
Plan detail of steel post carrying steel beam supporting blockwork moved outside thermal line to reduce thermal bridging.

150mm fibreglass (0.040 w/mK) between studs and extra PIR (0.022 w/mK) at steel post located outside the thermal fabric.

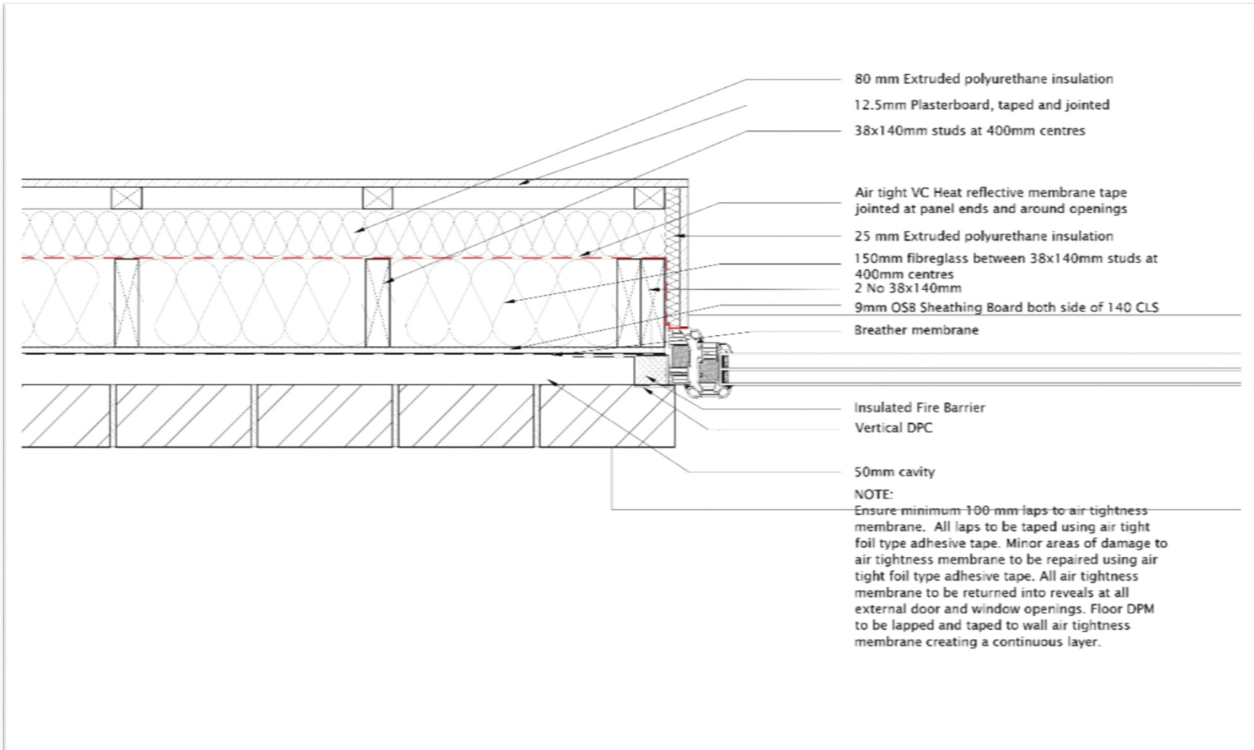


Head detail; 25mm PIR insulation (0.022 w/mK) to the underside of the head reducing thermal bridging. Airtightness membrane tape jointed to window and doors to create a continuous layer with no interruptions.

Airtightness membrane lapped behind all internal walls and under joist and tape jointed to window and doors to create a continuous layer with no interruptions. Membrane lapped at joints and taped with PIR on top to help protect it.

