Passivhaus Project Documentation
Fulford Passivhaus, York, UK

Abstract

Single-family detached dwelling in Fulford, York, North Yorkshire.

Building Data

Year of construction	2015	Space Heating	14kWh/m^{2}a
U-Value external wall	0.13W/m^{2o}k		
U-Value floor	0.123W/m^{2o}k	Primary Energy Renewable	59kWh/m^{2}a
U-Value roof	0.083W/m^{2o}k	Generation of renewable energy	89kWh/m^{2}a
U-Value window	0.8W/m^{2o}k	Non-renewable primary energy	114kWh/m^{2}a
Heat recovery	83%	Pressure test n_{50}	0.4/h
Special features	First UK certified Passivhaus Plus – 38No Hyundai solar panels.		

Information on the web at www.constructiveindividuals.co.uk

Phil Bixby BA Dip Arch Architect

Brief Description

The project has a relatively long history, with the clients originally approaching the architect in 2007 to explore options for remodelling and extending an existing house on the site. A substantial extension was designed, along with thermal upgrading of the existing structure, and planning consent obtained. In the event, early discussions with a likely building contractor identified that savings in VAT along with increased design freedom would merit demolition of the existing structure and construction of a new dwelling.

Design of the new house progressed swiftly, based around a simple planform and compact volume. The clients wanted to achieve Passivhaus certification from the start, and so the design was immediately put into PHPP so that as it developed the overall performance and compliance would be checked. The "European" appearance of the house (one-half of the client couple is Dutch) caused some minor issues with gaining planning permission, but the local authority supported the sustainability aims and approved the scheme.

The result is a three storey dwelling (with the upper storey incorporated into the roofspace) which faces south – currently across open fields, although future development is likely.

The construction of the house was carried out to watertight stage by a main contractor, with the clients completing the construction via directly-employed tradespeople.

Responsible project participants

Architecture and building physics: Phil Bixby of Constructive Individuals

Building services

MVHR design and supply: Adam Dadeby Passivhaus Store

Renewables: Solar array, Immersun units and electrics: The Phoenixworks

Structural engineer: Stuart Agars, Struct Sure

Craftsperson / parties involved:

Transcore Ltd, The Phoenixworks, HH Payne & Son Plumbing, Paul Hussey of Orchard Joinery, Paul Morley construction, JS Allison Ltd Plastering Contractors

Certifying body: Passivhaus Institut, Darmstadt

Certification ID: 4762 (Passive House Database)

Views of the building

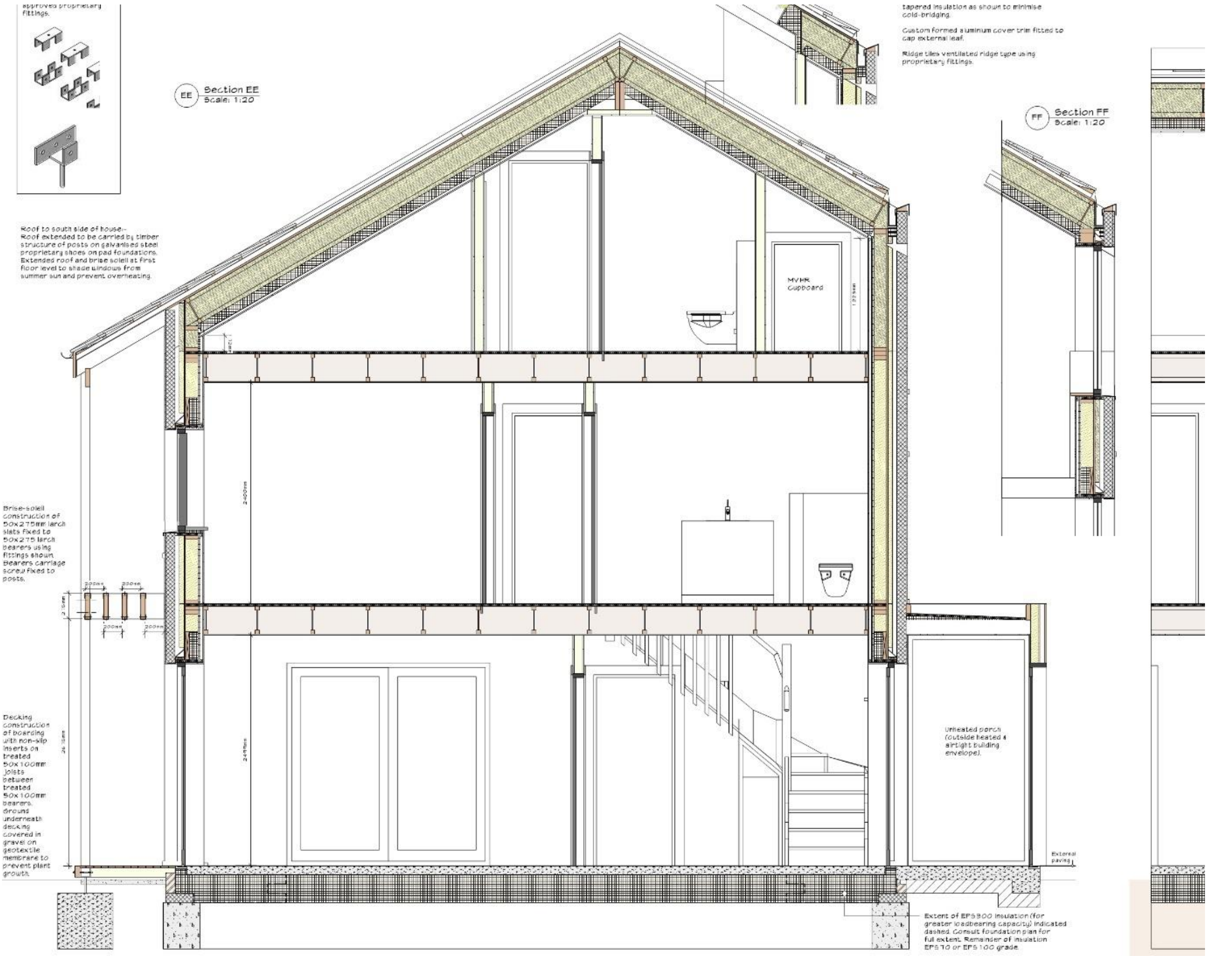
Approach to the building from the west side.

