Passivhaus Plus Project Documentation
Carrstone House, Maulden, Bedfordshire UK

Abstract

Single family detached three-bedroom home in Bedfordshire, England

Building data

Year of Construction	2016	Space Heating	**16** kWh/(m^{2}a)
U-Value external wall	0.143 W/(m^{2}K)		
U-Value floor	0.117 W/(m^{2}K)	Heating Load	10 W/m^2
U-Value roof	0.113 W/(m^{2}K)	Renewable Primary Energy (PER)	35 kWh/(m^{2}a)
U-Value window (avg.)	0.93 W/(m^{2}K)	Renewable Generation	87 kWh/(m^{2}a)
Treat Floor Area	221.2 m^2	Frequency of Overheating (>25 ^{o}C)	4%
Heat Recovery Efficiency	91.1%	Pressure Test (n_{50})	0.3 h-1
Special Features	Full Roof of Photo Voltaic panels		

Alan Budden
Architect, RIBA, ARB, Certified Passivhaus Designer
Eco Design Consultants www.ecodesignconsultants.co.uk

1.0 Brief description

Carrstone House has been designed to meet the clients desire for a highly environmentally sustainable life, achieving Passivhaus Plus certification. The house although only 3 bedrooms, has large living spaces and a downstairs bedroom making it suitable for the later years of life. This unfortunately makes the form factor larger due to half the house being single storey so additional insulation thickness was required.

The living spaces are arranged in an open plan format facing south to use maximum solar gain. The single storey living area has a sloping roof to provide 1 – 1½ story height rooms. The master bedroom and living are the most used rooms and are therefore located to the south maximising the views. A central utility spine separates private and public area within the house, providing a clear design feature.

The house optimises high levels of natural light, reducing energy usage and improving wellbeing. Solar panels incorporated into the roof provide 24kW peak of electricity provide enough energy to completely meet the power and heating need of the home, with excess to run an electric car. These panels are fitted seamlessly within the roof, having glass surrounds and integral roof lights. These panels make the house carbon neutral and energy positive. Efficient water fittings, water butts and sustainable drainage solutions are included to reduce the usage of water.

1.1 Responsible project participants

Architect:	Alan Budden – Eco Design Consultants
Structural Engineer:	MBC Timber frame
Contractor:	Nick Hull Builders / MBC Timber frame
Building Physics and PHPP:	Alan Budden – Eco Design Consultants
Building Services:	Williams Energy Design
Certifier:	Will South, Co-create Consulting
Certification body:	Passivhaus Institut, Darmstadt
Certification ID:	16370_Cocreate_PH_20170919_WS
Passive House Database ID,	ID: 5111

Author of the project documentation

Alan Budden

29th December 2020

2.0 Views of the Building

Front entrance elevation, north facing with smaller windows and separate garage.

Approach to the house from North, with feature local “Carrstone” wall, PV roof just visible.

Rear south elevation facing the garden with larger windows & good views over countryside. External awning on main patio doors used in summer.

Drone view of house, showing integrated PV roof, & roof lights (Garage just flat roof membrane).

Vertical drone shot showing house within garden.

Drone view of rear of house.

Interior hall with views through to the living space and garden beyond. MVHR ducts supply and extract ducts to kitchen and study visible. Supply of water to kitchen also housed in additional ventilation duct for easy routing.

Dinning / Living space overlooking garden with sloping roof.


View back to kitchen & pantry.

View back to hall and stair to first floor.