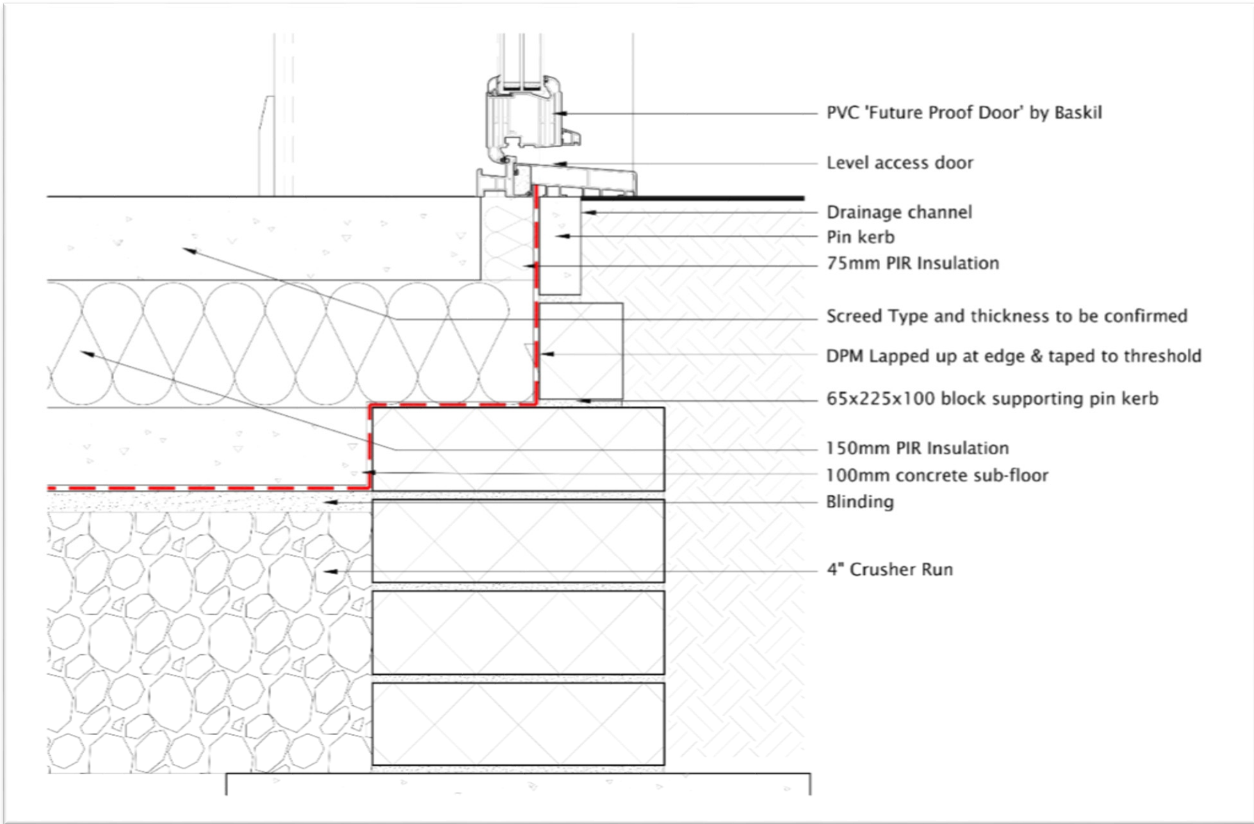


Sill detail; 25mm PIR insulation (0.022 w/mK) to the underside the sill board reducing thermal bridging. Airtightness membrane tape jointed to window and doors to create a continuous layer with no interruptions.



Reveal detail; 25mm PIR insulation (0.022 w/mK) to the reveal reducing thermal bridging. Airtightness membrane tape jointed to window and doors to create a continuous layer with no interruptions.

80mm PIR (0.022 w/mK) boards on walls with 25mm PIR (0.022 w/mK) around windows to reduce thermal bridging with service battens in place.



Threshold deail; 75mm PIR insulation (0.022 w/mK) at perimeter reducing thermal bridging. Airtightness membrane tape jointed to window and doors to create a continuous layer with no interruptions.

The windows and doors used in this project are passive house certified triple glazed PVC doors and 'Future Proof' PVC tilt and turn windows by Munster Joinery and tape jointed to the airtightness membrane.