South-east view of the house showing the shading to the south side and asymmetric roof.

South-west view showing the solar array.

North view of the house showing minimal glazing and projecting porch.

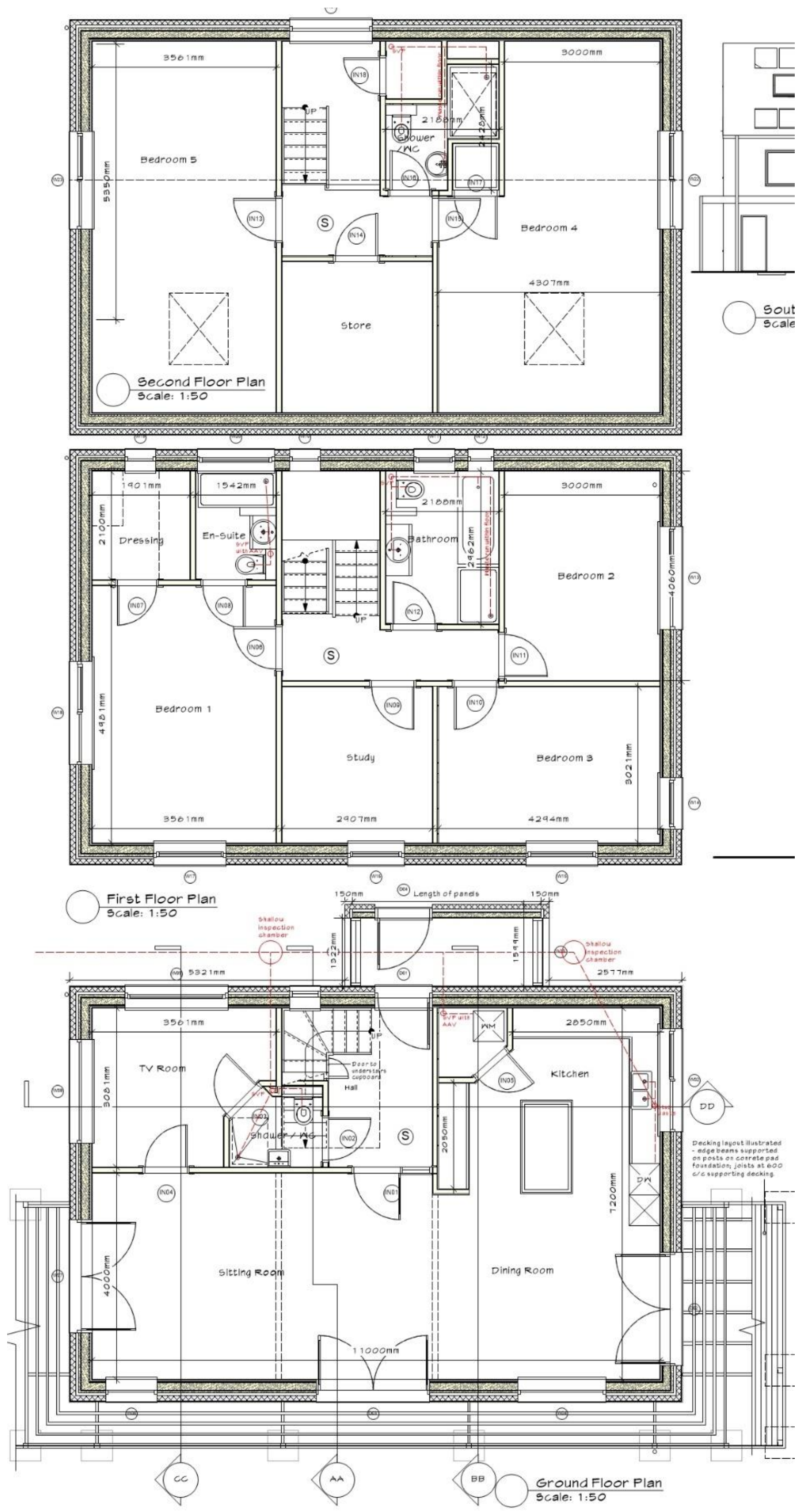
Sectional drawing



The building is three-storey with an asymmetric roof to maximise area for south-facing photovoltaics and to provide shading to south-facing glazing at first floor level. The uninterrupted insulation is visible – the porch to the north side is unheated and outside the building envelope.

Intermediate floors are of I-Joist construction and the illustrated joist direction is only illustrative.

Floor plans



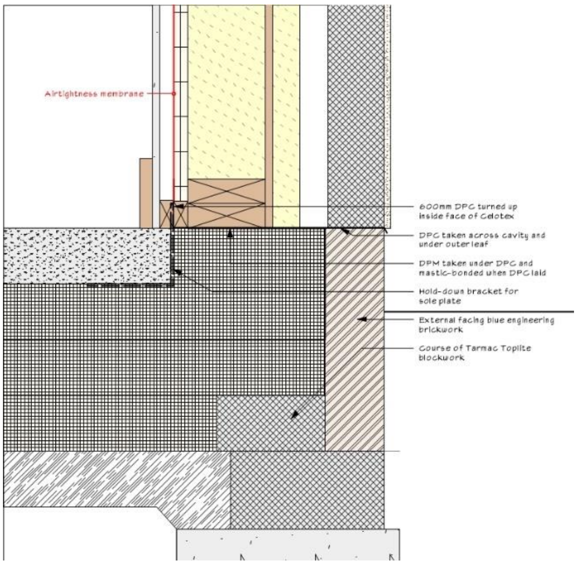
The second floor provides two bedrooms, with the ceiling following the soffit of the roof and a rooflight to th south side. Circulation space and a shower room are to the north side, and a store provides space for storage along with easy access to the photovoltaic inverters.

The first floor has the main bedroom on the west side, with a further two bedrooms and a family bathroom, plus a study. All internal walls are timber frame, insulated to provide sound separation for what is a family house.

The ground floor plan has the entrance on the north side, leading into the hallway and stairwell. Living spaces are arranged to the south side opening out onto a shaded terrace, with a TV room and kitchen on the north side and an internal shower room / WC.

