Project Documentation for Application for Passivhaus Designer

Certified Passive House
Passive House Institute

7 Convent Lane, Emsworth, UK

Photograph of building from entrance

Building Data

Year of Construction	2015	**Space heating**	**8.0 kWh/(m²a)**
U Value external wall	0.081 W/m²K		
U value basement ceiling	0.79 W/m²K	Primary Energy	95.8 kWh/(m²a)
U value roof	0.129 W/m²K	Generation of renewable energy	11.5 kWh/(m²a)
U value window	0.83 W/m²K avg	Mechanical Primary Energy Demand	62.2 kWh/(m²a)
Heat Recovery	82.4%	Pressure test n_{50}	0.55 /h
Special features	Solar collectors for hot water generation, solar electric array for electricity generation, high form factor, green roof for water management, cladding designed to create natural habitat for insects, solar shade sail		

7 Convent Lane is a new build home for Julian, his Architect wife and family. It is a 4 bedroom detached dwelling in Emsworth on the south coast of England. It is built on a tight urban brownfield site with multiple neighbours. The project comprises the main house and a detached garage. The design and construction team include:

Architect – Ruth Butler Architects

MEP Engineering – Julian Sutherland

Passivhaus Designer – Julian Sutherland

Contractor – Nicolas Coppin Limited

Passivhaus Certification – Warm Low Energy Building Practise

The project timeline is as follows:

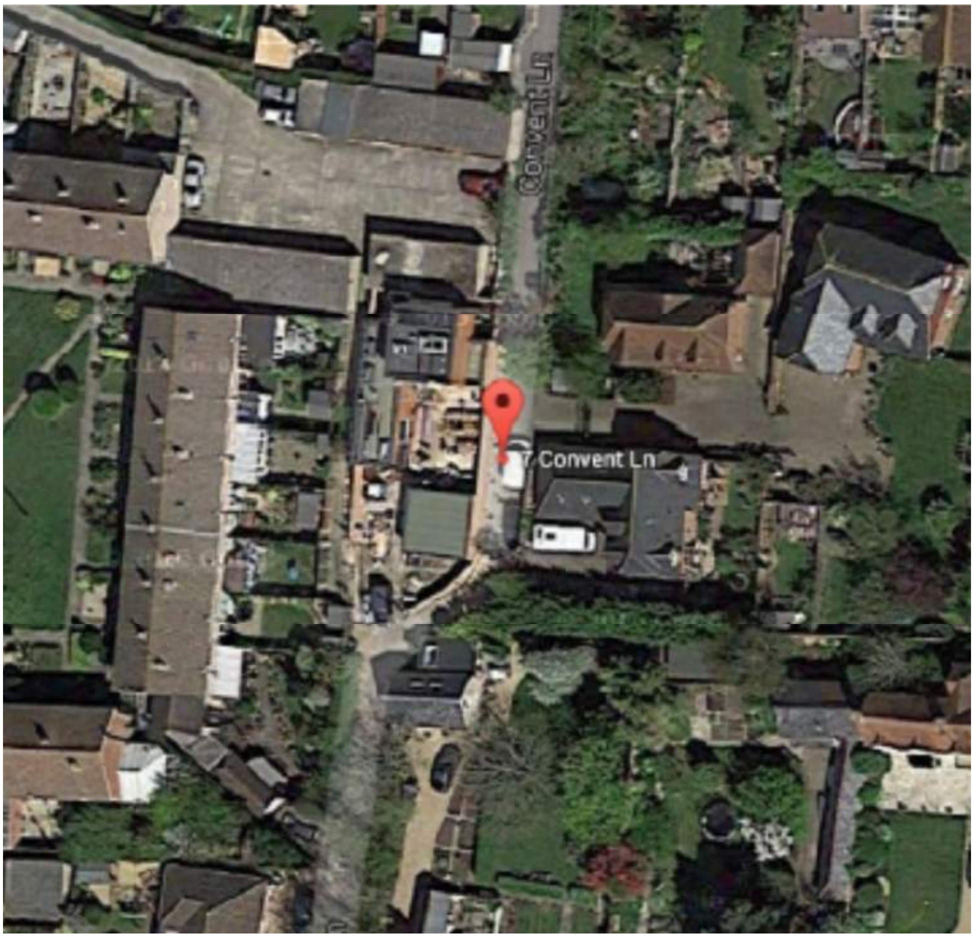
- Jan 2014 - Planning Consent
- Jan 2014 to Jul 2014 - Detail Design and Tender
- August 2014 – Start on site
- May 2015 – Completion and move in

The Site

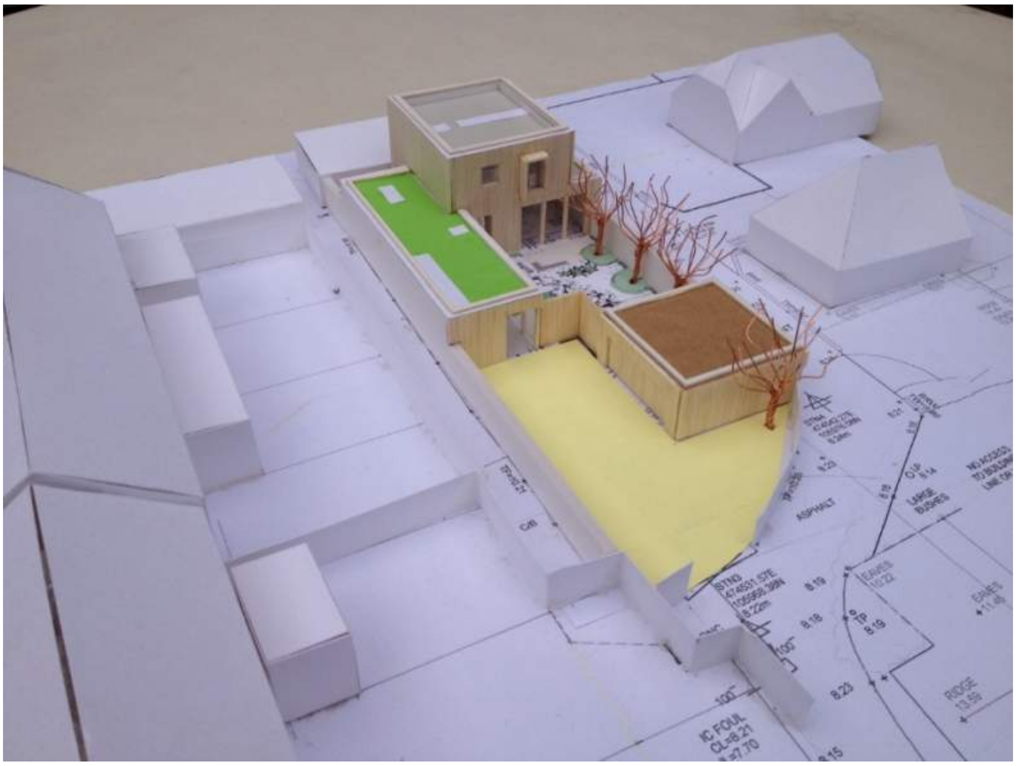
The site is constrained with neighbours to the west, a block of garages on the north and Convent Lane to the east and south. The site is approximately 300sqm and only 12m wide. The previous building was demolished and the site cleared prior to construction.

The location of the dwelling was carefully considered:

- to maximise south facing living spaces and access to outdoors and light
- with minimum glazing to east and west to avoid overlooking and low sun solar gains
- with shaded glazing with eyebrow detail to prevent overlooking and to shade glazing
- to minimise north facing garden spaces which are seldom used and poor quality
- to provide living spaces on the ground floor with garden access and sleeping spaces on first floor.
- to create a private courtyard garden
- to provide space for the garage and vehicle turning requirements



Google view of site



7 Convent Lane Project Model

Performance Criteria and Project Data

The dwelling was designed to the following performance criteria:

- Passivhaus 2015
- Code for Sustainable Homes Level 4 (72 points)
- Building Regulations Part L 2013 with 26% improvement
- 17% of regulated energy from renewables
- EPC A rated

Passivhaus Project ID - 11764_WARM_PH_20151009_PW

Passive House Database ID – not yet registered

Building Data

Responsible Project participant	Julian Sutherland
Signature	

The Building Design

Following are a series of images of the dwelling from each elevation.

Photograph of South Elevation showing private courtyard, primary glazed elements and main living spaces.

Photograph of East Elevation showing boundary with Convent Lane and solid east wall

Photograph of North Elevation showing boundary with neighbouring garages, minimal glazing and small courtyards.

Photograph of Internal Dining Space showing exposed timber walls, stair to first floor and high mass floor

Photograph of internal living space showing exposed timber surfaces and roof light to west for evening light.

Project Section

The building section is very simple with a clear line for the airtightness line (shown in red), continuous insulation (shaded in grey) and weatherproofing.

All the renewable technology is located on the highest roof to avoid overshadowing and ensure maximum solar access.

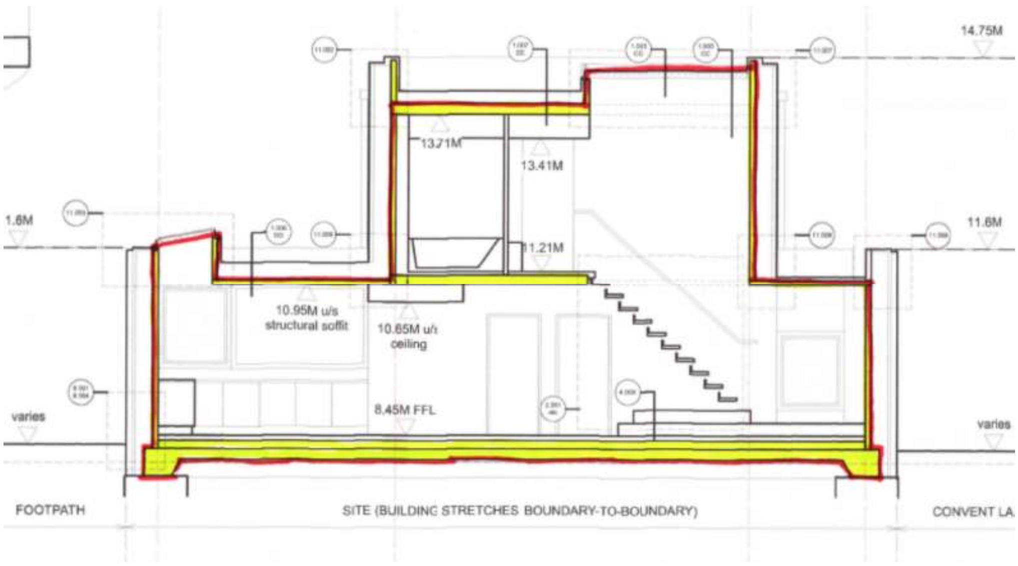
The timber frame, upper floor and roofs are all cross laminated timber (CLT). The CLT is self-finished with minimal plasterboard linings and ceilings. It forms the primary airtightness line. The ground floor slab is low carbon concrete with a quarry tile finish throughout.