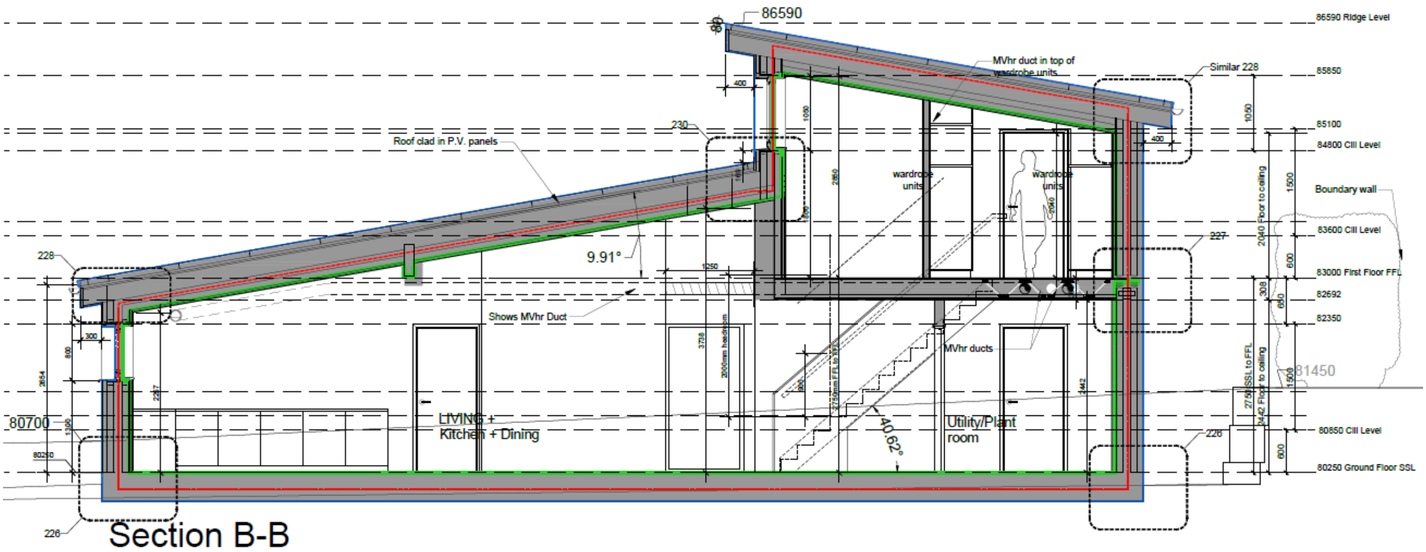
Evening sitting room / media room to north.

Study.

Master bedroom with views to the south.

Ground floor WC / shower room.

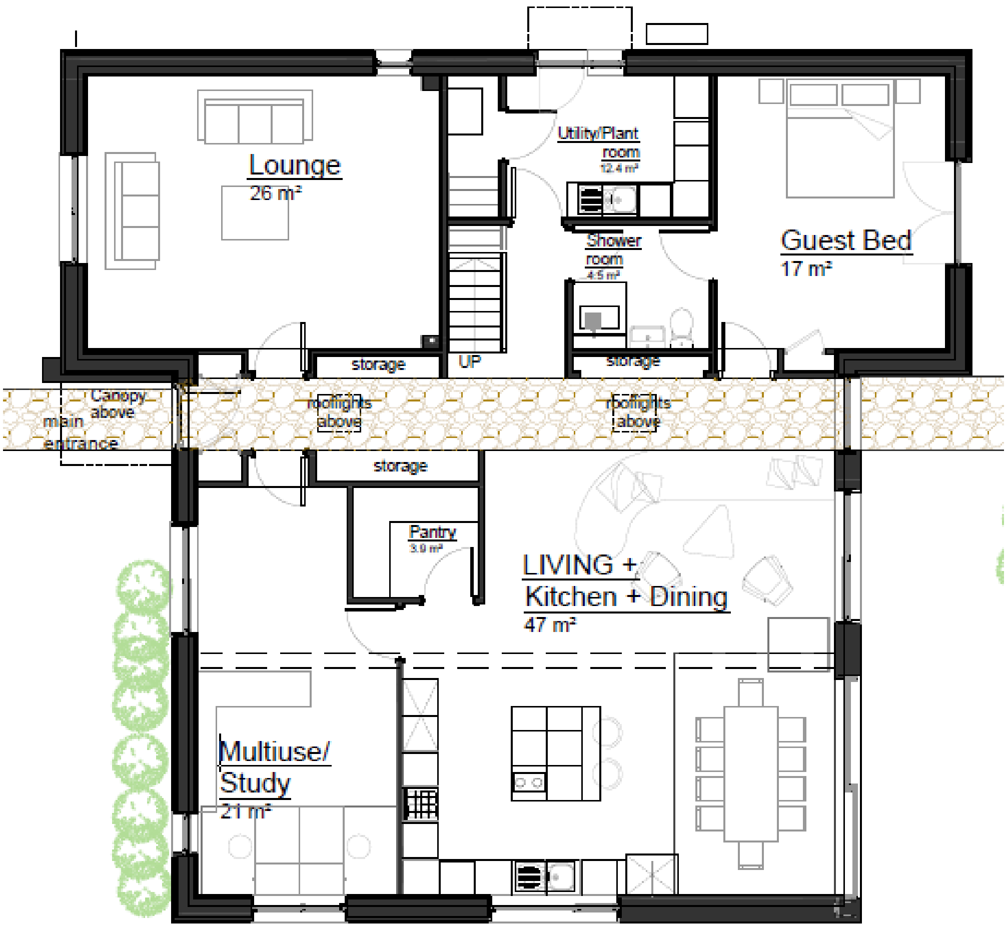
3.0 Sectional drawing



Section B-B

This typical section shows the sloping roof to the living areas, and the 2-storey sleeping area.