Description of the construction

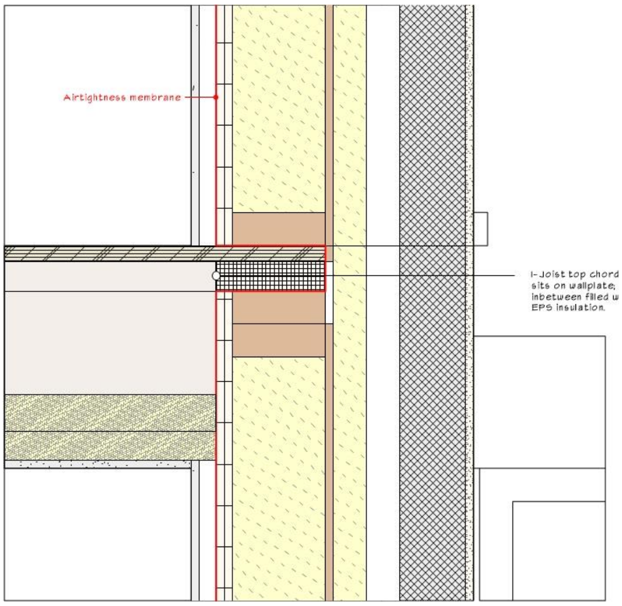
Ground floor



The ground conditions and loadings from the timber frame structure necessitated a hybrid substructure comprising perimeter strip foundation, together with loadbearing EPS insulation reinforced with pads beneath point loads. This was complex to construct but the contractor took great care with the insulation build-up and with airtightness / waterproofing layer.

Build-up:-	100mm Concrete with polished finish DPM airtightness layer 300mm Jablite (038) Hardcore and blinding **U-value = 0.123 W/(m2K)**

External walls

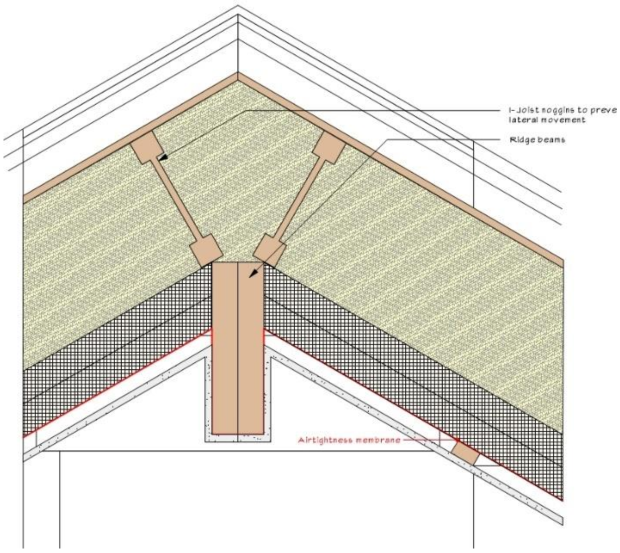


Cost constraints led to a cheap-to-build but rather complex external wall construction – the consequent advantage being that the multiple layers allowed for minimisation of cold-bridging. The main structure is timber frame, with a partially-insulated cavity and an external leaf of rendered blockwork. The timber frame was then internally insulated with PU insulation before creation of a service void and internal plasterboard finish.

All junctions were modelled using Psi-Therm software and detailing was adjusted to minimise cold-bridging.

Build-up:-	12.5mm Plasterboard 38mm Service void Proclima Intello plus 25 mm Celotex (variation 50mm on second floor) 140mm Mineral wool (035) 6.4 % studs) 9mm OSB 50mm Rockwool TB Batts 50mm Cavity 100mm Tarmac Toplite blockwork 1.5mm Render **U-value = 0.13 W/(m2K)**

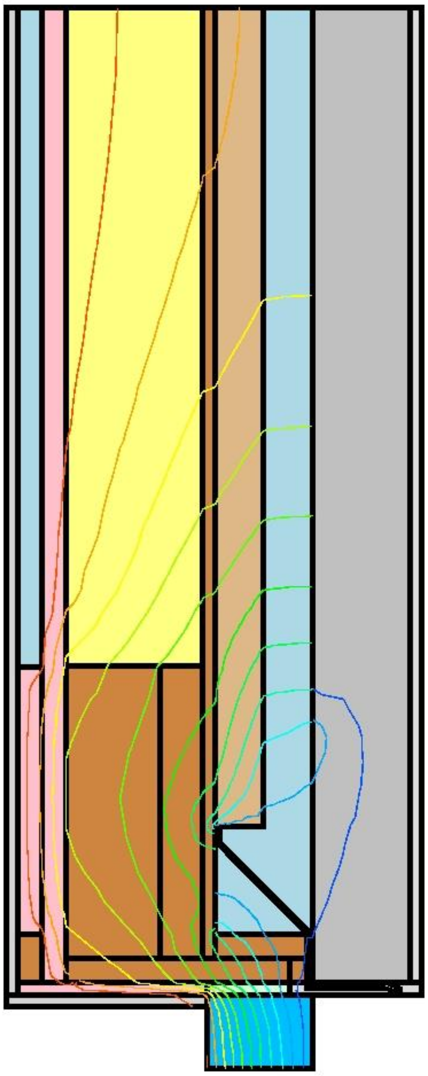
Roof



Again cost control had an impact on the roof construction – 300mm joists were cheaper than deeper ones, so were used with mineral wool filling in combination with internal lining of PU insulation to the soffit.