Photo of completed CLT frame

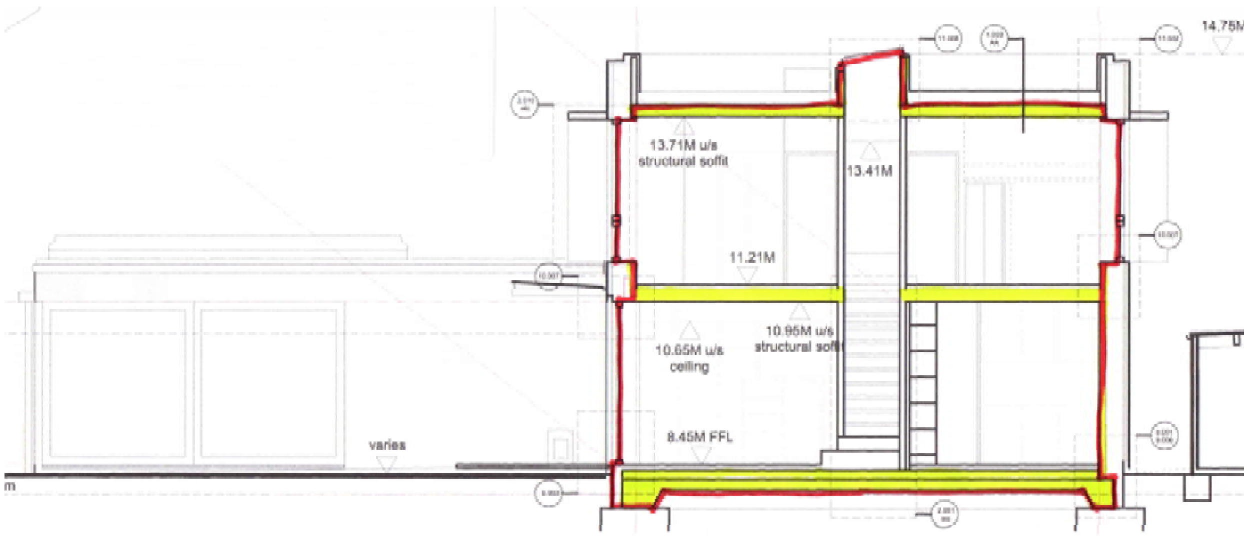
All roofs are a Bauder Duo membrane system with additional green roof on the lower living room roof.

The external cladding is non-structural in either brick or slatted Siberian Larch timber rainscreen.

The building is fully insulated on all surfaces.



East West Cross Section showing structure and airtightness line



North South Cross Section showing structure and airtightness line

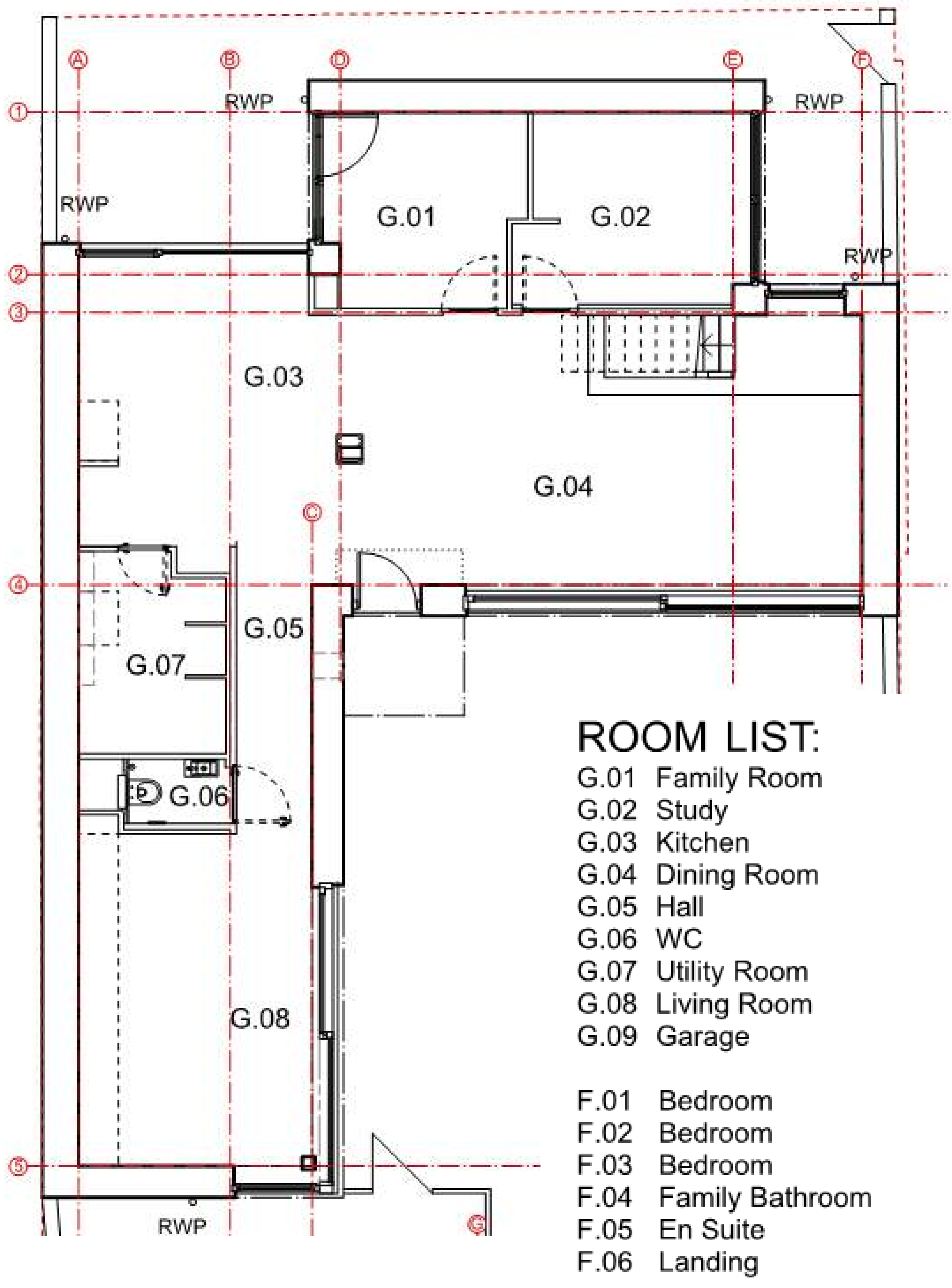
Floor Plans

The building floor plans are simple with minimal compartmentation. The ground floor living, dining and kitchen spaces are all open plan. The ground floor also includes the utility room, with plant room, a guest WC and 2 study spaces. One study space is used as a guest bedroom.

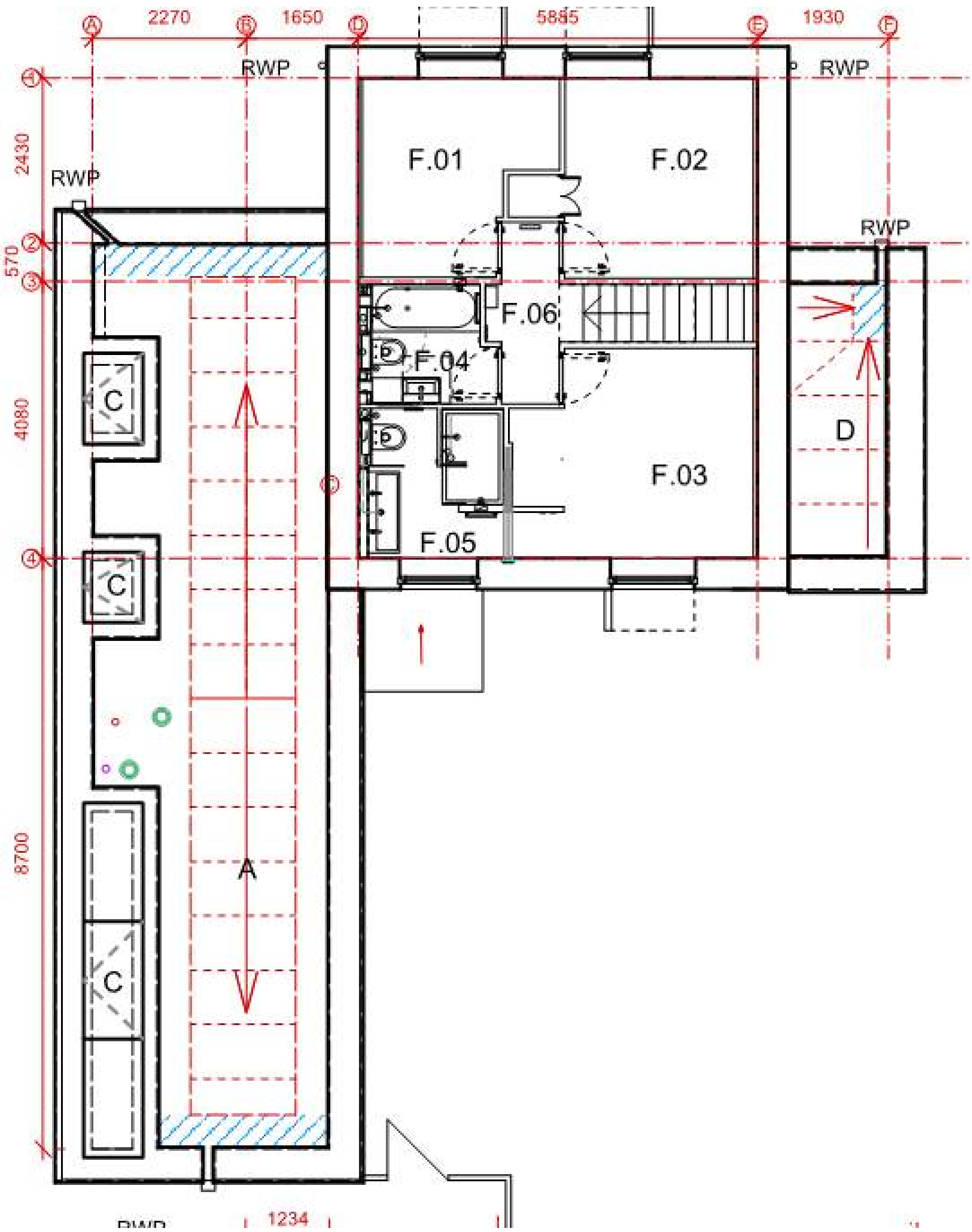
The first floor has 3 bedrooms, an ensuite and a family bathroom.

