Hampshire Passivhaus – Site Sensitive design for health, wellbeing and low carbon living

By: Julian Sutherland

Introduction

Hampshire Passivhaus is a Passivhaus Certified self-build home for Ruth Butler (Architect) and Julian Sutherland (Chartered Engineer) and their family, on the south coast of England. It is an L-shaped detached dwelling, creating private courtyard spaces, on a tight brownfield site with multiple neighbours. The home was designed as a low-carbon exemplar, helping to tackle climate change and fuel poverty. Performance in-use data shows a 34% improvement on the calculated performance.

The building location maximizes the south-facing courtyard garden. Two smaller courtyards to the north, flood the back rooms with daylight and natural ventilation. Sensitive to the neighbours, the form and massing responds to overlooking-issues with no first-floor windows to the east/west and “blinkers” to bedroom windows on the north/south. The house is frequently open for CPD sessions and to the public for Passivhaus Open Days each year, as a learning tool for others.

Contact:
Ruth Butler
Chartered Architect & RIBA Client Adviser
Ruth Butler Architects
p: 01243 379783 m: 07584 428403
w: ruthbutlerarchitects.com

Picture 1: View from inside dining room

This project had ambitions beyond Passivhaus. The Client/Designers were looking to create a home that was low energy, low carbon and promoted a healthy lifestyle. Key construction innovations include:

- Fabric-first approach to energy conservation via Passivhaus
- Super low-noise MVHR ventilation, complimented by stack driven cross-flow natural ventilation for summertime ventilation
- A careful blend of conventional and renewable technologies
- Near zero carbon development achieved by combining Passivhaus low energy and green utilities
- Wire and battery free light switching (EnOcean)
- Sustainably sourced materials - low carbon concrete slab (GGBS), FSC timber structure/cladding and interior finishes
- Prefabricated Cross Laminate Timber structure, erected and watertight in just 4 days and naturally airtight
- Exemplary Architecture for Contemporary Living to create a light and airy open plan living with excellent indoor-outdoor flow to the courtyard gardens. Garden design is by John Brookes MBE, one of the most influential landscape designers of the past fifty years

Hampshire Passivhaus has heating-related energy savings of over 75% compared to an average new UK home. It makes efficient use of the sun, internal heat sources and heat recovery. Summertime shading is provided by a deployable sail-shade to keep the interior comfortably cool.

Contemporary Architecture

This building has been designed for modern family living. It features, open plan, contemporary design, a central kitchen area, home office, flexible multi use room and direct connection to a covered outdoor space. This creates fabulous family moments, whilst delivering low energy bills, low carbon emission and excellent, indoor environmental quality.

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Low Energy Design

The primary objective of the project was to achieve Passivhaus standard with high quality architecture that responds to the opportunities and constraints of the site. This objective has the following additional benefits:

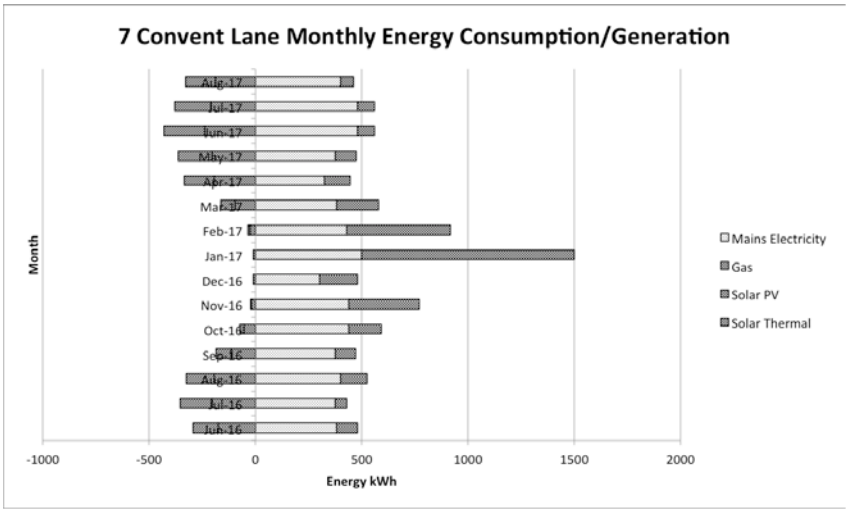

Diagram 2: Annual Energy use and generation profile

- The site is a tight urban brownfield site with significant overlooking from neighbours. The design solution is to create an L-shape form enclosing a private courtyard. This led to a very high building form factor (the ratio of external envelope and internal floor area), which is a challenge for a Passivhaus fabric-first approach. The design overcomes this challenge with increased fabric performance.
- Reducing north-facing windows, to minimise heat loss
- Optimising south-facing windows, for winter solar gains for free-heating
- Achieving excellent summer-time shading for interior comfort (deployable sail cloth).
- Super-insulating the envelope, with wall U values less than 0.1 W/sqmK
- Installing green roofs to attenuate rainwater (existing site has no soil absorption)

Annual energy use is very easily monitored via the primary energy meters and remote energy display.

	Jun-2015	May-2016	May-2017		Avg Annual kWh	Actual kWh/sqm annum		PHPP design		Carbon Emmissions	
						Final Energy	Primary Energy	Final Energy	Primary Energy	factor	Emmission
Elec Meter	4422	9241	14038	kWh	4808	36	93	24	63	0	0.00
Gas Meter	36	274	555	m3	2764	21	23	49	54	0.184	3.80
						57	116	74	117		3.80
				percentage of design		77%	99%				
PV generation	0	642	1911	kWh	956	7	-19	6	-11	-0.41205	-2.94
Solar Thermal	0	650	1291	kWh	646	5	-5	9		0	0.00
										nett	0.86

Table 1: Energy use data and generation meter data

Near Zero Carbon in Use

The project has been able to achieve Near Zero Carbon in Use by balancing low carbon design and renewables with low carbon utilities.

- Hampshire Passivhaus was certified Passivhaus in 2015
- Two years of in-use data demonstrates that the house performs 34% better than predicted at design stage using the PHPP software
- There is zero performance gap
- Near zero carbon by a combination of super low energy demand, local renewables and green utilities carbon offset
- Electricity and gas is purchased from Ecotricty, one of the UK's most innovative energy providers. Profits are invested in renewable generation and their power is almost zero carbon. They are currently investing in renewable gas generation systems.

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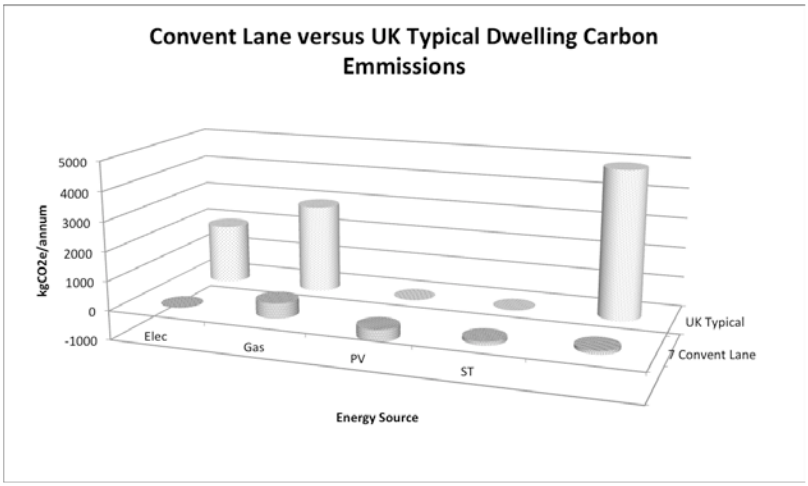
This modest, 140sqm home, has very low energy bills at only £700/annum compared with £2,000/annum for a typical house. The additional cost of Passivhaus' has been calculated at 7.4% of Net Construction Cost, giving a payback period of 30-years, for the investment. As energy prices rise, this payback period will reduce.