Build-up:-	12.5mm Plasterboard 38mm Service void Proclima Intelloplus 100mm Celotex in two layers 100mm Superglass flanges (035) 8.3 % Timber 206mm Superglass webs (035) 2.0% Joist webs 10mm OSB **U-value = 0.083 W/(m2K)**

Windows



Windows are Internorm HF310 timber and aluminium windows using high specification triple-glazed units (triple 48mm coated clear glass 4b/18Ar/4/18Ar/b4 (3N2), Ug value: 0,50 W/m²K and dB value: 34). A particularly high specification was chosen because of the large areas of glazing to the living areas and the wish to ensure all of this was usable without cold air coming off the glazing. Frame U-value is 0.86 and glazing g-value is 0.50.

Location of the windows within the structural openings was fine-tuned using Psitherm software. In the event the detailing of the frame around window openings was not what had been agreed with the frame supplier (timber beams were tripled up rather than allowing depth for insulation) so additional insulation was added to minimise cold-bridging.

The airtight envelope

The airtightness strategy was to ensure a single layer of airtightness by the use of proprietary airtightness membrane, and tapes / grommets / fittings etc from the same manufacturer. Proclima was chosen for its good reputation and extensive warranty.

Within the ground floor:- a 2000 guage DPM was used, carefully taped around any penetrations (drainage, service entries etc) and left oversized where brought up above the slab at ground floor level. Care was taken to protect this during the casting and polishing of the concrete slab.

Within the external walls:- The Proclima membrane was situated inside of the PU insulation which lined the timber frame, and outside of the 38mm service void. It was stapled in place and then taped on all joints and all lines of staples.

Window and door reveals were carefully cut and taped in accordance with the manufacturer's recommendations. The client acted as "airtightness champion" and supervised the work.

The membrane was taped to the DPM where this was brought up on the inside of the timber frame at ground floor level. At first and second floor level the membrane was taken outside of the floor construction and brought back in above the floor.

Within the roof:- The Proclima membrane was taken up the underside of the roof on the underside of the PU insulation layer, with a 38mm service void beneath. The membrane was taken underneath the ridge beam and was dressed into the rooflight openings using the same methods as for window openings.

Proprietary reveal linings were initially used as supplied by Fakro to match the rooflights, but these were ultimately discarded as being insufficiently reliable – the adhesive was not as secure as that of the Proclima tape, so in the event this was used instead.

Airtightness testing

Testing was carried out by the excellent Paul Jennings of Aldas. In addition to conducting the pressure tests to protocol he also spent considerable time using a smoke gun to check individual details and components. As a result it was possible to go back to the window manufacturers with a very detailed list of requirements in respect of adjustments and repairs to the window and external door functions.

Three airtightness tests were conducted:-

1. At “weathertight shell” stage, with all of the window and door installation complete, and the airtightness membrane complete.
2. After first fix of all services
3. At completion prior to occupation for certification purposes.

The initial testing was carried out in January 2015 and resulted in a test figure of 0.41/hr. A number of areas of leakage were identified and these were subsequently addressed. The second test in May 2015 gave a result of 0.46/hr, with the poorer result being attributed to issues resulting from the MVHR installation. These were addressed, in liaison with the supplier.

The final test was carried out in October 2015, and carried the following comments:-

The average Air Change Rate of 0.41 AC/Hr @ 50 Pa measured in the acceptance testing of the Fulford Passivhaus in York is a good result, meeting the newbuild Passivhaus standard by a substantial margin. Even though there was some temporary sealing at the time of the test, where waste pipes for future expansion of bathroom and kitchen facilities have been plumbed in but not yet fitted with traps, we are confident that any residual leaks occurring when these services are installed will not increase the leakage of the Fulford Passivhaus to any great extent. Therefore the air leakage rate will continue to meet the newbuild Passivhaus target of ≤ 0.6 AC/Hr @ 50 Pa by a substantial margin. Hence we are happy to issue an Air Leakage Certificate for the finished property.

Depressurisation and pressurization test results are shown below.