Following are the building floor plans

Ground Floor Plan



First Floor Plan



Ground Slab Construction

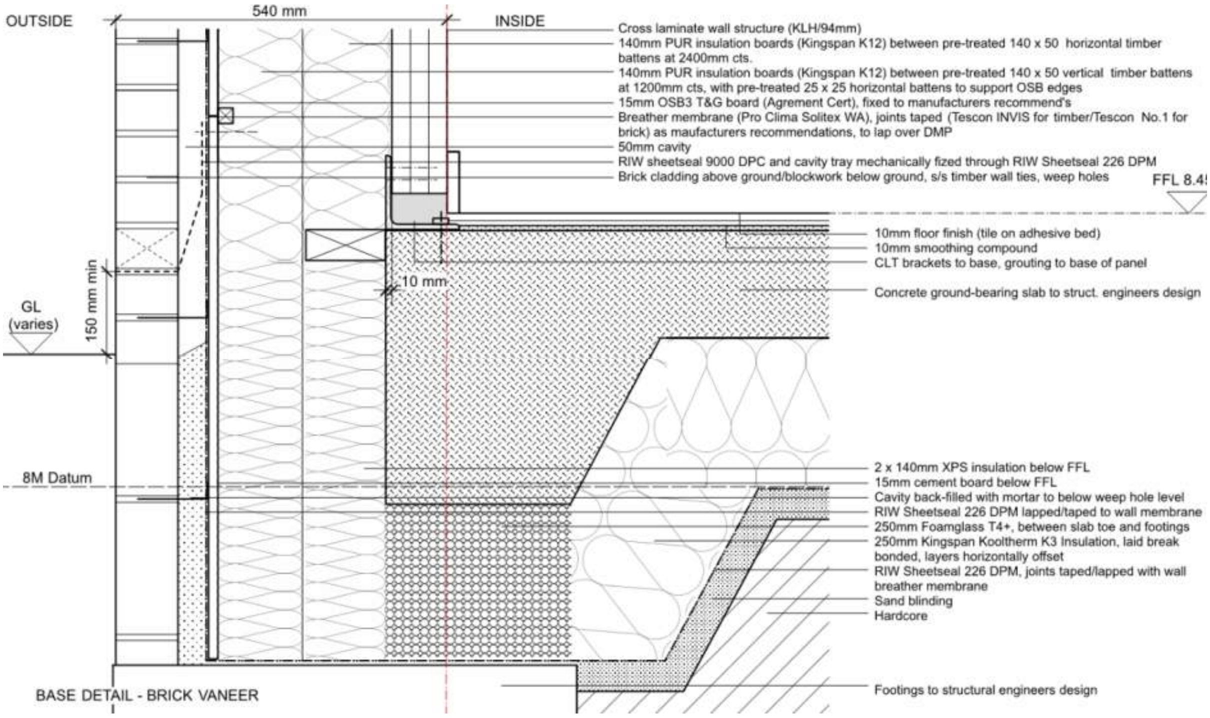
The ground floor slab is a ground bearing concrete slab with formed insulation below. The concrete is a low carbon concrete using PFA cement replacement. The slab build up comprises, mass concrete foundations, DPC, insulation, concrete slab and quarry tile finish. Insulation is typically Kooltherm K3 (pink material) with Foam Glas (black material) in high load areas under the strip foundations.

Piped services drop through the slab and pass under the insulation.

The slab was poured in a single pour to very tight tolerances (±10mm) to suit the CLT installation above.

Photo of ground slab insulation prior to concrete pour.

Ground slab Detail with brick wall above



External Wall Construction

The external walls have 2 versions. Both use the same primary construction with either a timber or brick rain screen cladding. From inside to out the walls are constructed as follows:

- 91mm CLT timber panel
- 140mm Kingspan K15 insulation board on vertical battens
- 140mm Kingspan K15 on horizontal battens
- OSB board to compress insulation
- External Solitex breather membrane (taped and battened)

Then either:

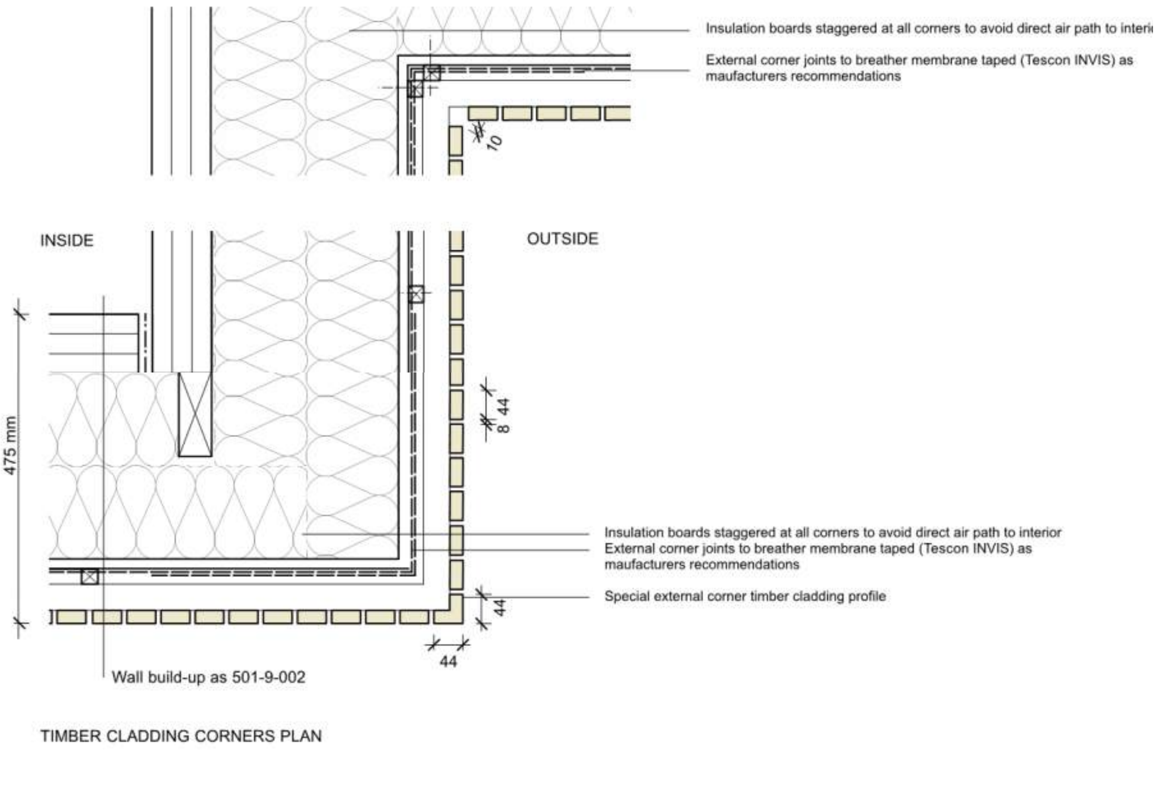
- Vertical and horizontal battens in void with vertical larch timber cladding

Or:

- 225mm cavity brick wall with ties back to OSB

The batten configuration has been included in the wall U value calculations in the PHPP analysis. Window openings are formed within the walls using a marine plywood box. Refer to window section for window installation details.

Drawing of typical wall detail



TIMBER CLADDING CORNERS PLAN

Photograph of roof light and wall external insulation

Roof Construction

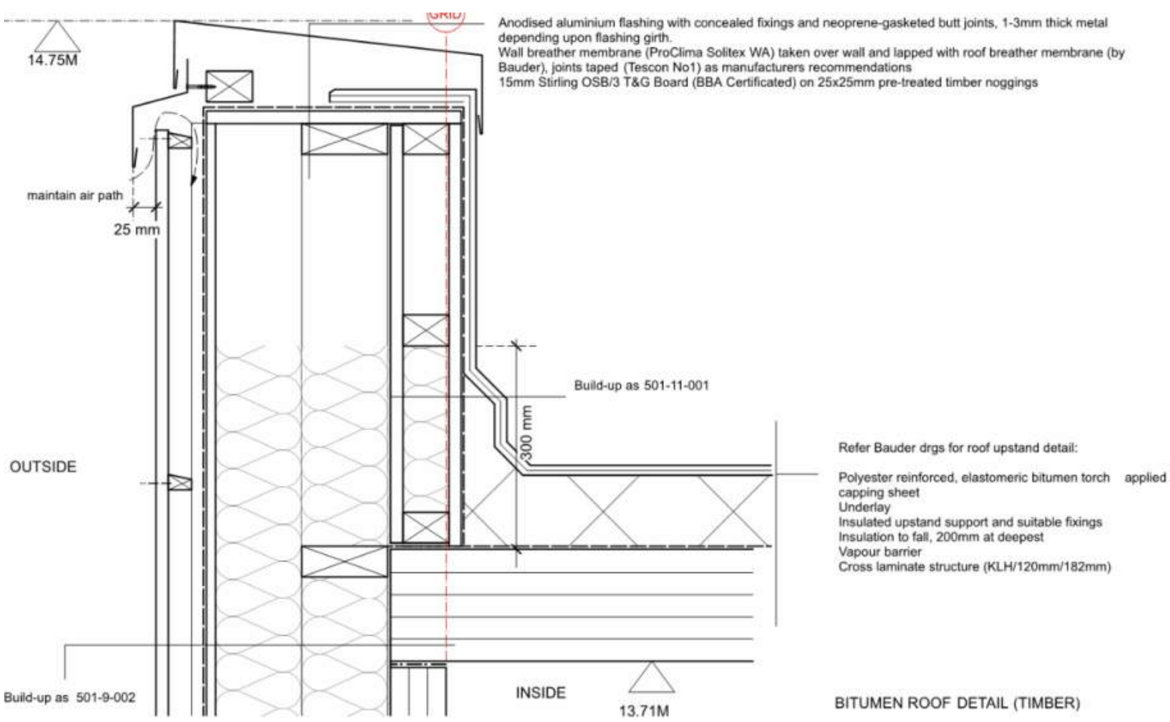
The roof construction is not dissimilar to the walls. From inside to out the construction is:

- 140mm to 250mm CLT timber panel
- Bauder Duo roof system lower membrane
- Tapered PUR insulation
- Bauder Duo upper membrane and wear layer
- Either green roof or direct exposed

Aluminium flashings are fitted over the parapets to protect the waterproofing and to cap the timber or brick

Photo of completed roof prior to flashings being installed

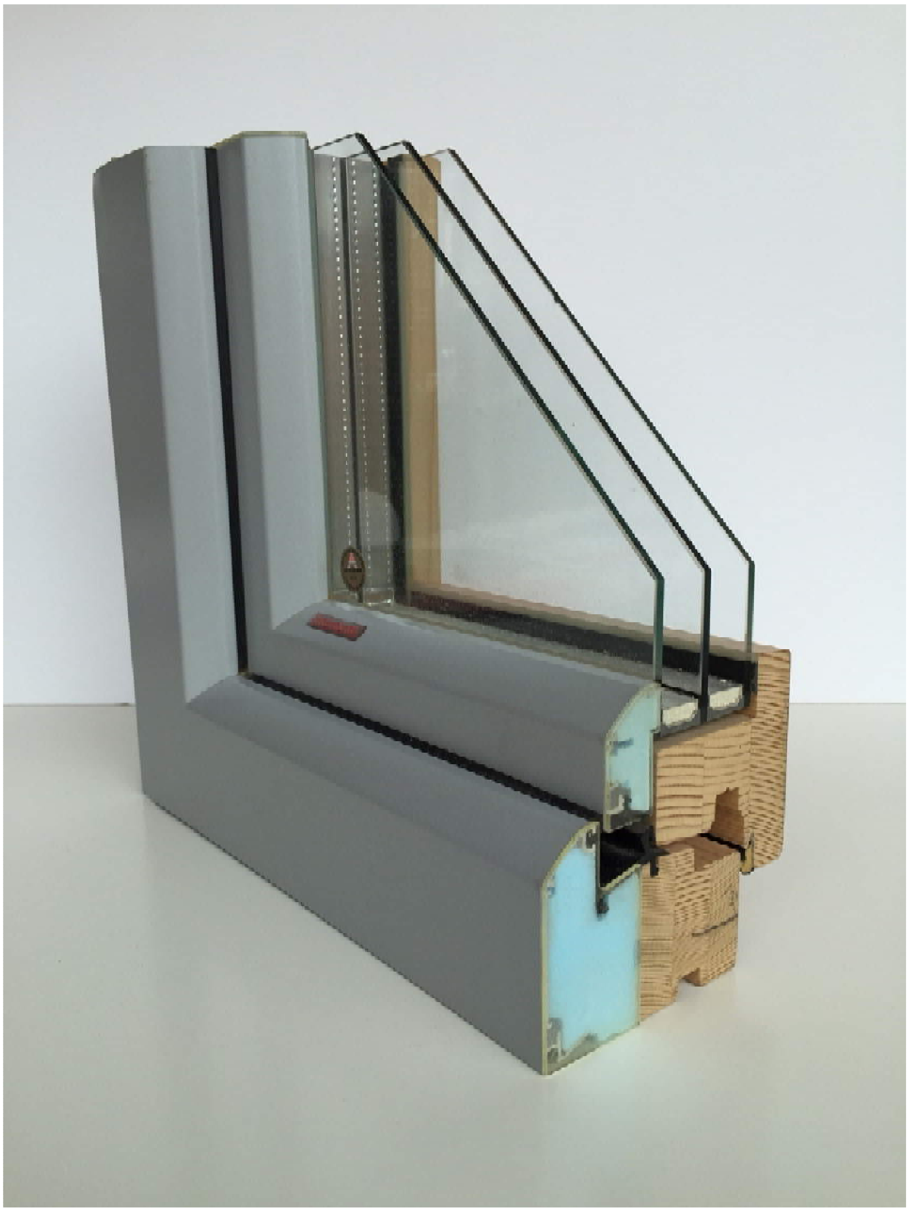
Drawing of roof construction with parapet



Window Selection and Installation

Window product

Internorm Passivhaus certified window and door systems were installed. These had superior performance to many commercially available products with frame performance being very similar to the glazing. Internorm provided full technical details for all windows.



Photograph of Internorm window frame sample

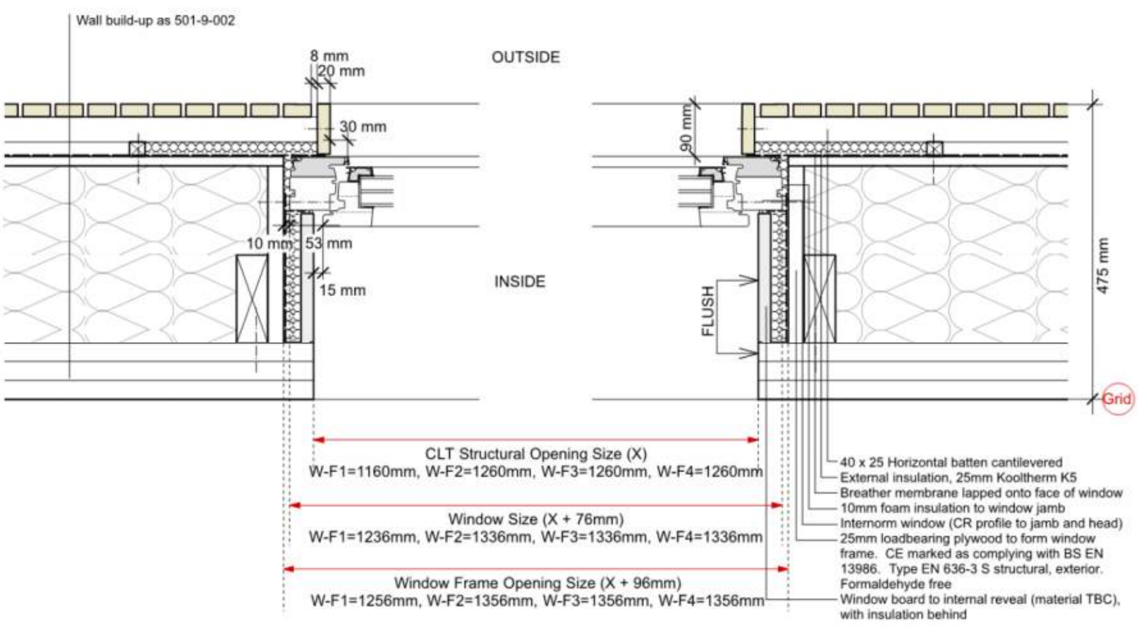
Window details:

- Internorm HF310 timber/aluminium home pure range
- Timber/foam/aluminium construction
- Triple gasket system
- Fully concealed locking systems with tilt and turn
- Thermal insulation range 0.69 to 0.72 W/m^{2}K
- U frame 0.86 W/m^{2}K
- PSI value 0.033W/mK as certified by DIN No B13.203.016.482EN

Sliding door details:

- Internorm HS330 timber/aluminium range
- Timber/foam/aluminium construction
- Glass fibre insulating threshold
- Triple gasket system
- Fully concealed locking systems with tilt and turn
- Thermal insulation 0.73 W/m^{2}K
- U frame 1.468 W/m^{2}K
- PSI value ranges from 0.034 to 0.042 W/mK depending on frame location, as certified by DIN No B14.203.004.489EN
- Glazing by St Gobain U = 0.5 W/m2K and G = 0.50

Typical glazing and door installation detail



PLAN OF WINDOW JAMB TO OPENING LIGHT (FOR W-F1, W-F2, W-F3, W-F4)

Rooflights

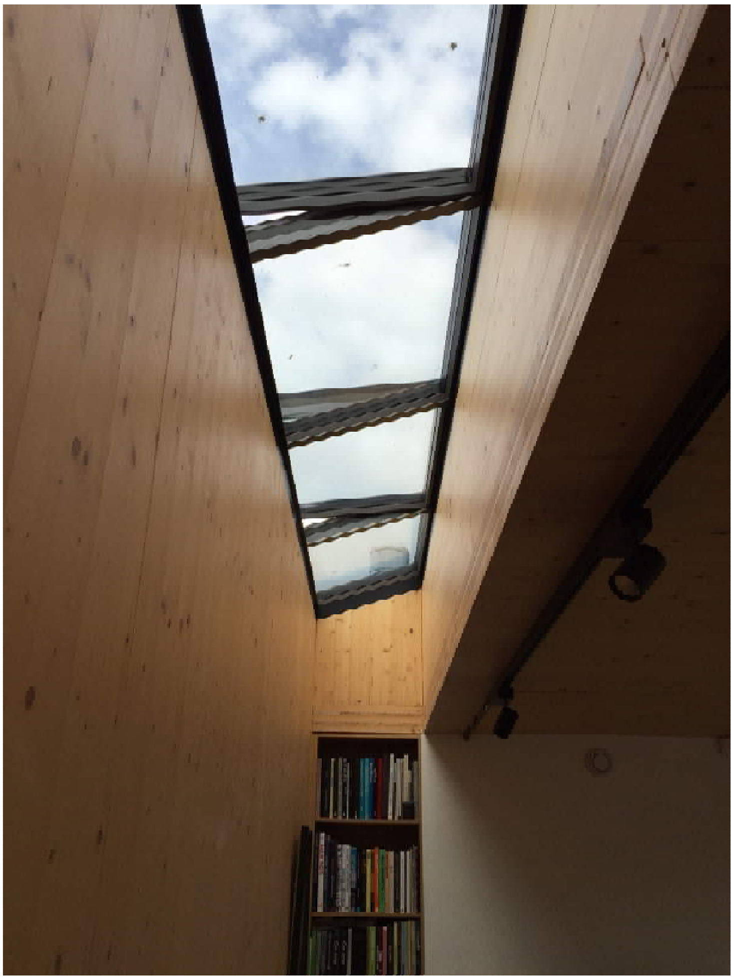
Rooflights have been used to provide daylight to internal rooms like the utility room and family bathroom, as well as to get late afternoon light into living spaces along the western boundary.