4.0 Floor plans

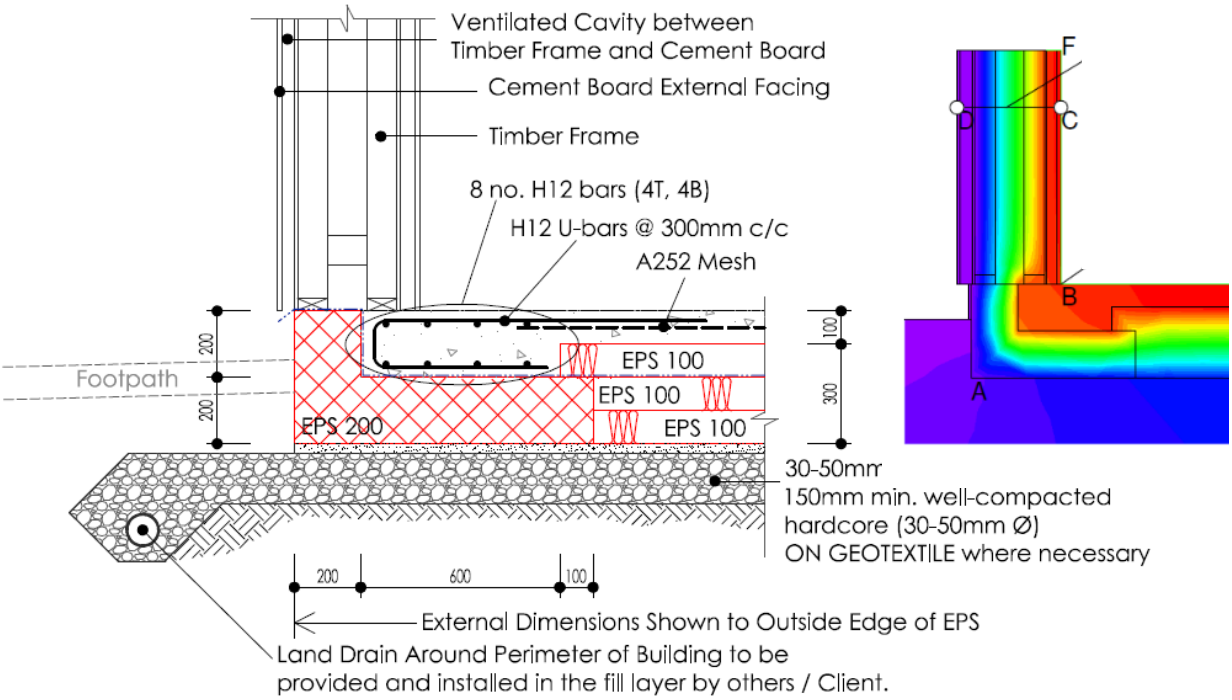


Ground floor provides living accommodation along with guest bedroom and study.

The first floor has the master bedroom and en-suite, a further bedroom and en-suite. Also included on this floor is the hot water tank, and heat pump.

5.0 Construction details of the thermal envelope

5.1 Ground floor slab



The ground floor is constructed of a 150mm concrete slab floating on bed of 300mm of EPS insulation (0.038). The edges of the slab are thickened by 100mm to provide additional strength for the walls and this is taken into account in the PHPP using a psi value of 0.050 W/(mK) for the foundation perimeter. The prefabricated Larson truss is then supported on the slab, with the outer leaf cantilevered out over the insualtion to form a relatively thermal bridge free junction. The heavy patio and front doors are supported on compact foam with bolts cast into the slab, where the doors are positioned within the insualtion zone.

