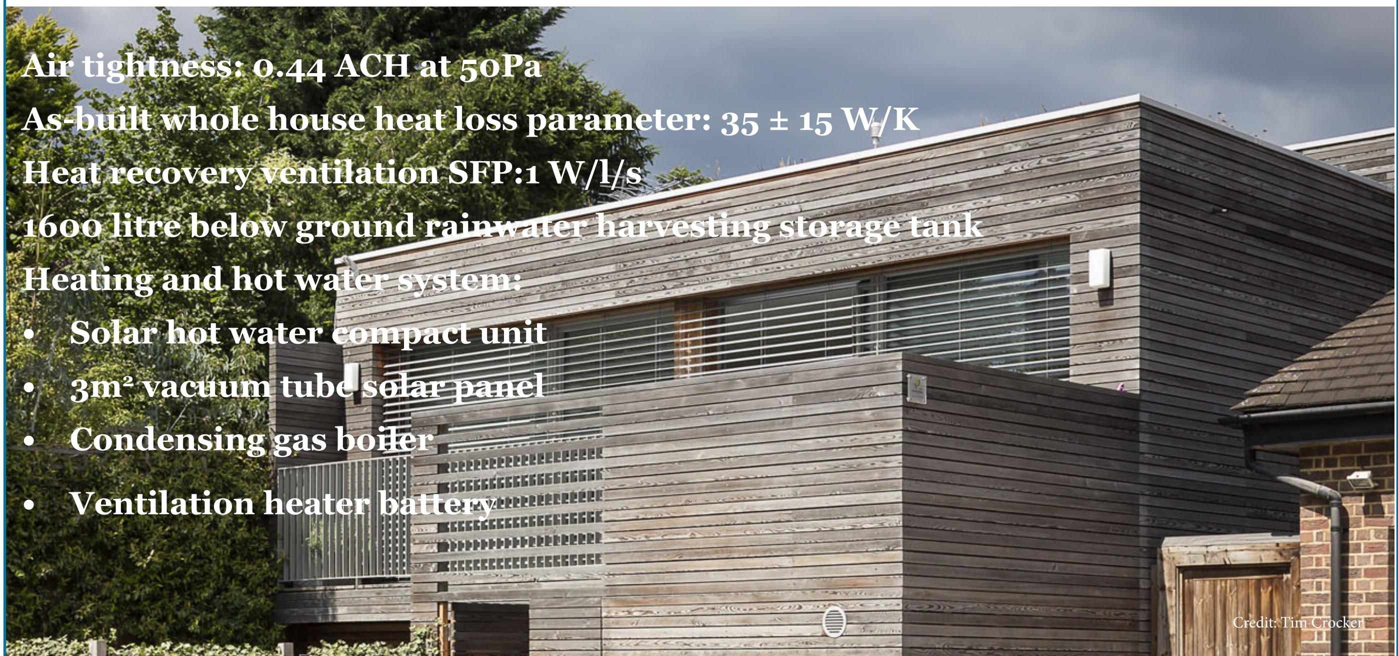
BUILDING PERFORMANCE EVALUATION CASE STUDY
CAMDEN PASSIVHAUS



Delivery Team

Bere:Architects (Architect)
Alan Clarke (Building Services advisor)
Rodrigues Associates (Substructure)
Green Building Store (Ventilation advisor)
Kaufmann Zimmerei (Timber frame suppliers and engineers)
Visco (main contractor) with Dominic Danner (Air-tightness champion)

Building Performance Evaluation Team

University College London
Jason Palmer
Bere:Architects
Good Homes Alliance

bere:architects
Jason Palmer
UCL
Alan Clarke
Technology Strategy Board
Driving Innovation

Good Homes Alliance

The project reported here is part of the Technology Strategy Board's Building Performance Evaluation programme and acknowledgement is made of the financial support provided by that programme. Specific results and their interpretation remain the responsibility of the project team.

This evaluation was conducted under the Technology Strategy Board's Building Performance Evaluation programme. To determine the effectiveness of the design and delivery strategy in Camden Passivhaus, real fabric performance indicators were tested to compare these results with anticipated performance. The project team followed the Technology Strategy Board protocols for fabric and services testing (Phase 1), conducting the following tests:

- Thermographic survey
- In-situ U-value tests
- Air-tightness tests
- Coheating test
- Services commissioning checks

The results from this testing are positive. The building fabric has exceptionally low heat loss in line with design predictions and the occupants are very happy with their house.