The roof lights are provided by Vitral. They are a well performing product with low visual profile. The number of rooflights has been kept to a minimum and are used along the western edge of the building, in internal rooms and at the top of the stair to bring in daylight. They are also a key part of the summer time ventilation system.

Technical details:

- Thermally broken aluminium triple glazed mono pitch rooflight
- U_f = 2.36 W/m^{2}K
- Psi 0.047 W/mK
- U_w = 0.79 W/m^{2}K
- Data provided by the Danish Technological Institute
- Glazing by St Gobain U = 0.5 W/m2K and G = 0.49

Glazing performance has been factored for orientation and derated for rooflights.



Photograph of Living room rooflight

Glazing performance

All glazing in doors, windows and rooflights is St Gobain triple glazing with the following performance:

Windows	U Value	0.5
	G Value	0.5
Rooflights	U Value	0.5
	G Value	0.49

The glass unit was Planilux /4/4/4 with 90% Argon fill and IBE Light low E coating

Installation method

The installation method was developed between myself, the Architect, main contractor and the Window Installer. It provided a simple installation process with clear responsibilities for sealing and dimensional control.

Each window sits inside a plywood box fixed directly to the CLT frame. The box is sealed to the CLT with airtightness tape and all window boards and additional insulation is added by the builder. The window installer fits the window into the box with double sided airtightness tape and specialist expanding foam seal. The builder has then taped the external weather membrane to the outside of the window frame.

Window to wall junction from inside

The large sliding doors use the same detail except for the base. Each door is very heavy and sits on a special Purenit insulation plinth which in turn sits on intermittent fabricated steel brackets. The external insulation is then fitted up to the underside of the purenit and over the brackets to provide a fully insulated construction. The internal arrangements are again similar to the window with the base of the door sealed to a cement board and this sealed to the concrete slab.

The rooflights are more difficult to integrate into the insulation layer. The full thickness insulation comes all the way up to the top of the rooflight upstand. The roof lights are then mounted into structural foam (Compacfoam) which is sealed to the rooflight frame and the CLT.

Front Door

The front door is a high performance unit for RK doors. This has triple seals and is fully insulated with a triple glazed vision panel. Installation is as per the door units.

Technical data for door:

- RK Exclusive profile
- 75mm tick
- 44mm triple glazing Ug 0.7W/m^{2}K
- Door U value 0.72 W/m^{2}K
- Roll hinges by Dr Hann

Photograph of front door

Description of the Airtight Envelope

Airtightness system and method of sealing junctions

The CLT timber frame is the primary air tightness layer for the walls and roof. CLT is a multi layer timber panel with polyethylene resin making it airtight. All joints within the CLT panels are taped with airtightness tape.

The concrete slab is sealed to the CLT by a grout and externally applied tape.

As described in the window section the windows, doors and rooflights are taped to the CLT via a marine ply box connecting frame to CLT.

The design has kept all the material junctions as simple as possible with rectilinear connections.

Clima brand airtightness tapes have been used throughout.

All services penetrations and there are very few are sleeved, fitted with a grommet and fully foam sealed.

Air pressure testing

During the construction process 3 air tests were undertaken. Each was at a key milestone to test the progression of the airtightness.

The final air permeability result was as follows:

Test 3	Pressurisation	0.51
	Depressurisation	0.6
	Average	0.55

Test 1 was just after the CLT frame had been completed and the window openings fitted with temporary plastic panels.

Test 2 was just after the windows had been installed, sealed and taped in place.

Test 3 was at completion of the works, following installation of the front door and sealing of the services penetrations.

Photograph of test fan installed in window opening and during air/smoke test

All air pressure testing was carried out by the Building Research Establishment based in Watford, UK. Full copies of the test results are available on request.

Air Test certificates

BRE, Garston, Watford, Herts, WD25 9XX
Tel: 01923 664000, Fax: 01923 664792
E-mail: airtightness@bre.co.uk

AIRTIGHTNESS TEST CERTIFICATE

Building Tested:	7 Convent Lane, Emsworth, Hampshire		0
CLIENT:	Nicholas Coppin Limited, Unit 3, Ford Lane Business Park, Ford, BN18 0UZ		
Date of test:	06/05/2015	BRE Report No:	pr0613-1001
Result: AIR PERMEABILITY AT 50 Pa, [AP50 = Q50 / A_E]			0.40 ($m^3/hr/m^2$)
Result Air Changes per Hour ACH @50pa			0.51

Test standard:	BS EN 13829:2001 &ATTMA TSL1 Method B		No none conformaties
Building Envelope area [A_E] m^2:	435.00	BS EN 13829:2001	Based on the supplied target
Building Volume	345.00		
Building design target n50:	0.60	ACH	This building has passed its airtightness test
Tube locations	ground and LHS test door	Building description	Detached Passivhaus Dwelling
Area tested	entire	Construction date	2014/15

Equipment ID		Calib expiry Date	Equipment ID		Calib expiry Date	Range
Duct blaster gauge	102696	24/03/2016	Duct blaster	IU100067	24/03/2016	mid
Temp probe	m4998	19/01/2016				
Barometic gauge	m3311	27/01/2016				

Environmental and Building Conditions:

	Barometric pressure		Internal temp		External temp		Fan off	Negative	Positive
Pre test	1004		12.4		7	P01	3.45	#DIV/0!	3.45
Post test	1004		12.5		7.3	P02	3.97	#DIV/0!	3.97
average	1004		12.45		7.15	overall	3.71		

Heating/Ventilation System: Natural and Mechanical

All internal doors open
All external doors and windows closed
Water in all traps

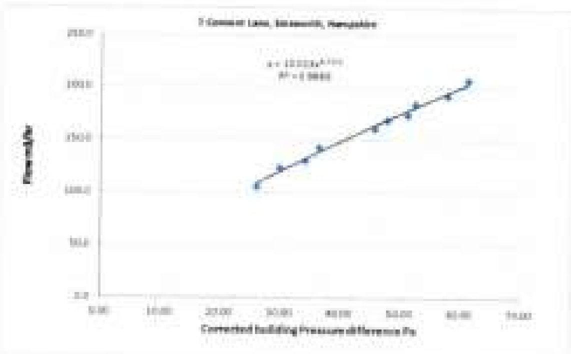
Calculations carried out in line with appendix a ATTMA TSL1 and BS EN 13829

AVERAGE VALUE ACH 0.55

Test Data:

Corrected Building (Pa)	61.29	57.69	52.39	51.09	45.59	36.39	34.09	29.79	25.99	47.69
Corrected Flow (m^3/hr)	206.2	192.3	183.8	173.3	160.6	143.3	130.6	123.8	105.3	168.7

Corrected Building Pressure VS Fan Flow



Curve fit parameters:

Air flow exponent [n]	0.7312
Correlation coefficient [r^2]	0.9886
Air leakage coefficient [C_L]	0.002796
Air flow coefficient [C_{env}]	0.002781
Air leakage rate [Q_{50}] (m^3/h @ 50 Pa)	0.05

Validity check

Number of points	Yes
N	Yes
R2	Yes
Fan off in side + 5pa	Yes
Pressure equal through building	Yes
Temporary sealing acceptable	Yes

bre

BRE, Garston, Watford, Herts, WD25 9XX
Tel: 01923 664000, Fax: 01923 664792
E-mail: airtightness@bre.co.uk

AIRTIGHTNESS TEST CERTIFICATE

Building Tested:	7 Convent Lane, Emsworth, Hampshire		0
CLIENT:	Nicholas Coppin Limited, Unit 3, Ford Lane Buisness Park, Ford, BN18 0UZ		
Date of test:	06/05/2015	BRE Report No:	pr0613-1001
Result: AIR PERMEABILITY AT 50 Pa, [AP50 = Q50 / A_t]			**0.47 ($m^3/hr/m^2$)**
Result Air Changes per Hour ACH @50pa			**0.60**

Test standard:	BS EN 13829:2001 &ATTMA TSL1 Method B		No none conformaties
Building Envelope area [A_t] m²:	435.00	BS EN 13829:2001	Based on the supplied target
Building volume	345.00		
Building design target n50:	0.60	ACH	This building has passed its airtightness test
Tube locations	ground and LHS test door	Building description	Detached Passivhaus Dwelling
Area tested	entire	Construction date	2014/15

Equipment ID		Calib expiry Date	Equipment ID		Calib expiry Date	Range
Duct blaster gauge	[illegible]	24/03/2016	Duct blaster	[illegible]	24/03/2016	mid
Temp probe	[illegible]	19/01/2016				
Barometic gauge	[illegible]	27/01/2016				

Environmental and Building Conditions:

	Barometric pressure		Internal temp		External temp		Fan off	Negative	Positive
Pre test	1004		12.1		6.9	P01	1.77	#DIV/0!	1.77
Post test	1004		11.9		6.5	P02	2.25	-0.2	2.522222
average	1004		12		6.7	overall	2.01		

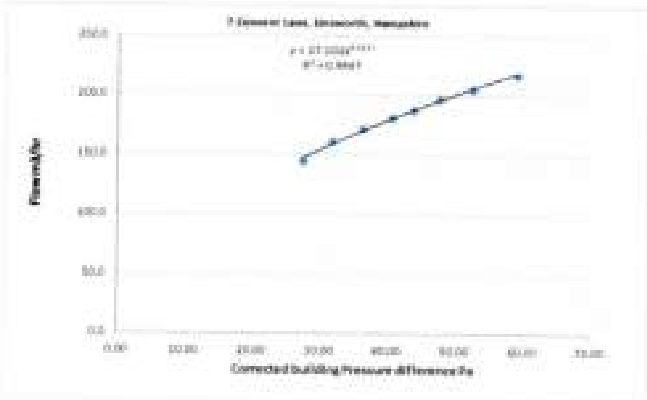
Heating/Ventilation System: Natural and Mechanical