Diagram 3: Carbon emission in comparison with typical UK Dwelling



Low Embodied Carbon Build

The project set out to minimise the environmental impact of as many building materials as possible using commercially available methods. This was surprisingly easy with a bit of research. The significant material substitutions include:

- Hanson Low carbon GGBS cement replacement in concrete slab.
- 53m3 of CLT panels were used on the house, removing 42.4 tonnes of CO2 and 'locking in' 13,000kg of carbon. FSC-certified timber though-out. Self-finished with acrylic fire protection
- Recycled existing buildings on site – bricks crushed into fill; recycled steel beams into new garage
- Long life quarry tile floors to ground floor
- Natural wool carpets on first floor. Sheep's wool is very renewable.
- Natural rubber flooring products to bathrooms
- Minimal internal linings of plasterboard
- No plaster and wet trades

Health, Wellbeing and Modern Lifestyles

We all spend significant time indoors and so it is essential that the indoor environmental quality is very good. This project achieves exceptional air quality by not using materials with off gassing and then providing very high-quality ventilation.

To achieve a healthy interior that supports wellbeing the project achieved:

- Excellent airtightness and MVHR gives fresh filtered air to the interior (winter mode)
- Excellent natural ventilation, using rooflights to drive stack effect and opening windows/ large sliding doors for cross ventilation in all rooms (summer mode)
- Specification of low or no VOC materials/finishes throughout e.g. undyed carpet in bedrooms and zero VoC paints.
- Air quality monitored using the Cundall ieQubes, demonstrating very low levels of particulates
- High levels of natural daylight to all rooms – from the main south-facing courtyard and two further courtyards facing north-east and north-west

Internally, materials chosen for health and wellbeing benefits include self-finished structural timber, stainless steel and quarry tiles, giving the interior a rich materiality. Monitoring was carried out before and during Passivhaus Open Days 2016 using Cundall ieQubes and the results were exceptional:

- VOCs levels 0 ppm
- CO2 levels < 300 ppm
- PM2.5 and PM10 < 5 micrograms per CU3

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- Temperatures 20 – 22 deg C
- RH 30 - 45%

Ventilation Strategy

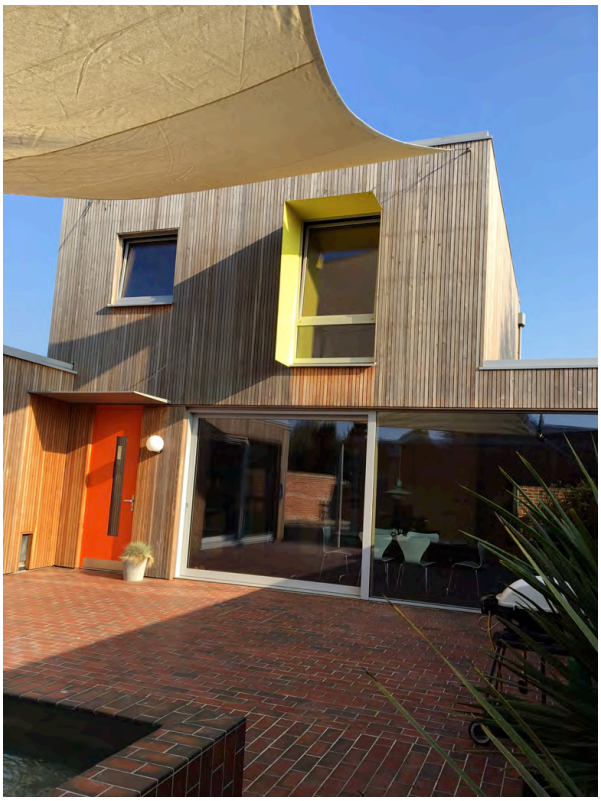
The ventilation strategy took some time to develop.

Winter ventilation is provided by a Paul Novus 300 MVHR, with low velocity metal ducting. This delivers 3 levels of ventilation at exceptionally low noise levels.