Depressurize Test Results

	Results				Results	Uncertainty
Correlation, r^2	0.999	95% confidence limits		*Air flow at 50 Pa, Q_{50} [m^3/h]*	229	+/-1.0%
Intercept, C_{env} [$m^3/h.Pa^n$]	11.2	10.0	12.5	*Permeability at 50 Pa, AP_{50} [$m^3/h.m^2$]*	0.60	+/-1.1%
Slope, n	0.77	0.74	0.80	*Equivalent leakage area at 50 Pa [cm^2]*	114	+/-1.0%
				Air changes, n_{50}	0.44	+/-1.1%

Pressurize Test Results

	Results				Results	Uncertainty
Correlation, r^2	0.999	95% confidence limits		*Air flow at 50 Pa, Q_{50} [m^3/h]*	193	+/-0.7%
Intercept, C_{env} [$m^3/h.Pa^n$]	10.3	9.5	11.0	*Permeability at 50 Pa, AP_{50} [$m^3/h.m^2$]*	0.50	+/-0.9%
Slope, n	0.75	0.73	0.77	*Equivalent leakage area at 50 Pa [cm^2]*	96	+/-0.7%
				Air changes, n_{50}	0.37	+/-0.9%

Ventilation system

Design of the ventilation system was carried out by Adam Dadeby of The Passivhaus Store, using a Brink Renovent Excellent 300 Plus MVHR unit and Ubbink semi rigid ducting. The MVHR unit has an Effective Heat Recovery performance of 75% and Electrical Efficiency of 0.45Wh/m3.

The manufacturers note:-

The Ubbink insulated MVHR ducting system and Ubbink Air Excellent semi-rigid MVHR ducting systems have many benefits:

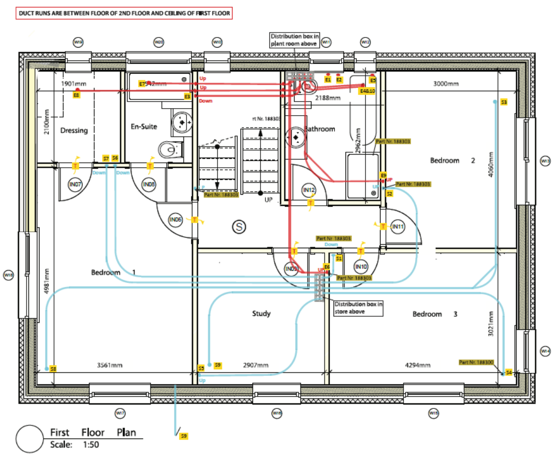
•Radial ducting with distribution boxes and separate ducts to each room simpler to install - less prone to installation errors - no crosstalk - smooth duct walls

•Simpler, more reliable installs, cut to length needed, easy snap-lock connectors where needed – less risk of air leaks through gaps in the ducting

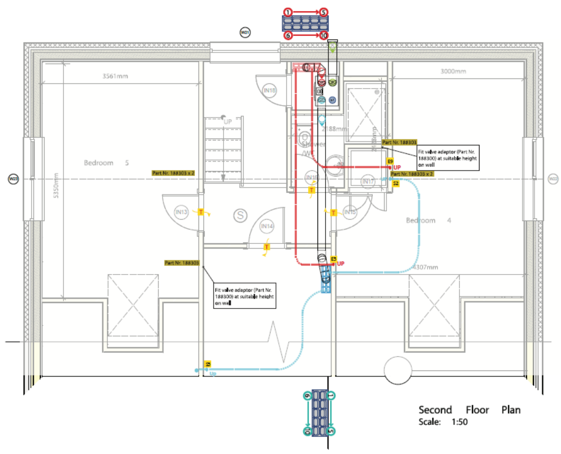
•AE34c/AE48c ducting offers radial ducting very cost-effectively.

The MVHR unit is located in a dedicated cupboard off the staircase half-landing. This is on the north side of the building and both inlet and extract ducts exit on this side – one through the external wall and one through the roof above, thus ensuring cool input air for summertime.

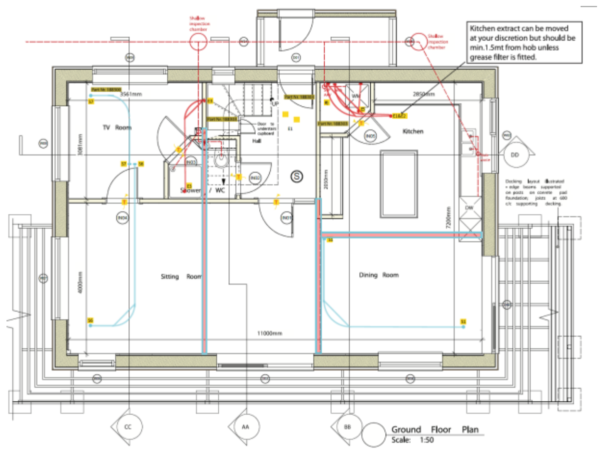
The ductwork was installed by the clients with assistance from the contractor's joiners and plumber/heating engineer.