All internal doors open All external doors and windows closed Water in all traps	Calculations carried out in line with appendix a ATTMA TSL1 and BS EN 13829 AVERAGE VALUE ACH 0.55

Test Data:

Corrected Building (Pa)	59.01	52.41	47.61	43.61	40.61	36.21	31.71	27.41	41.81	39.41
Corrected Flow (m^3/hr)	216.9	204.6	196.5	187.5	180.8	171.3	161.1	144.9	187.0	181.3

Corrected Building Pressure VS. Fan Flow



Curve fit parameters

Air flow exponent [n]	0.5108	Validity check	
Correlation coefficient [r^2]	0.9891	Number of points	Yes
Air leakage coefficient [C_L]	0.007738	N	Yes
Air flow coefficient [C_{env}]	0.007585	R2	Yes
Air leakage rate [Q_{50}] (m^3/h @ 50 Pa)	0.06	Fan off in side +-5pa	Yes
		Pressure equal through building	Yes
		Temporary sealing acceptable	Yes

Ventilation System Selection and Design

A full MVHR system has been installed. This provides supply air to all occupied rooms and removes extract air from all wet and utility rooms. The supply and extract rates are balanced and the system operates at speed 2 on the plant. The system is set up with a reduced volume on speed 1 for when the home is not occupied and speed 3 is a boost for rapid ventilation. The ventilation rates are in accordance with or exceed UK Building Regulations Part F, Passivhaus guidance and industry guidance.

The primary plant is a Paul Novus 300 with built in frost protection and a remote control adjacent the kitchen.

Ventilation Unit Details	
effective heat recovery efficiency	$\eta_{HR,eff} \geq 75\%$
electrical efficiency (in Wh/m³)	$P_{el} \leq 0.45\ Wh/m^3$

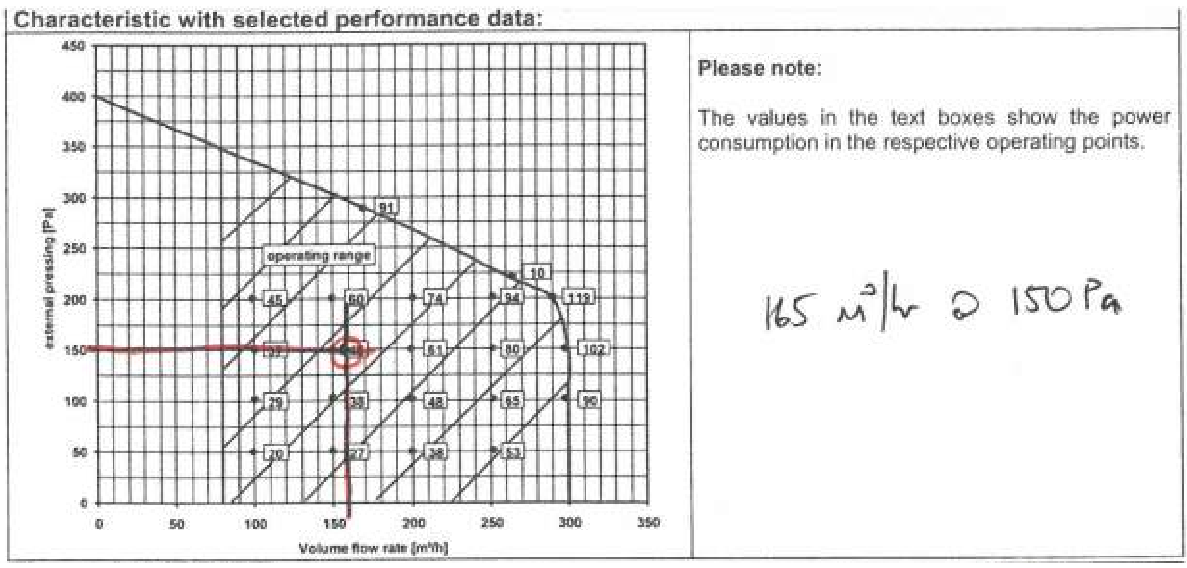


Image of fan curve and system operating point

The ventilation unit is mounted in the plant space at the back of the utility room with excellent access for servicing and filter replacement

The ventilation ductwork is spiral wound galvanised steel, slightly oversized to keep pressure drop to a minimum. There is no flexible ductwork in the system. Air inlet and exhaust are through the ground floor roof on the western side of the house. The 2 ducts have been kept apart to avoid recirculation with the air inlet upwind for the prevailing UK wind direction. Both inlet and exhaust ducts are insulated between the building thermal envelope and the ventilation unit with 50mm continuous Armaflex insulation.

Primary attenuators are fitted to the room side supply and extract directly off the main plant to control noise levels. The system is fully balanced and commissioned in accordance with UK Building Regulations. In duct attenuators are fitted between bedrooms as well as an offset branch duct configuration to prevent cross talk noise transfer between rooms.

The ductwork route is coordinated across the ground floor ceiling and rises up to the first floor in the bathroom risers, keeping ductwork to a minimum.

The entire system was checked for pressure drop (using a bespoke excel spreadsheet) and the system operating point plotted on the unit fan curve to check fan efficiency and noise levels. This was done using standard and specific fitting loss coefficients. Additional volume control dampers were fitted to the system to allow balancing independent of the supply and exhaust grilles.

The system is very quiet and barely audible even on boost mode.

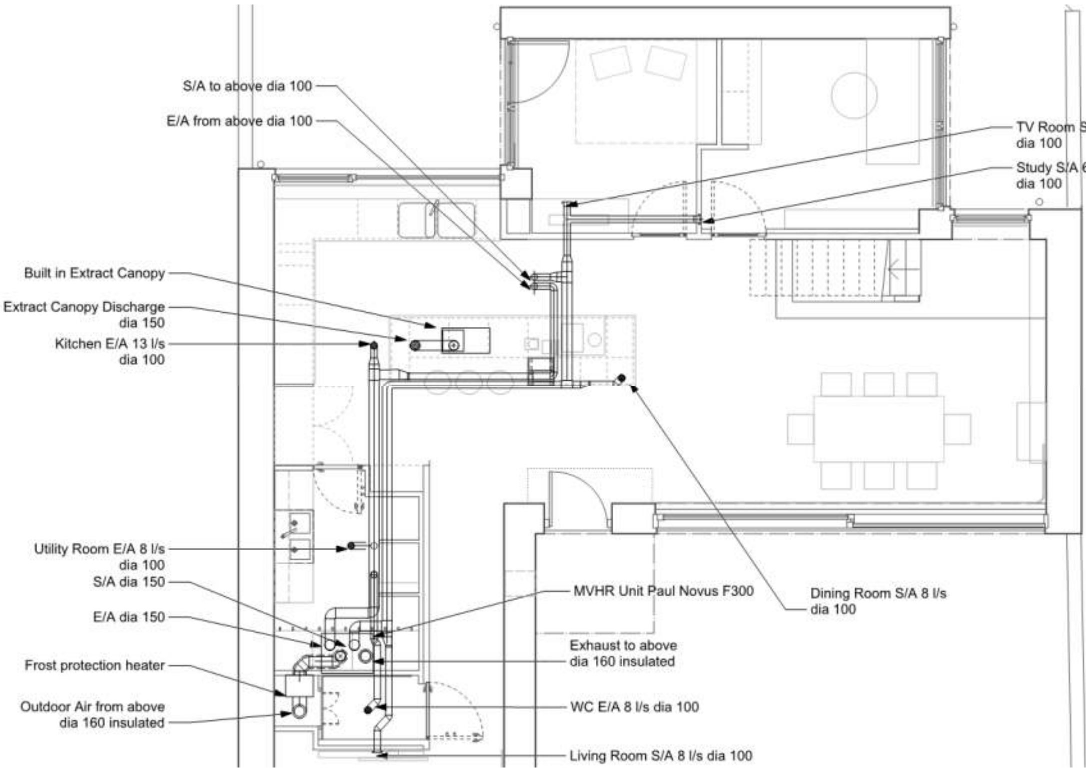
Photograph of ventilation Plant and primary ductwork

Photograph of typical grille details in ceilings and walls

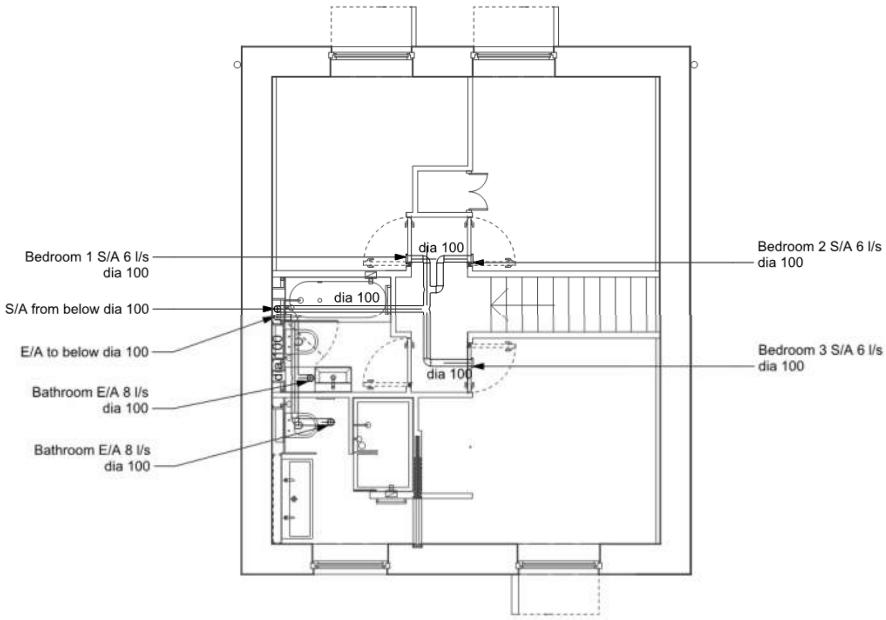
Return air is via door under and overcuts. These exceed 15mm in all cases and were checked by the MVHR installer.

Outdoor air inlet and exhaust are on the lower western roof with adequate separation (in excess of 2m) to avoid recirculation.

