Helpu Cymru i leihau ei Hôl Troed Carbon
Help Wales reduce its Carbon Footprint

Case Study 03

Llywodraeth Cymru
Welsh Government

Welsh Future Homes

www.cymru.gov.uk

Developer:
United Welsh Housing Association

Architect:
bere:architects

Location:
Ebbw Vale, Wales

Building Types:
Residential Community

Project Description

The Welsh Future Homes project is located in a former steel works site in Ebbw Vale and comprises affordable low carbon prototype homes. These consist of one certified Passivhaus code 6, zero carbon home, one certified Passivhaus code 5 home, a low carbon 'dragon board' home and a low carbon 'Ty Unnos' home currently used as a visitor centre. The development was built as a prototype for future social housing in Wales. The development is a partnership project between BRE Wales, the Welsh Government, Blaenau Gwent Council and United Welsh Housing Association.

The Larch House, designed to Level 6 of the Code for Sustainable Homes (CSH), is the first of its kind in Wales.

Key Drivers

The project forms part of larger sustainable regeneration proposals for an area of 200 acres at the former Ebbw Vale steel works, which aims for a 60% reduction in carbon dioxide emissions against Building Regulations across the development. Key drivers for the Welsh Future Homes project include:

- The creation of "The Welsh Passive House";
- The determination of what is the most suitable approach to deliver a low energy/low carbon house in Wales, accounting for local natural resources, climate and geography;
- Compliance with Welsh Government's target for all buildings built from 2011 to meet CSH Level 5;
- Compliance with the Development Quality Requirements (DQR) standard for social housing and the requirements of the United Welsh Housing Association; and
- Establishment of realistic and achievable concepts that demonstrate how Passivhaus compliance can be delivered in low cost housing.

Conceptual model of The Larch House, Ebbw Vale. Reproduced with permission of bere:architects

Renewable & Low Carbon Technologies

- Passivhaus
- Photovoltaic array
- Solar Hot Water collectors

"If we are to have any real chance at de–carbonising the UK grid, we must firstly reduce our energy consumption and then utilise renewable generation to meet demand."
Justin Bere
bere:architects

Key features

Two of the four dwellings have been certified to achieve the Passivhaus standard (The Larch House and The Lime House). Key features of these two homes include:

- 'Fabric first' approach to energy efficiency;
- Roof mounted photovoltaic (PV) arrays (4.6 kW on Larch House, 2.5 kW on Lime House);
- Solar thermal glazed flat plate collectors (GFPC);
- Mechanical Ventilation with Heat Recovery (MVHR); and
- Both dwellings are built and certified to the Passivhaus standard; they are highly insulated and free from draughts and cold bridges.

Passivhaus Standard

A Passivhaus uses internal and external heat gain, as well as heat recovery ventilation (over 90% efficient) to provide almost all of the heat needed in the winter months. Because the demand is so low, any supplementary heat can be met by pre–heating the trickle of air provided to meet hygiene ventilation. Put simplistically, to achieve Passivhaus certification, the dwelling needs to meet, amongst other things, the following, but the details will vary according to a number of factors, including location, orientation, horizon line, size and shape of building:

- Opaque u values < 0.15 $W/m^2.K$
- Space heating demand <15 kWh/m^2
- Window/doors overall U values (including frames) < 0.8 $W/m^2.K$
- Minimal thermal bridging
- Airtightness <0.6 air changes per hour at 50 Pa
- MVHR achieves 75% heat recovery or better (in practice over 90% is normally required).
- Primary energy demand including unregulated energy <120 kWh/m^2.

A Passivhaus uses little or no energy to heat or cool itself, relying on maximum insulation and draught free construction, amongst other factors, to retain heat generated by the building occupants.

Other sustainable features of the development include:

- A low energy visitor centre, designed to consume energy at a rate of no more than 18 kWh/m^2/year; and
- A three bedroom dwelling constructed to meet CSH Level 5 using innovative 'dragon board', with a roof mounted PV array.

Procurement

The Welsh Future Homes project was initiated through a competition launched by Welsh Government and Blaenau Gwent Council in association with the Building Research Establishment (BRE).