First floor layout



Second floor layout



Ground floor layout

Legend:-

Supply air ductwork shown in blue

Extract ductwork shown in red

Heat supply

The low heating requirement of the house and the large photovoltaic installation led to an early decision that the house would be all-electric, and an existing gas supply to the site was removed (unusual in UK at present). The PV array is set up to initially put spare production into the thermal store / HW cylinder via 2No Immersun units and 4No immersion heaters each of 3kW capacity, and to subsequently put spare production back into the grid.

Space heating delivery is initially via a Brink 1kW post-heater on the supply air. Beyond this, there are four Terma towel heater radiators distributed among the bathrooms / shower rooms with a total of 1.42kW capacity. The intention is to install an additional electric radiator into the Living Room, but this has not so far proved necessary.

Design of the building services installation was coordinated by the client and comprised:-

- Design of the PV system by Phoenixworks, including the Immersun installation and specification of the DHW cylinder/immersions.
- Design of the MVHR system by Adam Dadeby of The Passivhaus Store, including incorporation of post-heater.
- Design and specification of the residual space heating installation by agreement between the architect and the client.
- Design of all other elements of the installation by the plumbing and electrical contractors.

PHPP

The project was always conceived as being designed and built to Passivhaus standards (although this pre-dated the introduction of the Passivhaus Plus and Premium categories). In any event the architect uses PHPP as a design tool on all new-build projects, so was familiar with the requirements in terms of input information.

Passive House Verification

Building:	Osborne House	
Street:	School Lane	
Postcode/City:	Fulford, Yorl	
Province/Country:	Yorkshire and the Humber	GB-United Kingdom/ Britain
Building type:	Detached Dwelling	
Climate data set:	GB0011a-Leeming	
Climate zone:	3: Cool-temperate	Altitude of location: 12 m
Home owner / Client:	Rob Aitken and Karin de Vries	
Street:	28 Key Way, Fulford	
Postcode/City:	York YO19 4	
Province/Country:		

Architecture:	Phil Bixby / Constructive Individuals	**Mechanical system:**	
Street:	70A Holgate Road	Street:	
Postcode/City:	York YO24 4A	Postcode/City:	
Province/Country:		Province/Country:	
Energy consultancy:		**Certification:**	
Street:		Street:	
Postcode/City:		Postcode/City:	
Province/Country:		Province/Country:	