Ground Floor ductwork layout



First Floor ductwork layout



Summer Time Ventilation

Early calculations showed that overheating was possible in summer due to the glazing design. To control overheating shading is applied to the upper floor windows with the wrap around blinkers. A fabric shade canopy will be fitted to the south courtyard to protect the larger glass areas. This shade will be removable to allow solar gain in during winter.

To ensure adequate ventilation in summer the house was designed to achieve excellent levels of cross flow ventilation.

The building is fitted with a range of openable elements:

- Large sliding doors to the living and dining room
- Large tilt and turn windows to all occupied rooms
- Motorised rooflights to living room, utility room, family bathroom and central stair

The primary method of cross flow vent is between windows/doors and rooflights. Typically all windows, doors and rooflights are manual operation but an automatic sensor controlled function was fitted to the rooflight above the stair. This is set to open the rooflight if the internal space temperature reaches 22 degC. The setpoint is variable and is lowered in summer to precool the space or disabled during winter when the heating is on.

In addition to the cross flow vent each habitable room has an openable window with a tilt open free area in excess of 5% of the nett floor area.

A full shading analysis and cross flow ventilation model was done using the PHPP worksheets.

Photographs of 1st floor windows in minimum vent position

Heating Systems

Heat Generation

A Viessmann 242F integrated gas fired boiler, domestic hot water cycling and thermal solar system has been installed. This provided a fully developed and optimised thermal energy generation system. External weather compensation and a wireless internal thermostat is fitted.

The compensation slope and setpoint have been tuned over the winter months with much reduced operating temperatures.

Heating System

A conventional low temperature hot water system was installed with 2 radiators on the ground floor and 1 radiator in the common lobby at first floor. Each radiator is fitted with a thermostatic radiator valve.

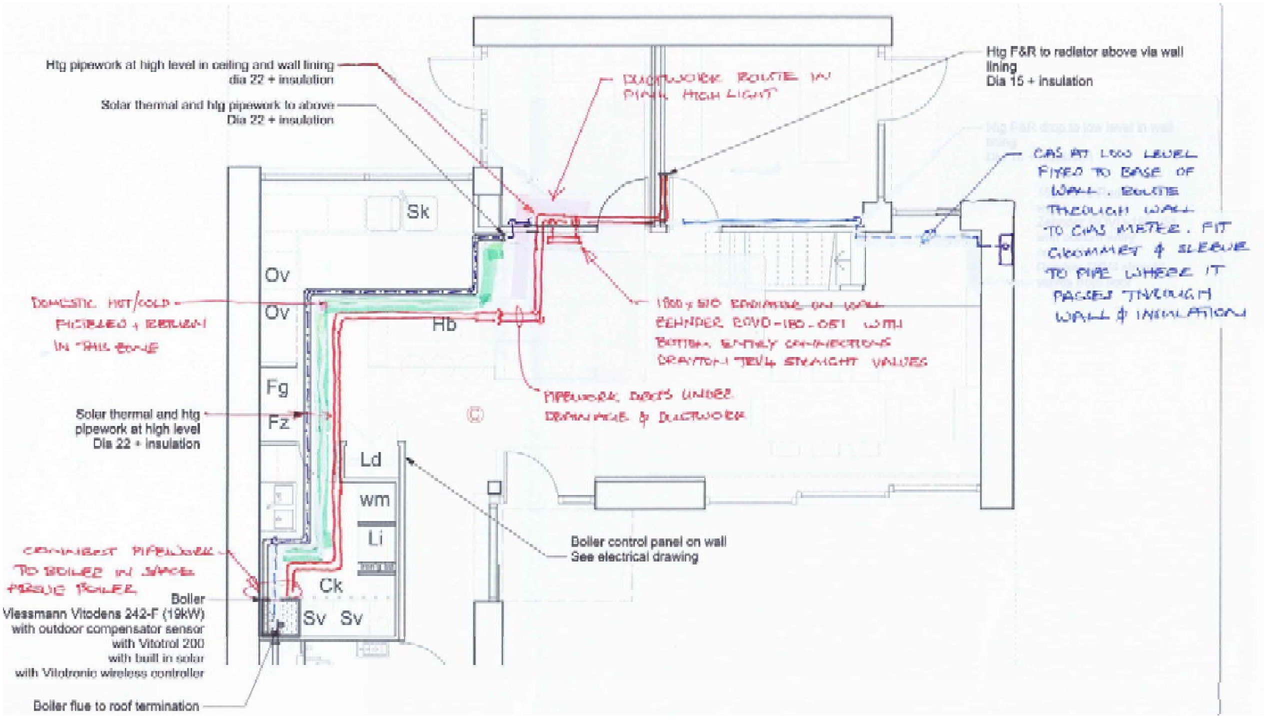
All pipework is continuously insulated from source to the radiator tails.

Image of heating unit

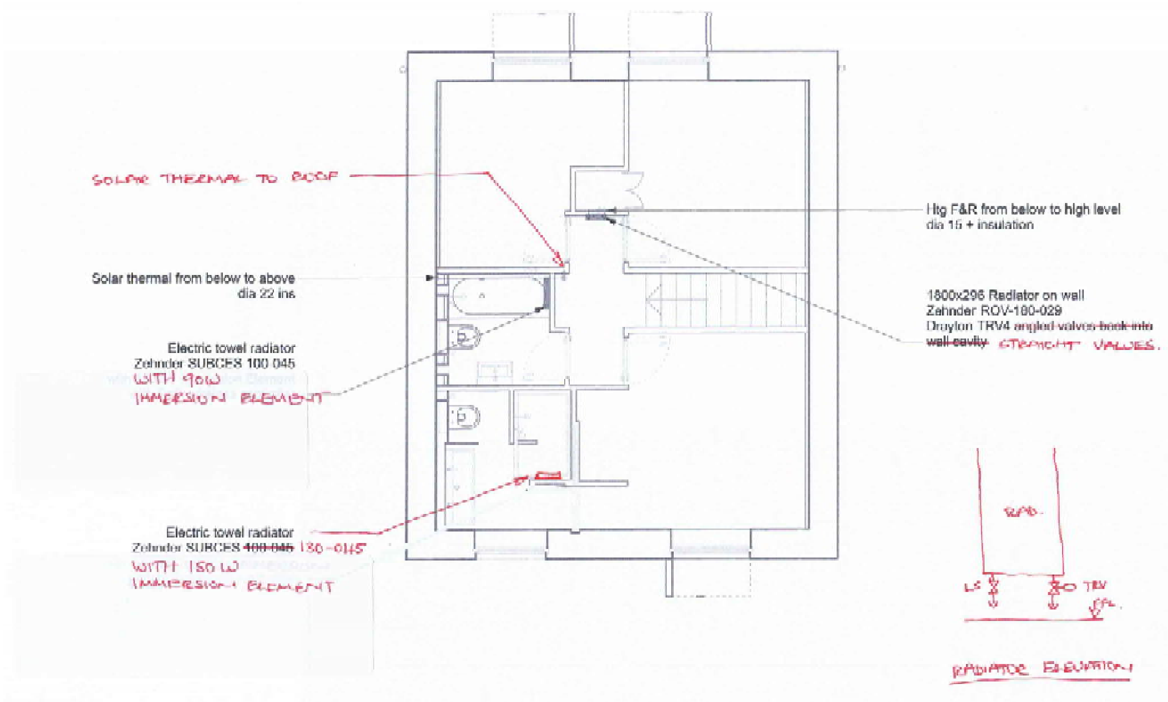
Image of heating system controller and primary radiator

An electric towel radiator is fitted in each bathroom and these are fitted with timers to minimise energy use. To date these are seldom used.

Ground floor heating installation drawing



First floor heating installation drawing



Domestic Hot Water System

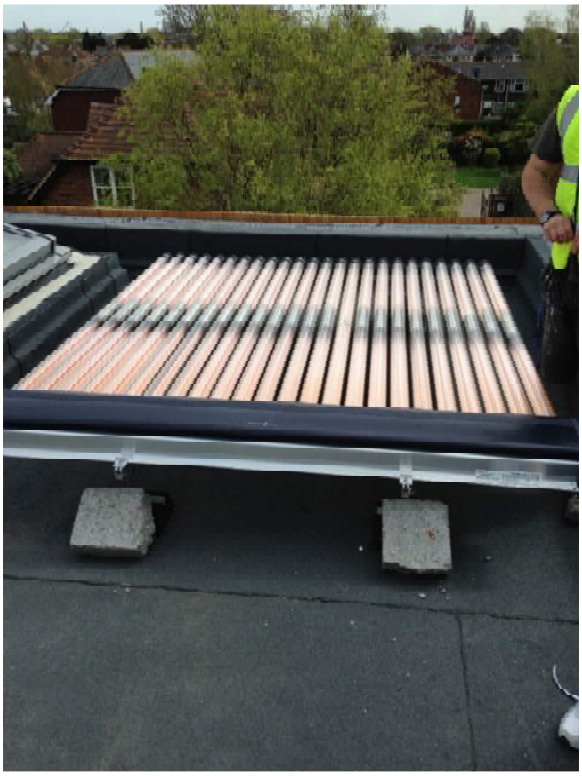
Domestic hot water is provided by the integrated hot water cylinder in the Viessman 242 F unit. This is heated firstly by a solar thermal circuit and topped up by the gas boiler.

The array is generating typically 4kWh of thermal energy on a clear day.

A DHW circulation pump is fitted to reduce pipework losses and to ensure fast flow of hot water.

All pipework is continuously insulated from the source to point of use.

Photograph of Viessmann Vitosol Solar thermal array



Pipework Insulation

A bespoke pipework insulation method was developed for the project. This allowed continuous 19mm armaflex insulation from boiler to fitting. The pipework was fabricated at low level, the insulation sleeve fitted and then plastic support rings fitted before using electrical plastic ties to secure the pipework to the timber soffit.

Photograph of the pipework fixing and insulation method

Electrical Installation

The electrical installation is to UK wiring regulations and is very standard for a house of this size. There is a standard 100Amp incoming single phase supply from the local utility company and this terminates in 2x15 way consumer units.

Individual circuits are run for most pieces of equipment to allow individual metering of installed equipment in the future.

A 1.6kW peak solar electric array is fitted to the house. This generates up to 8kWh on a clear summer day. The inverter is fitted in the utility room and connected for use in the house or grid export.