A key aim of the winning project teams' designs was to maximize the use of locally sourced building materials and components. The dwellings are constructed using between 80% and 90% of materials sourced from Wales, including the claddings and timber frames. The photovoltaic arrays were procured from Sharp in Wrexham, with solar hot water panels made by Filsol in Camarthenshire.

Due to the limited examples of Passivhaus dwellings currently in the UK, very few UK manufacturers make Passivhaus certified products. Prior to the development of the Welsh Future Homes, there were no window manufacturers able to provide Passivhaus certified windows.

A team consisting of German window manufacturer Bayer, bere:architects and an independent window designer, collaborated to specify, design, certify and guide in the construction and installation of Passivhaus certified windows made and installed by Welsh contractors, in Wales.

Scheme costs and finance

The average cost of social housing constructed to CSH Level 3 is £1,200 per m^2, excluding solar thermal and photovoltaic panels. The build costs of the two "one–off" Passivhaus dwellings, Larch House and Lime House, including the cost of all the solar panels were £1736/m^2 and £1467/m^2 respectively. The increased expense was almost entirely due to the integration of PV arrays, which were included to show that a Passivhaus building, due to its extremely efficient fabric, can achieve zero carbon code 6 or code 5 using only panels that fit on a small area of roof.

High performance triple glazed windows and MVHR systems also added to the cost, but the omission of a central heating system and radiators, as well as an extremely cost effective timber frame saved costs. Forecasted costs for a terrace of two–bed "Lime Houses" have been calculated, using costs derived from the prototypes, at around £1250/m^2, which is very close to the average of £1200/m^2 for a building regulation house.

Funding for the project came from the Heads of the Valleys Programme, funded by the EU, and Blaenau Gwent Council.

The operational energy costs of the two Passivhaus dwellings are significantly lower than other dwellings, at an annual cost of as low as £50 for a two bed dwelling. The figure overleaf provides comparative running costs for the Larch House.

A comparison of capital payback periods and whole life costs was undertaken by bere:architects, for Passivhaus dwellings and dwellings built to be compliant with Part L of the Building Regulations 2006. It was found that even without installation of PV systems, a Passivhaus became less expensive than a Building Regulations dwelling after just 23 years.

Lime House
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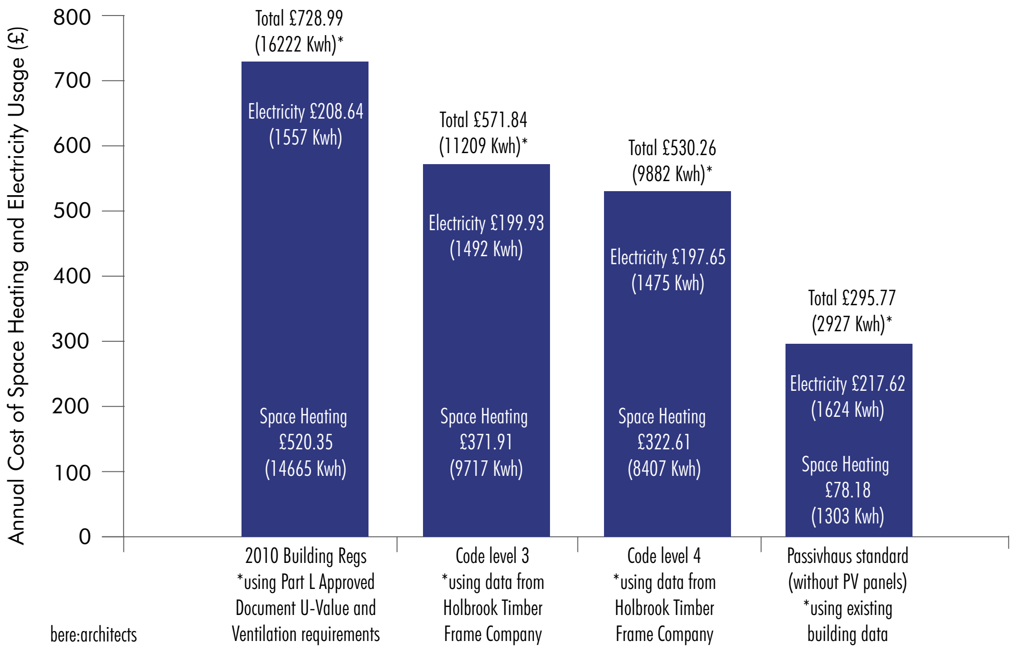

Comparative operational costs of 3 bed Welsh PassivHaus against Part L Building Regulations and Code for Sustainable Homes Levels 3 and 4. Diagram reproduced and adapted with permission of bere:architects.