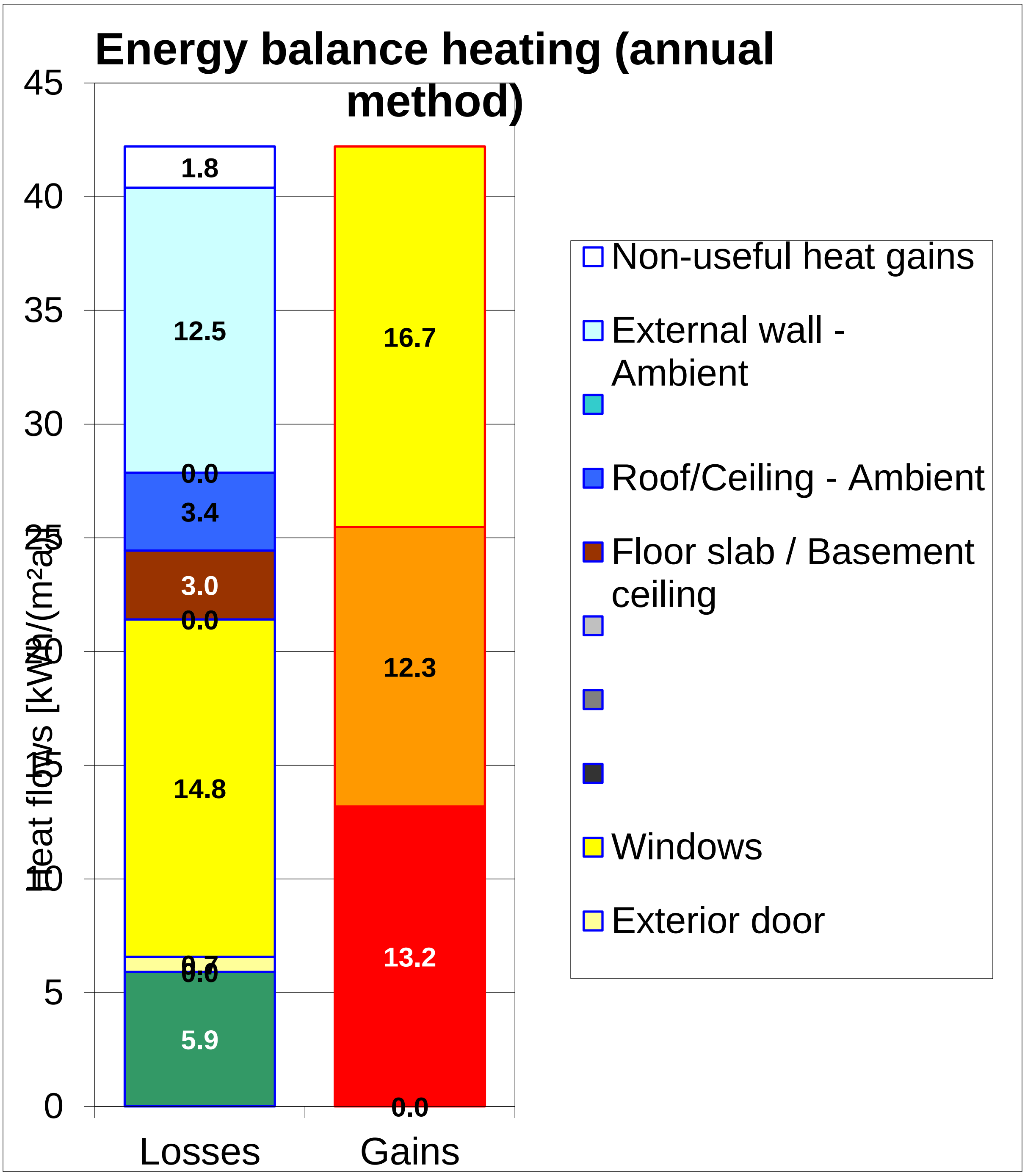
Year of construction:	2015	Interior temperature winter [°C]:	20.0	Interior temp. summer [°C]:	25.0
No. of dwelling units:	1	Internal heat gains (IHG) heating case [W/m²]:	2.4	IHG cooling case [W/m²]:	2.4
No. of occupants:	3.1	Specific capacity [Wh/K per m² TFA]:	60	Mechanical cooling:	

Specific building characteristics with reference to the treated floor area

				Criteria	Alternative criteria	Fullfilled?[2]
	Treated floor area m²	185.9				
Space heating	Heating demand kWh/(m²a)	14	≤	15	-	yes
	Heating load W/m²	10	≤	-	10	
Space cooling	Cooling & dehum. demand kWh/(m²a)	-	≤	-	-	-
	Cooling load W/m²	-	≤	-	-	
	Frequency of overheating (> 25 °C) %	6	≤	10		yes
	Frequency excessively high humidity (> 12 g/kg) %	0	≤	20		yes
Airtightness	Pressurization test result n_{50} 1/h	0.4	≤	0.6		yes
Non-renewable Primary Energy (PE)	PE demand kWh/(m²a)	114	≤	-		-
Primary Energy Renewable (PER)	PER demand kWh/(m²a)	59	≤	45	59	yes
	Generation of renewable energy kWh/(m²a)	89	≥	60	87	

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

Monitoring equipment is being installed to check whether the house performs as is predicted by PHPP. The homeowners and selfbuilders, Rob Aitken and Karin de Vries, will write a blog about this starting in 2016 (@kdviy).



As would be expected, the main losses are from windows and external walls. The glazing area to the west and east is larger than ideal but justified in terms of wishing to make the most of views and provide good daylighting to bedrooms which would effectively be “living rooms” for teenage children. The wall construction was, as noted, a compromise required for cost-saving reasons and while it complies with Passivhaus requirements a higher level of insulation would have been ideal.

Costs

Detailed costs for the project are not known as the main contract was only to weathertight stage, and the works were project managed by the clients after this point. For information though the contract cost to weathertight stage was around £170,000, or around £913/m^2 TFA.

User satisfaction

The clients are so far happy with the performance of the house, although final details are still being sorted out. They have opened the house for visits on the national Passivhaus Open Day and also for local "Open Green Doors" events and have discussed the house – and the benefits of Passivhaus in general – with many visitors.