Photograph of 1.6kWp PV array

PHPP Results

Verification worksheet and discussion.

Specific building demands with reference to the treated floor area				Requirements	Fulfilled?*
	Treated floor area	133.7	m²		
Space heating	Heating demand	**8**	**kWh/(m²a)**	15 kWh/(m²a)	**yes**
	Heating load	**10**	**W/m²**	10 W/m²	**yes**
Space cooling	Overall specif. space cooling demand		**kWh/(m²a)**	-	-
	Cooling load		**W/m²**	-	-
	Frequency of overheating (> 25 °C)	1.7	%	-	-
Primary energy	Heating, cooling, auxiliary electricity, dehumidification, DHW, lighting, electrical appliances	**96**	**kWh/(m²a)**	120 kWh/(m²a)	**yes**
	DHW, space heating and auxiliary electricity	62	kWh/(m²a)	-	-
	Specific primary energy reduction through solar electricity	11	kWh/(m²a)	-	-
Airtightness	Pressurization test result n_{50}	**0.6**	**1/h**	0.6 1/h	**yes**

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

Passive House?	**yes**

The PHPP spreadsheet was a very useful design tool. The direct feedback of different input parameters was extremely helpful during design and allowed us to confirm window system performance and building U values very effectively.

The solar gains calculations were very useful to check for overheating and to understand the heating design options and solar control strategy.

The pipework heat losses were easily modelled with and without return loop and confirmed a DHW circulator was the best solution.

When it came to choosing appliances the tool again helped us see the impacts of different energy ratings. The subtle differences in appliances had a significant impact on the annual energy consumption.

Ventilation design was modelled well in the tool but the design was a result of many years of experience with natural ventilation design and rules of thumb. The tool provided good feedback on the design parameters.

Construction Costs

Net construction cost for the occupied dwelling including green roofs, renewable technology and internal fitout.

Overall construction cost for the total development, which includes a 40sqm garage, landscaping, boundary walls, consents, consultants, enabling works and all project elements

Construction costs	Net building cost	£4,000 /sqm

Post Occupancy Feedback

Comfort

The house has been super comfortable at either extreme of season. The summer of 2015 was deemed pretty average by the UK met office and winter saw temperatures below zero on numerous occasions. The internal temperatures are very even and no cold draughts are evident.

Air quality has been very good during winter and summer.

Daylight levels are high due to the careful placement of glazing and lighting use is very low.

The cross flow ventilation has been very effective in summer and no overheating has been observed.

Energy Consumption figures

The dwelling has now been in use for 12 months and following meter readings , the performance is confirmed.

This shows a reduction in energy consumption over the design targets for final energy and a little over the target for primary energy.

	Jun-2015	May-2016		In Use kWh	Actual kWh/sqm annum		
					Final Energy		Primary Energy
Elec Meter	4422	9241	kWh	4819	36	2.6	94
Gas Meter	36	274	m3	2535	19	1.1	21
					55		114
PV generation	0	642	kWh	642	5	-2.6	-12
Solar Thermal	0	650	kWh	650	5	-1.1	-5

Electricity consumption is higher than predicted and gas lower. We are in the process of investigating this, with a view to optimising energy consumption, PV energy use and timer based electrical loads.

Domestic metering equipment does not allow consumers to see exactly how much energy they are actually consuming. The utility company meter records imported electricity less PV generated power use, rather than energy used. Typical home energy monitors only reflect this figure and do not have the internal processing to identify the true energy use.

Controls

Simple controls have been very effective. User instigated, manual control has been the most effective way to moderate internal temperature and energy consumption.

It has taken some time to get used to how to live in the house, how to manage the heating and operate the MVHR and well as summer natural ventilation systems.

The automatic rooflight internal temperature sensor has a 4 deg dead band which is too wide to react quickly enough to increasing internal temperatures. We have resorted to reducing the setpoint to get the rooflight to operate early with a degree of precooling.

Typical domestic equipment control bands are too wide for a Passivhaus. It is worth considering industrial sensors with increased accuracy.

Heating System

2 of the 3 radiators have been turned off and have not been necessary to keep the house warm even at very low external temperatures. These will be removed in due course.

We have also found the thermal inertia of the wet based heating is too slow to react to rapid winter solar gains during sunny periods and causes internal temperatures to rise above setpoint despite the boiler shutting down. Electric heating panels would be more suitable.

The heating compensation control slope and end point have now been adjusted to suit the thermal properties of the house, providing very stable internal temperatures in winter.

The minimal heating requirements make electrical based heating very attractive. Electrical heating will also be more responsive to solar gains and prevent winter setpoint overshoot. Although there is a primary energy conversion factor penalty in the UK for an electric based system, final energy use will be reduced by more use of PV generated power.

With electric space heating a simple solar thermal domestic hot water system with electric top up is possible.

Solar electric can then be used to offset all energy consumption. This combined with an electrical energy store would minimise energy use and utility energy import.

Appendix 1 – Copy of PHPP verification Sheet

Passive House verification

Building:	7 Convent Lane						
Street:							
Postcode / City:	Emsworth						
Country:	UK						
Building type:	Residential Dwelling						
Climate:	[UK] - South England (Efford)					Altitude of building site (in [m] above sea level):	8
Home owner / Client:	Ruth Butler and Julian Sutherland						
Street:							
Postcode/City:							
Architecture:	Ruth Butler Architects						
Street:	7 The Green, Rowlands Castle						
Postcode / City:	Hampshire PO9 6BW						
Mechanical system:	Julian Sutherland						
Street:	7 The Green, Rowlands Castle						
Postcode / City:	Hampshire PO9 6BW						
Year of construction:	2014		Interior temperature winter:	20.0	°C	Enclosed volume V_e m³:	352.0
No. of dwelling units:	1		Interior temperature summer:	25.0	°C	Mechanical cooling:	
No. of occupants:	4.0		Internal heat sources winter:	2.1	W/m²		
Spec. capacity:	84	Wh/K per m² TFA	Ditto summer:	3.4	W/m²		

Specific building demands with reference to the treated floor area

				Requirements	Fulfilled?*
	Treated floor area	133.7	m²		
Space heating	Heating demand	**8**	**kWh/(m²a)**	15 kWh/(m²a)	**yes**
	Heating load	**10**	**W/m²**	10 W/m²	**yes**
Space cooling	Overall specif. space cooling demand		**kWh/(m²a)**	-	**-**
	Cooling load		**W/m²**	-	**-**
	Frequency of overheating (> 25 °C)	1.7	%	-	-
Primary energy	Heating, cooling, dehumidification, DHW, auxiliary electricity, lighting, electrical appliances	**96**	**kWh/(m²a)**	120 kWh/(m²a)	**yes**
	DHW, space heating and auxiliary electricity	62	kWh/(m²a)	-	-
	Specific primary energy reduction through solar electricity	11	kWh/(m²a)	-	-
Airtightness	Pressurization test result n_{50}	**0.6**	**1/h**	0.6 1/h	**yes**

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

Passive House?	**yes**

We 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 application.

Name:	**PHPP Version 8.4** **Registration number PHPP:**
Surname:	**Issued on:**
Company:	**Signature:**

Appendix 2 – Compliance Certificate

WARM: Low Energy Building Practice
3 Admirals Hard, PLYMOUTH, PL1 3RJ UK +44 (0) 1752 542 546
www.peterwarm.co.uk

Authorised by:
Passive House Institute
Dr. Wolfgang Feist
Rheinstr. 44/46
D-64283 Darmstadt

Certificate

WARM: Low Energy Building Practice **awards the seal "Certified Passive House" to the following building**

7 Convent Lane, Emsworth, Hampshire, PO10 7JJ, UK

Client:	**Mr & Mrs Sutherland** 7 Convent Lane, Emsworth, Hampshire, PO10 7JJ
Architect:	**Ruth Butler Architects** 7 Convent Lane, Emsworth, Hampshire, PO10 7JJ
Building Services:	**Julian Sutherland** 7 Convent Lane, Emsworth, Hampshire, PO10 7JJ

This building was designed to meet Passive House criteria as defined by the Passive House Institute. With appropriate on-site implementation, this building will have the following characteristics:

- Excellent thermal insulation and optimised connection details with respect to building physics. The heating demand or heating load will be limited to

  15 kWh per m² of living area and year or a heating load of 10 W/m², respectively
- When outdoor temperatures are high, thermal comfort can be ensured with passive solutions or with minimal energy demand for cooling and dehumidification according to the location-specific Passive House requirements.
- A highly airtight building envelope, which eliminates draughts and reduces the heating energy demand: The air change rate through the envelope at a 50 Pascal pressure difference, as verified in accordance with ISO 9972, is less than

  0.6 air changes per hour with respect to the building's volume
- A controlled ventilation system with high quality filters, highly efficient heat recovery and low electricity consumption, ensuring excellent indoor air quality with low energy consumption
- A total primary energy demand for heating, domestic hot water, ventilation and all other electric appliances during normal use of less than

  120 kWh per m² of living area and year

This certificate is to be used only in combination with the associated certification documents, which describe the exact characteristics of the building.

Passive Houses offer high comfort throughout the year and can be heated or cooled with little effort, for example, by heating/cooling the supply air. Even in times of cold outdoor temperatures the building envelope of a Passive House is evenly warm on the inside and the internal surface temperatures hardly differ from indoor air temperatures. Due to the highly airtight envelope, draughts are eliminated during normal use. The ventilation system constantly provides fresh air of excellent quality. Energy costs for ensuring excellent thermal comfort in a Passive House are very low. Thanks to this, Passive Houses offer security against energy scarcity and future rises in energy prices. Moreover, the climate impact of Passive Houses is low as they reduce energy use, thereby resulting in the emission of comparatively low levels of carbon dioxide (CO_2) and air pollutants.

issued:

PLYMOUTH, October 2015

Certificate-ID: 11764_WARM_PH_20151009_PW

Appendix 3 – Design statement by the project Architect

I confirm that the applicant was responsible for the parts of the planning that were relevant for the Passive House Standard and that they delivered the PHPP calculations and MEP design

Signed

Ruth Butler

Ruth Butler Architects

Courtyard Studio

Seven Convent Lane

Emsworth Hampshire

PO10 7JJ