Purge ventilation is provided by opening windows and the MVHR boost mode.

Summer ventilation is provided by a cross flow, stack effect ventilation system. This system features:

- Minimum 5% of floor area opening vent to every room
- Secure inward opening windows for night-time ventilation
- Careful location of vents to ensure effective cross-flows
- Roof lights used to drive stack effect (fitted with temperature and rain sensors)
- Overheating predicted to be 1.7% at 25 degC



Summer ventilation is supported by a well-developed shading strategy. This includes:

- Deployable sail cloth for summer-time shading (for a family of keen sailors)
- Fixed window “blinkers” and recessed windows for mid-season shade
- Glazing ratio 34.6%
- MVHR with automatic by-pass

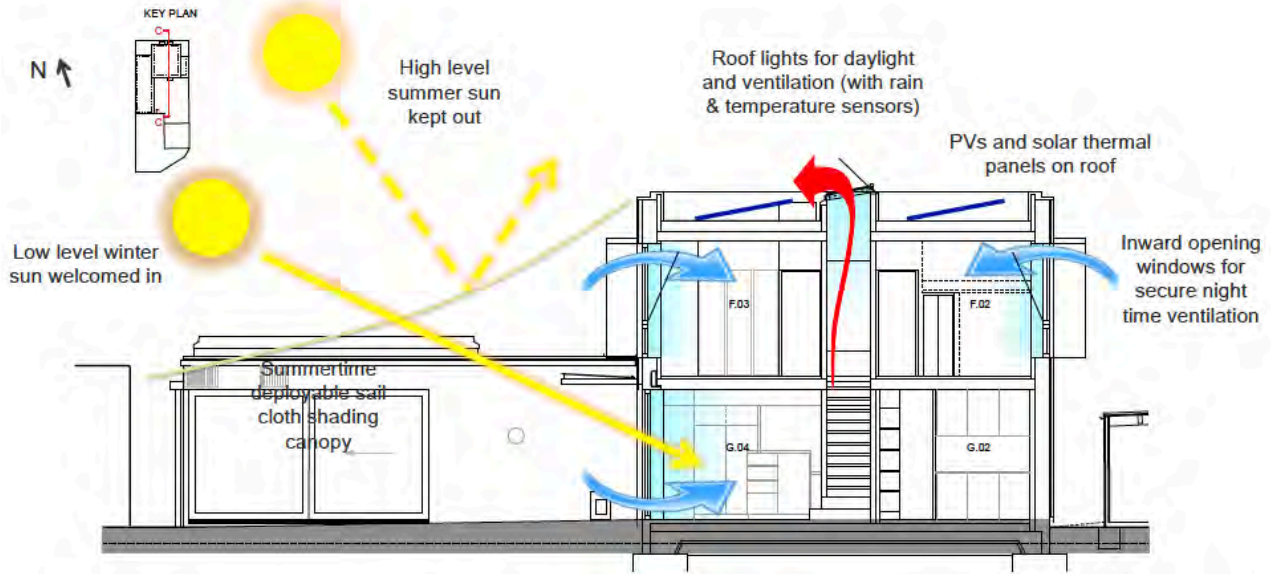


Diagram 1: illustration of shading and ventilation strategy

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Owner Feedback, Lessons Learnt and Awards

“As a Building Services Engineer, the levels of comfort in our house have exceeded my expectations. It’s draught-free and uniformly comfortable throughout the year.” Julian Sutherland

"We love living in this house. The house is flooded with daylight, the spaces are beautiful and the air quality is fabulous.” Ruth Butler

“Between April & September we open the big sliding doors and live in the courtyard because we don't need to worry about heating or cooling.” Ruth Butler

Shortlisted for: Hampshire Countryside Awards;

Shortlisted for the 2018 CIBSE Building Performance Awards

Winner 2017 UK Wood Awards, Private Category.

The project is included as a Case Study on the Passivhaus Trust website.

Picture 2: View from site entrance

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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		

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