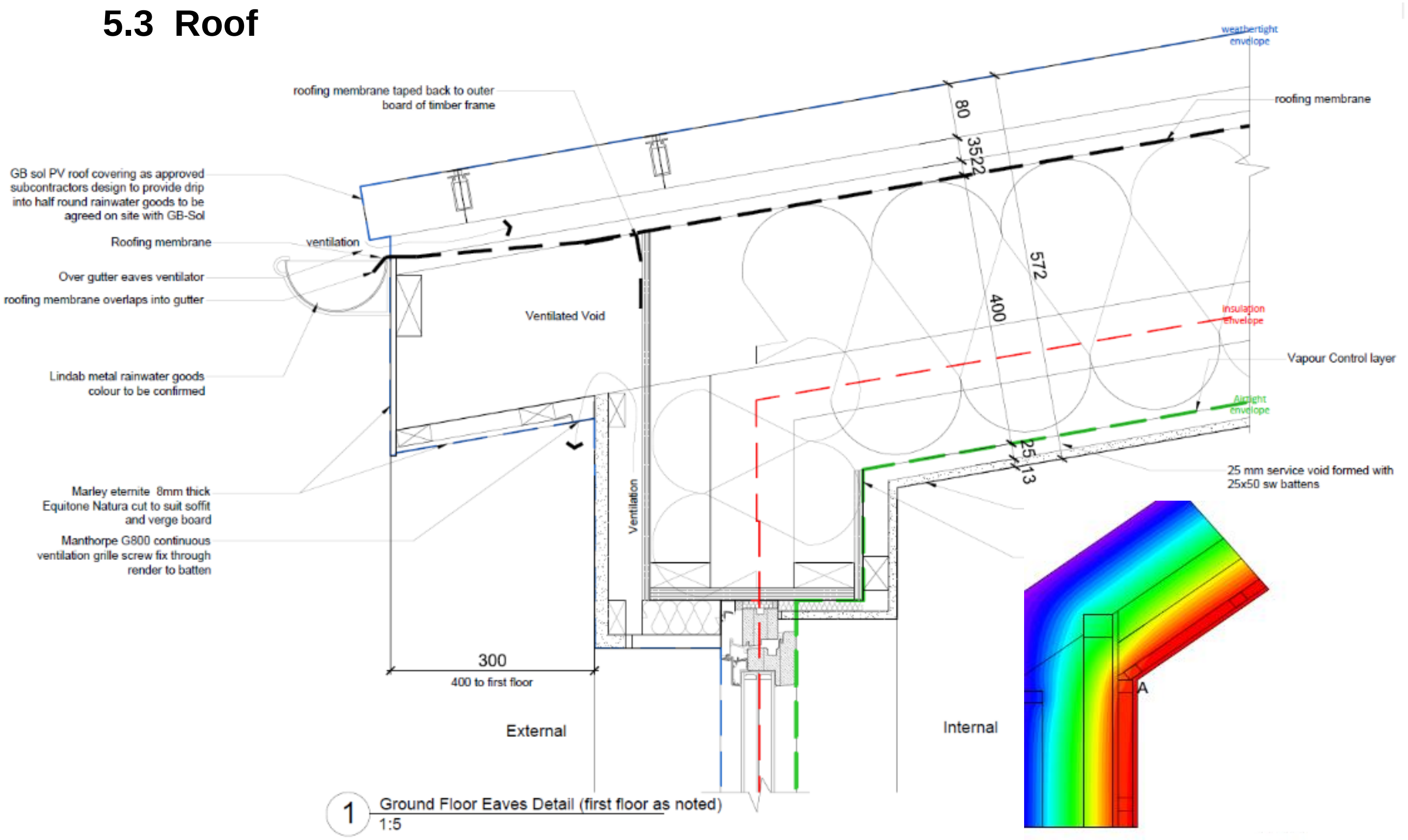
U Value = 0.123 W/(m^{2}K)

5.2 Exterior walls

The external walls were constructed by MBC Timber frame, using prefabricated wall panels with twin studs 89 x 38 forming a 300mm cavity filled with Warmcell insulation (recycled newspaper) (0.036 W/(mk). A proprietary airtightness OSB board is used on the inside to form the airtightness barrier taped at all junctions. Followed by battens to plasterboard to from a service cavity. Timber and plywood gussets were used to cantilever the outer frame. The outside of the frame is formed with timber board and weather proof membrane. The outside of the wall is then battened to form a ventilated void and cement board and render finish.

U-value = 0.136 W/(m^2K)