Design and Construction

London's first certified Passivhaus dwelling, this 101 m^2 (TFA) two-storey detached house in Camden, north London was completed in the spring of 2010, with the occupants moving in at the end of 2010. The house is built using a prefabricated timber frame, with the ground floor set within a concrete retaining wall, supporting earth at the back and sides of the house.

The procurement route was traditional, with selective tendering. Bere felt it was important that full control over the design was retained once construction began to ensure the airtightness and thermal performance of the building would meet Passivhaus certification standards.

As well as the prospect of low heating bills, the client was interested in good indoor air quality, as his daughter suffers from asthma. Based on both the low energy and good air quality advantages of the Passivhaus model, he agreed to embrace the standard.

The house is occupied by a working couple, who are gone during most of the day. They moved into the house during Christmas 2010 holidays.

The house has two layers of insulation in the walls: 240-280mm of Rockwool Flexi between the timber studs, plus 100mm of natural wood fibre insulation inside the vapour control layer It has 400mm of PIR insulation on the roof and 400mm wood fibre insulation on the floor slab, and an airtightness membrane stapled and taped throughout, designed to achieve an air permeability of 0.6 ACH (at 50Pa).

Camden Passivhaus incorporates heat recovery ventilation (HRV, or MVHR), extremely good insulation and air-tightness, and high performance glazing to create comfortable and healthy conditions, and minimise energy requirements. External automatic blinds were fitted to the large south-west facing windows to reduce the incidence of summer overheating and to provide more privacy.

The general layout is not traditional for homes in the UK. The ground floor consists of two bedrooms with private bathrooms, plus an additional WC, while an open-plan kitchen, dining room and living room are on the first floor. Large windows are essential to the passive solar heating strategy.

The following design targets in Table 1 were set to in order to achieve overarching Passivhaus requirements.

Annual space heating	13 kWh/(m^2a)
Primary energy	99 kWh/(m^2a)
Whole house heat loss	63.6 W/K (PHPP)
Air permeability	≤0.6 ACH at 50Pa
U-value: roof	Flat roof 0.067 W/m^2K, Sloping roof 0.116W/m^2K Terrace 0.139W/m^2K
U-value: walls	Lower 0.125W/m^2K, Upper 0.116W/m^2K
U-value: ground floor	0.103 W/m^2K
U-value: windows	0.76 W/m^2K
U-value: doors	0.78 W/m^2K
MVHR: electrical efficiency	0.36 Wh/m^3
MVHR: heat exchanger efficiency	92%
Boiler efficiency (SEDBUK)	89.4%

Table 1. Design Targets

The heating system is classic Passivhaus, with the heat requirement provided through the air flow of the ventilation system. Supply air from the HRV is ducted to a heater battery which is supplied with heat from a compact solar hot water unit, which has a small integral backup gas boiler. In addition to the heat provided in the ventilation air, the boiler and solar combination also supplies heat to two towel rails in the bathrooms.

Hot water is provided from a cylinder which is an integral part of the Viessmann Vitodens boiler and solar panel system, located in the ground floor utility room. Rainwater harvesting has also been installed, providing irrigation to the south garden and sloping green roof.

The occupants were provided with O&M manuals for the house by the main contractor. Additionally an A1 wall-mounted, pictorial User Guide was provided by the architects, as part of the Soft Landings process.

To meet the stringent air tightness target, the contractor employed an "airtightness champion" to supervise on-site, to make sure the installation of the membrane was provided with a sufficient seal and that all details were constructed as they were designed. The airtightness champion also briefed workers from the construction team about the importance of airtightness.

Real performance

Bere Architects carried out a thermographic survey on the 1st April 2011 during the Coheating test when the indoor spaces were heated to an elevated temperature of 25°C, in order to accentuate cold bridging and make any easier to find. The study revealed at most only a few very minor thermal bridges. Any bridges that were found were expected from design psi calculations.

University College London performed the main fabric testing. They used heat flux meters to look in detail at the thermal performance of the lower walls and floor insulation. They found that both marginally out-performed the design intentions (see Table 2).