4.1 Frame thermal transmittance (following the principles of BS EN ISO 10077-2)

Munster Futureproof Frame Profile	Frame Thermal Transmittance (U_f)
Fixed	0.6 W/(m²·K)
Sash Rein	0.8 W/(m²·K)
Mullion	0.8 W/(m²·K)

4.2 Linear thermal transmittance (following the principles of BS EN ISO 10077-2)

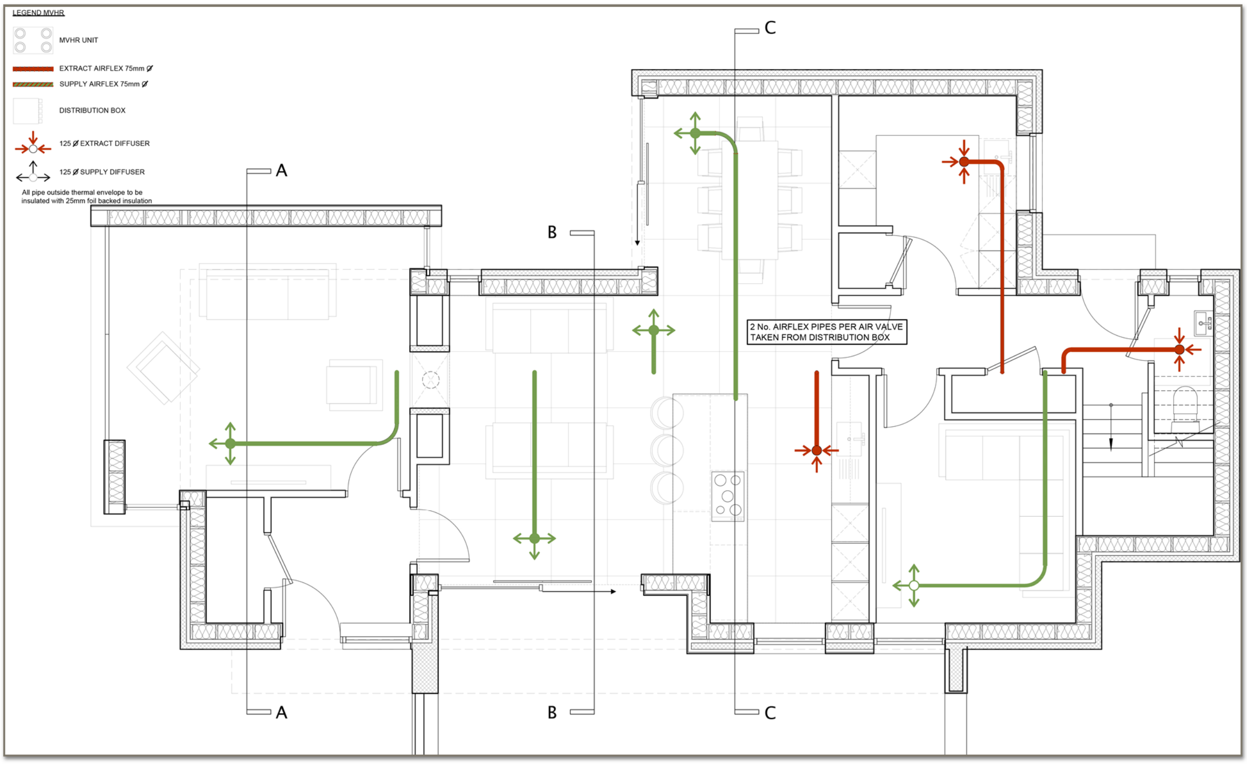
Munster Futureproof Frame Profile	Linear Thermal Transmittance (ψ)
Fixed	0.028 W/(m·K)
Sash Rein	0.027 W/(m·K)
Mullion	0.028 W/(m·K)