5.3 Roof

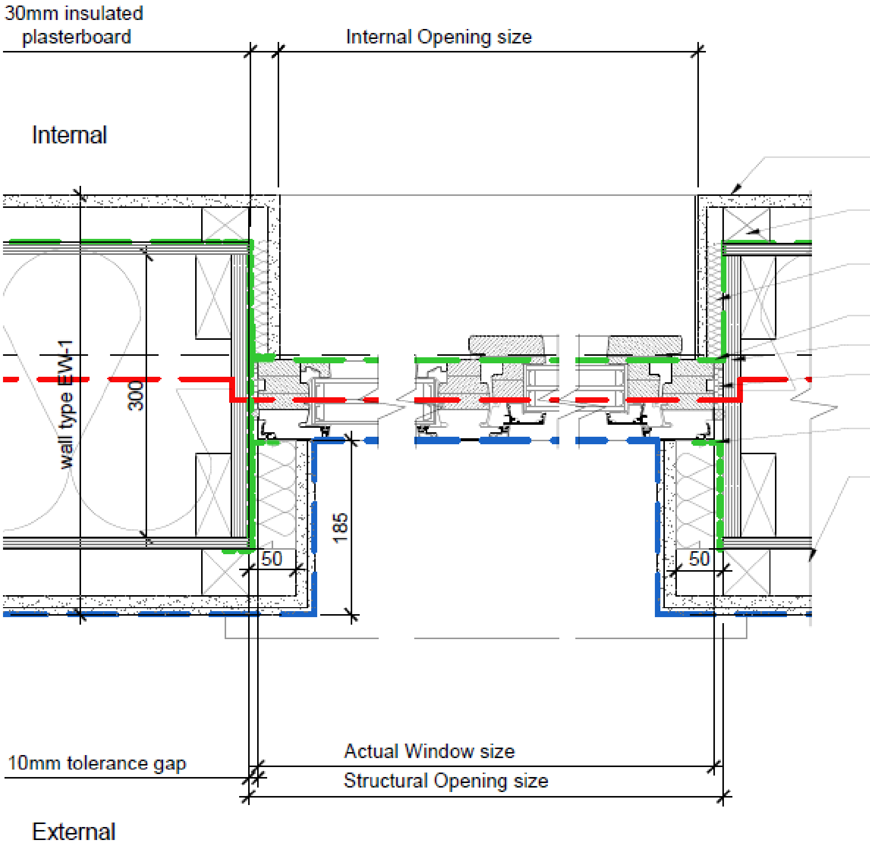


The roof was constructed like the walls with twin joists from the eaves to abutment and filled with Warmcell insulation. The upper deeper chord taking the load, being much thicker. An inner finish of taped proprietary airtightness OSB board again is used for the airtightness barrier, followed by a service void and plasterboard. Careful detailing at the eaves also kept the thermal bridging to a minimum.

The surface of the roof utilises the GB Sol PV integrated PV system with glass PV panels supported on an aluminium railing system. Glass was used to the perimeter to limit the amount of PV provided to 24kW peak, as this was the maximum allowed by the district network operator. The eaves and verge were then finished with aluminium flashings.

U-value = 0.113 W/(m^{2}K)

5.4 Windows



1 Typical Window Jamb detail
1:5

The windows on this project are Internorm HF310's, timber aluminium windows, KF410's UPVC in the bathrooms upstairs and HS330 timber aluminium sliding doors in the lounge. All have thermally broken frames, the U value of the frame varying from 0.72 W/(m²K) to 1.44 W/(m²K) for the sliders. The glazing is triple glazed with low e coatings and argon gas filled. Ug is generally 0.50 and the g value 47%

Sliding doors were selected over bifold due to their superior air tightness. The windows are tilt and turn and open to the inside allowing additional insulation to be added around the frame on the outside, reducing the area of visible frame and consequential heat losses considerably. Internal comfort around the windows is high enabling siting and reading by them even on the coldest days.

The overall average U value for the windows was 0.93 W/(m^{2}K).

6.0 Airtight envelope

A continuous air tight layer is essential in keeping draughts out and meeting the Passivhaus standard. All detailed drawings showed the airtightness layer in red, this included, the concrete slab, proprietary airtightness boards, tapes, window frames and glass.

The airtightness strategy involved lining the inside of the external walls and the roof with proprietary airtightness boards taped with Siga & Pro Clima airtightness tapes at all joints and junction with the concrete slab, window openings and service penetrations. At intermediate floor junctions an airtightness membrane was used to link together the airtightness board on the ground floor to the walls above, going around the wall plate. In addition to this a good wind tight barrier was formed on the outside using a wind tight membrane.

The resulting air pressure tests carried out by Rhys Davies of Melin, provided a pressurisation air change rate of just 0.269 h-1@50 Pa, and the depressurised result was 0.280 h-1@50 Pa. giving an average of 0.27 ach/hr.

Melin London | Bristol | Llanelli

Air Permeability Test Certificate

Engineer registration number: Rhys Davies

Test Number: Carrstone

Report reference number: 505643

This is to certify that the following test results were carried out fully in compliance with Approved Document L1a of the 2010 Building Regulations.