Paul Jennings, air leakage specialist at GAIA Aldas, conducted a final airtightness test on completion of the building contract as part of the certification process on 24th March 2010. The test revealed a result of 0.40 m^3/m^2hr at 50 Pa (0.44 ACH at 50 Pa). This value is around a twenty-fifth of the leakage of the minimum required in Building Regulations.

A Coheating test was carried out at the Camden Passivhaus for 13 days between the 20th March and 1st April 2011. A whole house heat loss of 35 ± 15 W/K (ventilation and fabric losses) and 33 ± 12 W/K for fabric losses alone was found. This compares favourably with the designed value of 65.4 W/K (whole house heat loss) and the value of 63.6 W/K for fabric losses alone in the Passivhaus design package (PHPP) and suggests the building is performing within its designed thermal heat loss.

The ventilation unit's Specific Fan Power (SFP) was measured at around 1W/l/s. At a measured 1 W/l/s this exceeds the SAP Appendix Q figure for this particular unit of 0.6 W/l/s but translated to the Passivhaus units of measurement (the testing methods differ as well), the in-use figure of 0.3 Wh/m3 is slightly better than the Passivhaus Institute's tested figure of 0.36 Wh/m3, which was the figure used in the design.

	Predicted	Real
Whole house heat loss coefficient	63.6 W/K (calculated in PHPP)	35 ± 15 W/K for both ventilation and fabric losses
Air permeability	0.6 ACH @50pa	0.40 $m^3/(m^2h)$ and 0.44 ACH at 50 Pa
Ground floor slab	0.103 W/m^2K	0.099 +/-0.013 W/m^2K
Lower Wall	0.125 W/m^2K	0.097 +/-0.020 W/m^2K
Roof	0.067 W/m^2K	Not tested to avoid damaging ceiling finishes

Table 2. Closing the Performance Gap.

The occupant semi-structured interview, combined with the walkthrough, was carried out on the 20th of July 2011, with one of the two occupants. Bere architect Sarah Lewis also participated in the walkthrough, asking the occupant questions and giving suggestions how the house can be used in a more efficient and user-friendly way.

The occupants like the aesthetics of the house and are happy with room sizes, but stated that the house may not be large enough if in the future they were to have a family with two children or more. The occupant considers the house to be easy to maintain. She understands and is satisfied with the ventilation system and is aware that the filters in the HRV unit need to be changed regularly.

The Camden Passivhaus scored very well in the Building Use Survey (BUS), although results are different from most BUS studies because only one person (out of two living there) completed the survey. The occupant appears to be happy with nearly all aspects of thermal comfort, with only some concern about the summertime temperature. The respondent said: “Gets too hot at night - can leave window open but then no control of temperature so may get too cold.”

Key Observations

1. The design and detailing have achieved a high standard of air tightness and heat loss, greatly improving upon Building Regulations standards.
2. Thermography indicated that the building has no unexpected cold bridging.
3. The heat recovery ventilation system was designed and commissioned to a high standard and appears to be performing correctly.
4. Better skills and coordination are needed in the construction supply chain concerning Passivhaus standards in order to help lower the cost of Passivhaus delivery.
5. Having a dedicated airtightness champion or a person with Passivhaus experience on site was invaluable.
6. Balancing the heating is much more difficult in a home with MVHR, when heat is provided along with fresh air, but was achieved on this project.
7. The filters for the MVHR were visibly dirty after six months’ use and were replaced.

Key Lessons Learned

1. To help with the uptake of new construction skills, it helps if the architect takes an active role on site and assists in knowledge transfer to the site team.
2. Making the air barrier explicit on drawings helps reduce errors on site.
3. Owners should try to elect designers and contractors with sufficient experience or understanding of Passivhaus if they wish to achieve certification of their project, as design and site work requires meticulous detailing and execution, and greater site supervision than usual.
4. Contractors on Passivhaus projects must have high quality site management and supervision in place to meet the demanding standards of airtightness and insulation. Construction of Passivhaus projects requires a different attitude on site.
5. Providing a straightforward manual for occupants, beyond standard manuals, is helpful for occupants.

The Technology Strategy Board is a business-led executive non-departmental public body, established by the Government. Its role is to promote and support research into, and development and exploitation of, technology and innovation for the benefit of UK business, in order to increase economic growth and improve the quality of life. It is sponsored by the Department for Business, Innovation and Skills (BIS). T: 01793 442700 www.innovateuk.org