4.3 Centre pane U-Value of glazing calculated in accordance with BS EN 673.

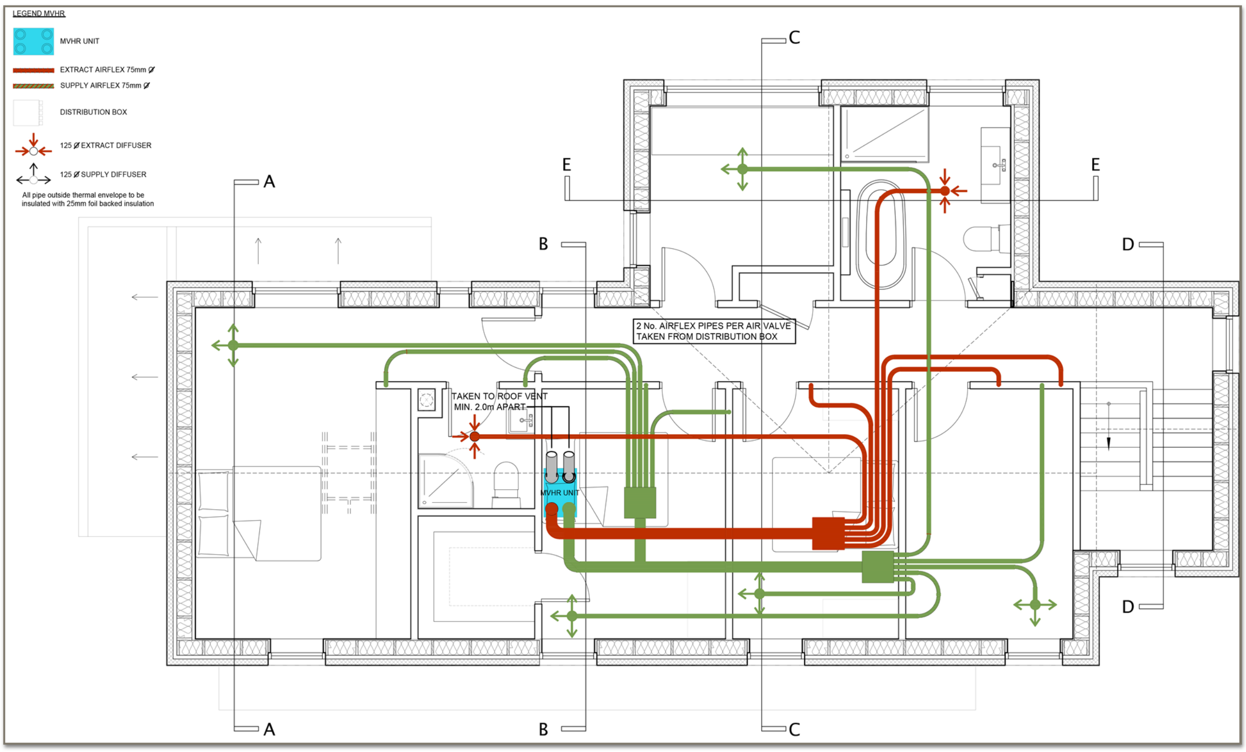
Glazing Unit	Centre Pane U-value (U_g)
4-20-4-20-4 Low-E 0.05 uncorrected emissivity (SGG Planitherm Total +) Internal and central panes, 90% Argon , 10% Air filled, Float Outerpane (SGG planilux) glazing unit with SGG Swiss Spacer V spacer bar with Polyurethane Secondary Seal giving 12mm sightline	0.6 W/(m²·K)

Nominal 4mm etc to ***0DP***, others ***1DP***			
Glazing dimensions and properties:			
Thickness of pane 1		**4**	mm
Pane 1/2 distance		**20**	mm
Gas fill (1/2)		**Argon 90%**	
Thickness of pane 2		**4**	mm
Complete next 3 cells for TG IGU			
Pane 2/3 distance		**20**	mm
Gas fill (2/3)		**Argon 90%**	
Thickness of pane 3		**4.0**	mm
Glazing Trans. - ***3DP***	U_g	**0.568**	W/(m²·K)
g-value - ***2DP***	$g_\perp$	**0.61**	

2.8 Ventilation System & Layout



Ground Floor MVHR layout



First Floor MVHR layout

Duplexvent DV145SE

The Duplexvent DV145SE is a highly efficient mechanical supply and extract ventilation unit with heat recovery for an air capacity of up to 594 m3/hr. It is a wall mounted unit and is delivered complete with a wall mounting plate and condensate drain, and has a 20mm thick insulation in the casing avoids any thermal bridging and significantly reduces noise levels.
The DV145SE includes an easily removable, aluminum heat exchanger that transfers warmth from the outgoing waste airstream into the incoming fresh air where its thermal efficiency reaches 90%. At no point do the airstreams mix. This unit is equipped with an automatic, 100% bypass which totally isolates the heat exchanger so that no air passes through it. This provides effective cooling in the summer season along with passive cross ventilation.

Thermal efficiency	Up to 90%
Fans	EC
Summer bypass damper	100% automatic
Electrical supply	230v / 1ph / 50Hz
Max. power consumption	350w
Electrical efficiency	~0,4Wh/m³

Ventilation ducts running between the posi joist with outlet in the TV room downstairs.