Dwelling plot/address: Carrstone

Test Date: 2017-01-18

Design air permeability	0.6	ACH @ 50 Pa	r^2=	0.9996	(>0.98)
Measured air changes per hour	**0.27**	ACH @ 50 Pa	n =	0.677	(0.5 – 1.0)
Volume area of dwelling	**608**	M^3			

Accredited engineer

Name: Rhys Davies Signature: [signature] Organisation: Melin Consultants

e-mail: davies.r@melinconsultants.co.uk

Carried out for : Paul Wilson

A connected approach to sustainable building solutions

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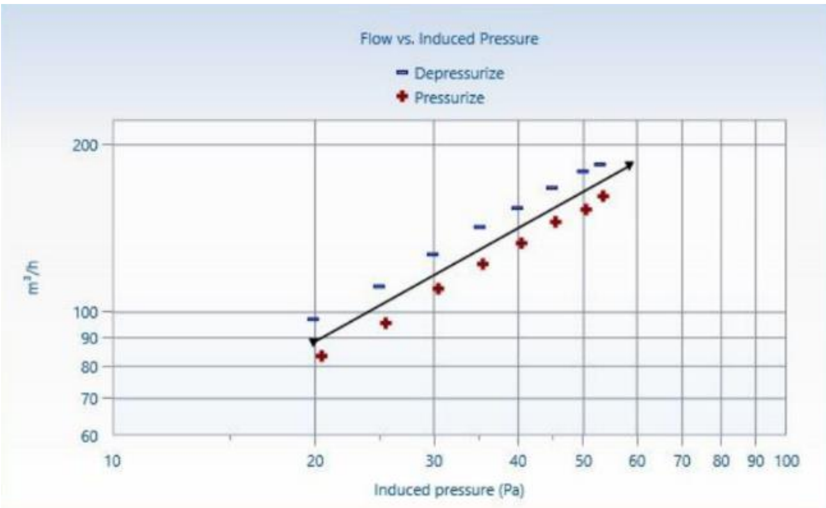
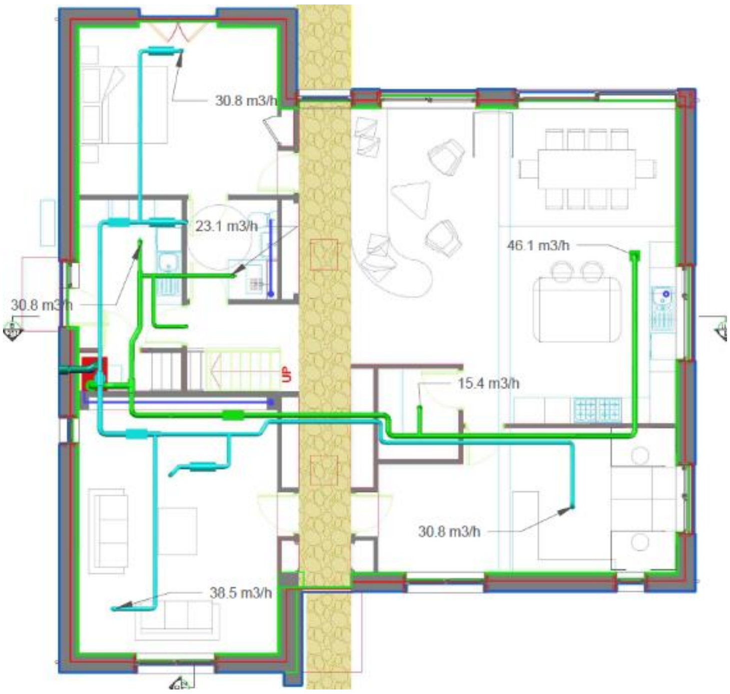


7 Ventilation System

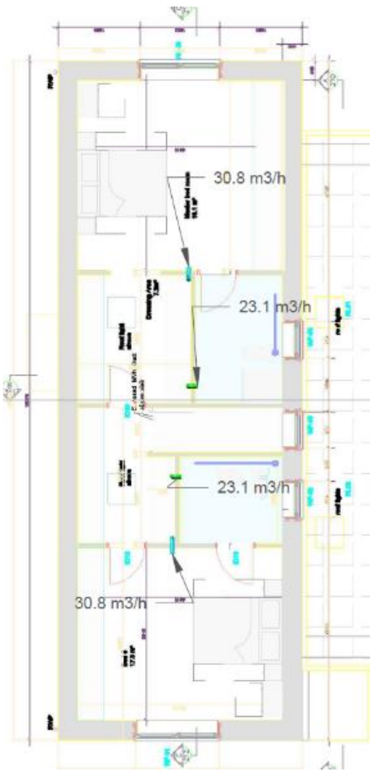
7.1 Ventilation ductwork

The MVHR unit is located on the ground floor in the utility room, it was going to be enclosed in a cupboard, but as the ducting was so neat it was left exposed, allowing easy access. The fresh air intake and exhaust are taken straight through the wall, keeping duct lengths to a minimum. All ductwork is in ridged galvanised steel, with sound attenuators, as necessary.