Ventilation ducts penetrating through airtight membrane at 1st floor ceiling and sealed around with airtightness tape, with 100mm batten on ceilings for services. The airtightness membrane is continuous across the ceiling and walls tape jointed together and around all openings and penetrations and to DPM.

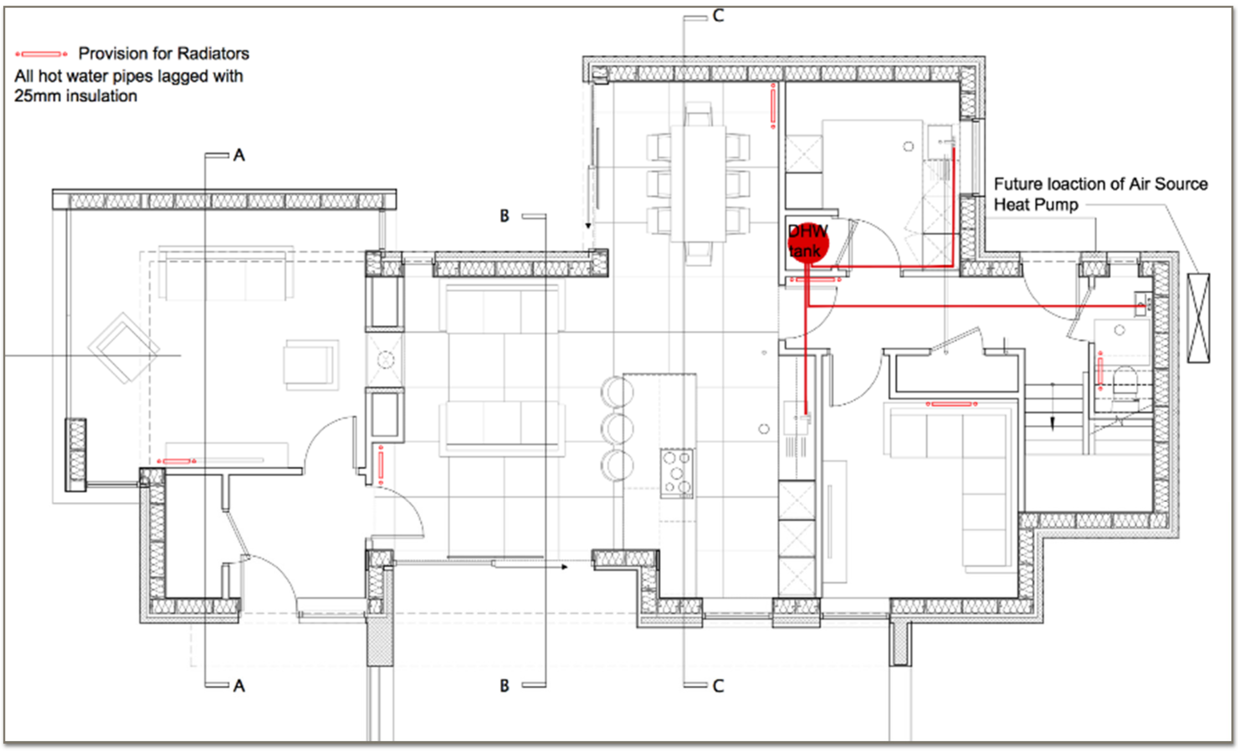
20mm air gap above and below doors allowing air flow between spaces with extract and fresh air inlets.