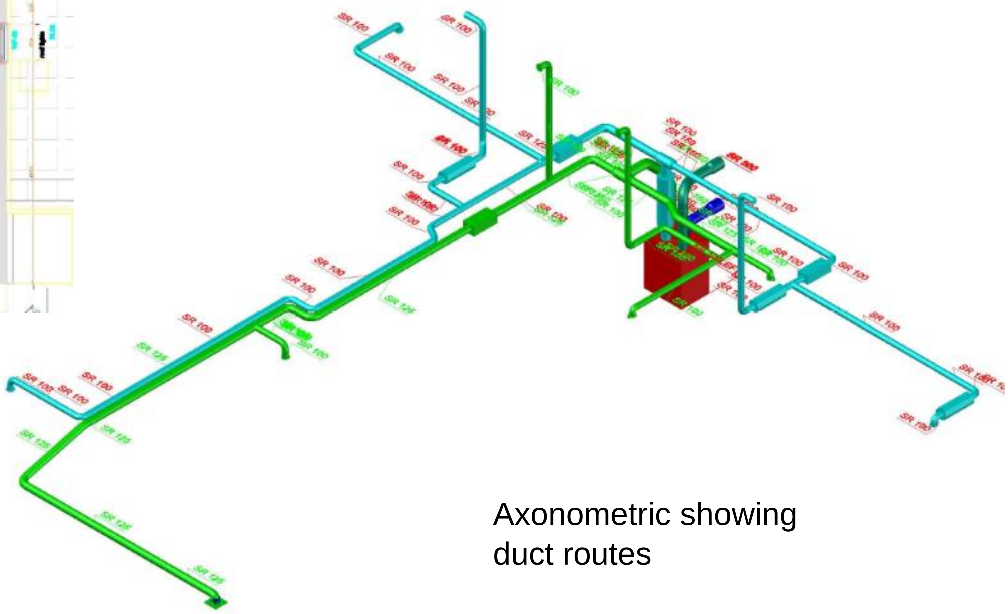
Air is distributed to the bedrooms, living room, and study via ducts within the first floor, and exposed ducts in the study and pantry. This air is then transferred under doors and through the hall to the kitchen extract and extracts in the bathrooms. Air transfer routes are provided under doors, note that the extract from the kitchen, utility and shower room is greater than the supply and so this draws additional air down the stairs from the first-floor bedrooms, keeping the hall way ventilated.



Ground floor



First floor



Axonometric showing duct routes

7.2 Ventilation Unit

Ventilation is provided by the Passivhaus Institute certified Paul, Novus 300. Located in a ground floor utility room, with short, insulated ducts to the outside for supply and extract.

The heat recovery system has an effective heat recovery efficiency of 93% and an electrical efficiency of 0.24Wh/m3. Overall, the system has an efficiency of 90.9%

8.0 Heat supply system

The roof was to have as much Photo Voltaic (PV) panels as possible to generate electricity for the house, the electric car, and the grid. Due to the size of the PV array, we proposed, we were required to obtain a power station licence from the district network operator, this was obtained but limited to 25 kW peak, as the grid infrastructure could not take anymore. Unfortunately, this left us short of the aim of achieving the Passivhaus Premium Standard. The options we had were additional generation provided through additional PV but capping this supply to the grid and storing on site in Batteries, however due to the 3-phase system this proved expensive as 3 battery systems would be required. The second option was to buy shares in a new renewable energy scheme, this was explored however a suitable scheme was not found but may be done in the future.

It made sense to use as much of this free electricity as possible to heat the house. Direct electric heating was considered, however utilising an air source heat pump provide much greater efficiency, and this could also heat the domestic hot water needed for the property.   Heating is provided by a Mitsubishi Ecodan PHUZ-W50VHA 5kW air source heat pump, linked with a Mitsubishi EHPT15 – 170 Litre pre plumbed slimline space heating and hot water cylinder. From this underfloor heating on the ground floor is supplied as well as towel rails in bathrooms. As the house retains its heat, the underfloor heating is rarely used, and the main reason for installing it was for resale value, as potential buyers would understand it and the additional cost of laying the pipes in the concrete floor as minimal. Domestic hot water is also provided by this system with electrical immersion heater top up / backup.