2.9 Heating System & Layout

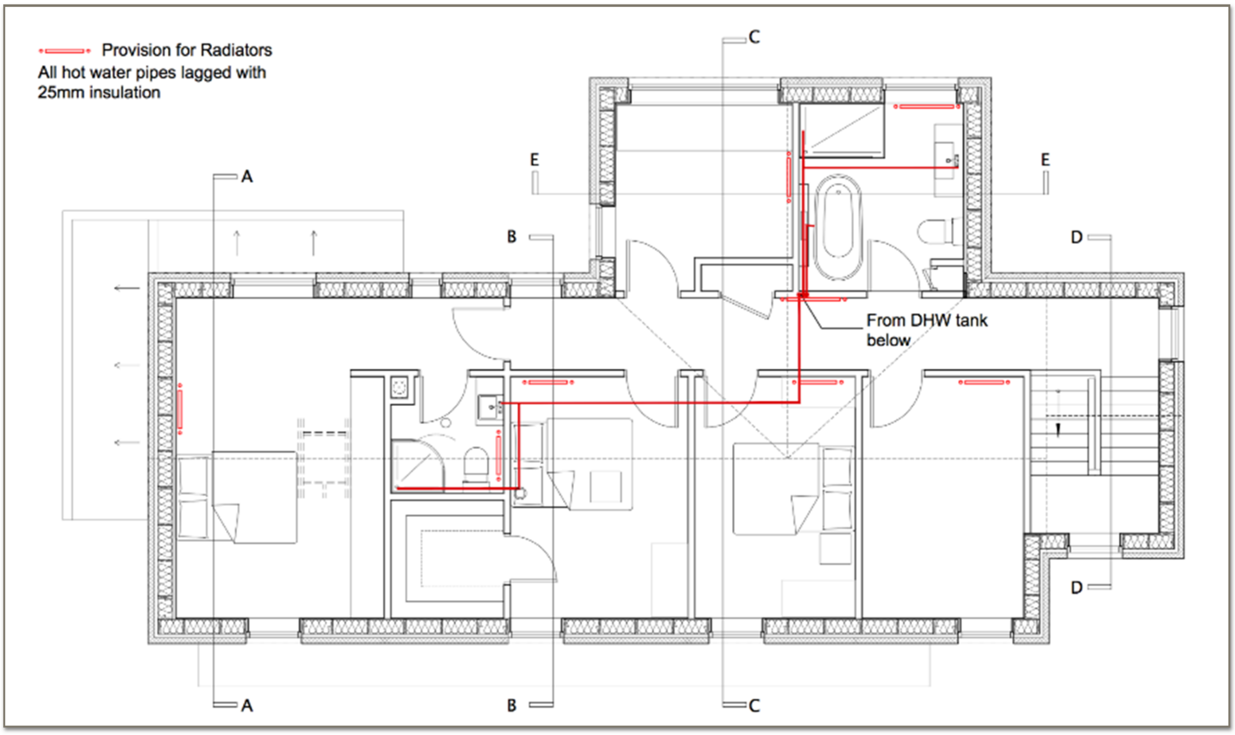
During the original brief the client wanted underfloor heating with air source heat pump, but cost constraints due to an unexpected cut in their mortgage, we had to reduce costs and one of these areas was in their heating system. By taking out the underfloor heating, wet flow screed, air source heat pump and PV panels they reduced their build by around £19,000. We then explored various cheaper options taking into account;

- installation costs
- running costs
- long term/ short term options

In the end they went with a temporary short term option that still allowed them to achieve a passive house standard. For their hot water demands they went with Economy 7 and installed a large hot tank that was also suits an air source heat pump. Their primary space heating is through a double fronted wood burning stove that is strategically located in the center of the dwelling between their 2 main living spaces and we built high density block around it, for thermal mass absorbing excess heat and act as a storage heater. Secondary heating is a few (3 No) small cheap 1kw electric heaters with built-in timers, allowing them to be programmed to come on before they get up if the morning, again utilizing the cheap Economy 7. In their bathroom the have a built in bioethanol fire for heat if required. They also plumbed the house for radiators and an air source heat pump and wired to bring in their PV panels (they now have their PV Panels on). They also had been waiting for grants to come available for the air source and now plan to install their air source heat pump and radiators in the summer. The hot water tank is located in a central location close to the bathroom and kitchen to minimize heat loss from the pipes, which are plastic pipes lagged with 25mm insulation.



Ground Floor hot water layout



First Floor hot water layout

Double fronted wood burning stove above and 1kw electric heater below (3No) with times to add some heat in the morning before the occupants get up.