9.0 PHPP Key results

The results of the PHPP show that it meets the requirements of Passivhaus Plus.

assive House Verification

Cocreate

Building:	Carrstone	
Street:	Clo	
Postcode/City:	Maulden	MK
Province/Country:	Bedfordshire	GB-United Kingdom
Building type:	House	
Climate data set:	GB0002a-Silsoe	
Climate zone:	3: Cool-temperate	Altitude of location: 60.5 m
Home owner / Client:	Mr & Mrs Paul Wilson	
Street:	San	
Postcode/City:	Maulden	MK
Province/Country:	Bedfordshire	GB-United Kingdom

Architecture:	Eco Design Consultants	
Street:	The Mansion, Bletchley Park	
Postcode/City:	Milton Keynes	MK13 6EB
Province/Country:	Buckinghamshire	GB-United Kingdom/ Britain
Contractor:	MBC Timber Frame	
Street:	Unit 1 & 2 Cahir Business Park	
Postcode/City:		Cahir
Province/Country:	Co. Tipperary	IE-Ireland
nergy consultancy:	Eco Design Consultants	
Street:	The Mansion, Bletchley Park	
Postcode/City:	Milton Keynes	MK13 6EB
Province/Country:	Buckinghamshire	GB-United Kingdom/ Britain
Certification:	Cocreate Consulting	
Street:	3 Dufferin Avenue	
Postcode/City:	London	EC1Y 8PQ
Province/Country:	UK	GB-United Kingdom

Year of construction:	2015	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]:	2.3	IHG cooling case [W/m²]:	2.3
No. of occupants:	3.1	Specific capacity [Wh/K per m² TFA]:	60	Mechanical cooling:	

fic building characteristics with reference to the treated floor area

				Criteria	Alternative criteria	Fullfilled?[2]
	Treated floor area m²	221.2				
e heating	Heating demand kWh/(m²a)	16	≤	15	-	yes
	Heating load W/m²	10	≤	-	10	
e cooling	Cooling & dehum. demand kWh/(m²a)	-	≤	-	-	-
	Cooling load W/m²	-	≤	-	-	
	Frequency of overheating (> 25 °C) %	4	≤	10		yes
	Frequency of excessively high humidity (> 12 g/kg) %	0	≤	20		yes
htness	Pressurization test result n_{50} 1/h	0.3	≤	0.6		yes
renewable Primary Energy (PE)	PE demand kWh/(m²a)	83	≤	-		-
ary Energy wable (PER)	PER demand kWh/(m²a)	35	≤	45	35	yes
	Generation of renewable energy (in relation to projected building footprint area) kWh/(m²a)	87	≥	60	48	

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

irm that the values given herein have been determined following the PHPP methodology and based on the characteristic s of the building. The PHPP calculations are attached to this verification.

Passive House Plus? yes

Task:	First name:	Surname:	Signature:
tifler	Will	South	WSouth

Certificate ID	Issued on:	City:
_Cocreate_PH_20170919_WS	25/09/17	London

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10.0 Construction Costs

The total cost of the build was £497,514 this included the garage, new access drive to the house and extensive ground works. Excluding the abnormals this equates to approx. £2,130 of treated floor area.

11.0 User satisfaction

The owners are extremely happy with the house, and have been willing to show there house in a number of the International Passivhaus open days, and this year due to Covid restrictions allowed us to make a film for the open day.

https://www.youtube.com/watch?v=m2gMdGa_XVk&t=6s

12.0 References

The Daily Telegraph, Saturday 3rd March 2018.

The article titled 'Make your house pay its own bills' features this project alongside other sustainable projects around the country. It talks about how the homes have been designed to be as energy efficient as possible. Our clients Paul and Belinda say:"It's an extremely comfortable house to live in and we only need the underfloor heating for three months of the year. We are on the highest feed-in tariff, so our energy costs us nothing, and we generate enough electricity to charge our Tesla car for free".

House Planning Help Pod cast

HPH164 – Taking the role of Principle Designer – with Belinda & Paul Wilson.

https://www.houseplanninghelp.com/hph164-taking-on-the-role-of-principal-designer-with-belinda-and-paul-wilson/

Build it Magazine, March 2018

Eco Excellence -'A sustainable design and build resulted in a high-performing, award winning Passivhaus home for Paul and Belinda Wilson'.