2.10 Airtightness

In this project we due to the timber frame construction method, we specified an airtightness membrane located back from the internal plasterboard to reduce the chance of it being inertly getting punctured during or after the clients are occupying the dwelling. We used a SIGA airtightness membrane that was tacked back to the timber frame and each tack taped over, lapping and taping each joint using DAFA Airtight Tape. On the wall the membrane is fixed to the timber frame with 80mm PIR insulation on top with a 35mm service void and 12.5mm plasterboard. The wall membrane is taped to all openings and around all service penetrations and to the DPM in the floor before the screed is poured. The membrane to the 1st floor ceilings was tacked to the roof trusses lapped and tape and tape joined to the membrane on the walls.

Depressurize Test Results

	Results		
Correlation, r^2	**0.9880**	95% confidence limits	
Intercept, C_{env} $[m^3/h.Pa^n]$	**33.45**	**26.05**	**43.01**
Slope, n	**0.5302**	**0.4626**	**0.5979**

	Results	Uncertainty
Air flow at 50 Pa, Q_{50} $[m^3/h]$	**272.5**	**+/-0.0048**
Permeability at 50 Pa, AP_{50} $[m^3/h.m^2]$	**0.535**	**+/-0.0111**
Equivalent leakage area at 50 Pa $[m^2]$	**0.01363**	**+/-0.0048**
Air changes, n_{50}	**0.4636**	**+/-0.0111**

Pressurize Test Results

	Results		
Correlation, r^2	**0.9880**	95% confidence limits	
Intercept, C_{env} $[m^3/h.Pa^n]$	**33.45**	**26.05**	**43.01**
Slope, n	**0.5302**	**0.4626**	**0.5979**

	Results	Uncertainty
Air flow at 50 Pa, Q_{50} $[m^3/h]$	**267.0**	**+/-0.0244**
Permeability at 50 Pa, AP_{50} $[m^3/h.m^2]$	**0.525**	**+/-0.0263**
Equivalent leakage area at 50 Pa $[m^2]$	**0.01335**	**+/-0.0244**
Air changes, n_{50}	**0.4545**	**+/-0.0264**

2.11 Summary

Specific building demands with reference to the treated floor area					
	Treated floor area	186.6	m²	**Requirements**	**Fulfilled?***
Space heating	Heating demand	**15**	**kWh/(m²a)**	15 kWh/(m²a)	**yes**
	Heating load	**12**	**W/m²**	10 W/m²	**-**
Space cooling	Overall specif. space cooling demand		**kWh/(m²a)**	-	**-**
	Cooling load		**W/m²**	-	**-**
	Frequency of overheating (> 25 °C)	3.3	%	-	-
Primary energy	Heating, cooling, dehumidification, DHW, auxiliary electricity, lighting, electrical appliances	**105**	**kWh/(m²a)**	120 kWh/(m²a)	**yes**
	DHW, space heating and auxiliary electricity	75	kWh/(m²a)	-	-
	Specific primary energy reduction through solar electricity		kWh/(m²a)	-	-
Airtightness	Pressurization test result n_{50}	**0.5**	**1/h**	0.6 1/h	**yes**

* empty field: data missing; '-': no requirement

This project was completed June 2014, the builders finish this build cost approx. £140,000.

The client has moved in approx. 1 year, they found the wood burning fire a chore to light coming in from work on the cold winters nights. They also found that the heat from the electric radiators didn't travel as far as the end bedroom, there was a 'cold wall' as you walked through their master bedroom door. Their predicted electric bill for the year in £1100-1200 plus about £200 on wood for their fire, taking their running cost to approx. £1400/per. Even though they are happy with the heat performance of the house in the winter, they thought having to light the fire and constantly having to put more wood on wasn't partial for their life style. They have decided that they will install an air source heat pump with a few radiators before next winter. They have now installed 4 kw of PV and when they have the air source heat pump installed it should leave them with no energy bills and with the possibility of being energy positive. Marshall McCann Architects are continuing to monitor and analyze the performance, to create a feedback loop to improve their designs.

In the summer they were extremely happy with the way the cross ventilation and shading keeps the house cool on really hot days the opening of the large sidling doors at either side rapidly cools the main living area and by opening the corridor windows upstairs keeps the upstairs cool also.

Passive House Designer: Martin Marshall - Marshall McCann Architects - MMcCarchitects.com
Passive House Builder: Mark Gribbin - Setanta Construction - setantaconstruction.com
MVHR: BPC Ventilation - bpcventilation.com
Structural Engineer: Robert Paul - Structures 2000 Ltd