Technology selection process

Given the aspiration for Passivhaus standard dwellings, and the precautionary decision to design for 10 year worst–case weather data, primary objectives of the Larch House and Lime House included insulation (achieving U values of 0.095 for walls, 0.074 for roof, and 0.076 for ground floor), and airtightness (at 0.2 air changes per hour at 50 Pa). The airtightness achieved made a considerable improvement on the Passivhaus requirement of <0.6 air changes per hour.

Due to the very high levels of insulation and airtightness, the space heating for a Passivhaus is very low. Consequently, the only technologies viable for the Welsh Future Homes development were those associated with hot water and electricity provision. The complimentary technologies of solar thermal and solar PV were therefore selected as suitable technologies for the development.

The location of the Ebbw Vale site, at 300 m above sea level, with cold winters and high levels of mist and humidity throughout the year, was a very challenging environment in which to achieve Passivhaus standard. Typically, Passivhaus design criteria such as insulation specifications are based on average local weather data. However, due to the unusually misty, exposed climate of Ebbw Vale, it was required by the BRE as a precaution, that worse weather data was used based on a 1 in 10 year weather event. This resulted in increased fabric insulation thickness of approximately 100 mm. Building performance during the extreme conditions of winter 2010–11 has confirmed that the extra cost of worst–case weather data is not necessary. This decision will save thousands of pounds in build costs for future developments and risks only 100 watts additional power requirement in a worst–case weather event.

Achieving an efficient thermal envelope significantly reduces the space heating demands of the building such that much of the space heating in the Passivhaus is provided by the occupants themselves. We generate heat by performing everyday domestic activities, such as cooking, watching television, in addition to simply radiating body heat. The highly insulating Passivhaus envelope allows this heat to be retained and captured by the fresh air ventilation, thus maintaining a warm indoor environment.

As dwellings built to Passivhaus standard are extremely draught–free, MVHR is used in winter to achieve an extremely high quality of indoor air (typically around 1000 ppm CO_2, which is an improvement on most ordinary houses). Fresh air is supplied from outside and warmed by a heat exchanger, which derives its warmth from outgoing stale air.

A solar thermal hot water system with a back–up gas boiler was selected to provide domestic hot water for the homes. The solar thermal water panels provide approximately 65% of the hot water demand. Domestic hot water is pre–heated by the SHW system, with temperature top–up provided when needed by the gas boiler. The solar hot water (SHW) system was sized to prevent summer over–heating of the water in a simple system without a temperature–regulating mixing valve. The contribution of The Larch House SHW system to total heat demand is shown in the graph overleaf.

As Larch and Lime houses were designed as social housing, the floorplans are very compact, at between and 69 m^2 and 87 m^2. Consequently, available space is limited and so no thermal stores have been installed.

The PV arrays were sized to theoretically fully meet the electricity demands of the dwellings. 12 No. 210 W polycrystalline PV panels were installed on the roof of Lime House, while 16 No. 235 W panels and 3 No. 210 W panels were installed on the roof of Larch House.

Monitoring and operation

The aim for the homes was to deliver a 75–85% carbon dioxide (CO_2) emissions reduction compared to a house built in line with Part L of Building Regulations 2006. Under credit Ene 1 of the CSH, the Larch House achieves a 146% reduction on the dwelling emission rate compared to a home compliant with Building Regulations, while the Lime House achieves a 100% reduction. The dwelling emissions rate is a unit rate of annual CO_2 emissions for a dwelling, measured in kilograms of CO_2 emitted per m^2 of internal floor area.

The annual carbon dioxide emissions for both The Larch House and Lime House are shown in the table below, calculated by a Standard Assessment Procedure (SAP) assessor to demonstrate compliance with CSH.

The Larch House, Ebbw Vale.
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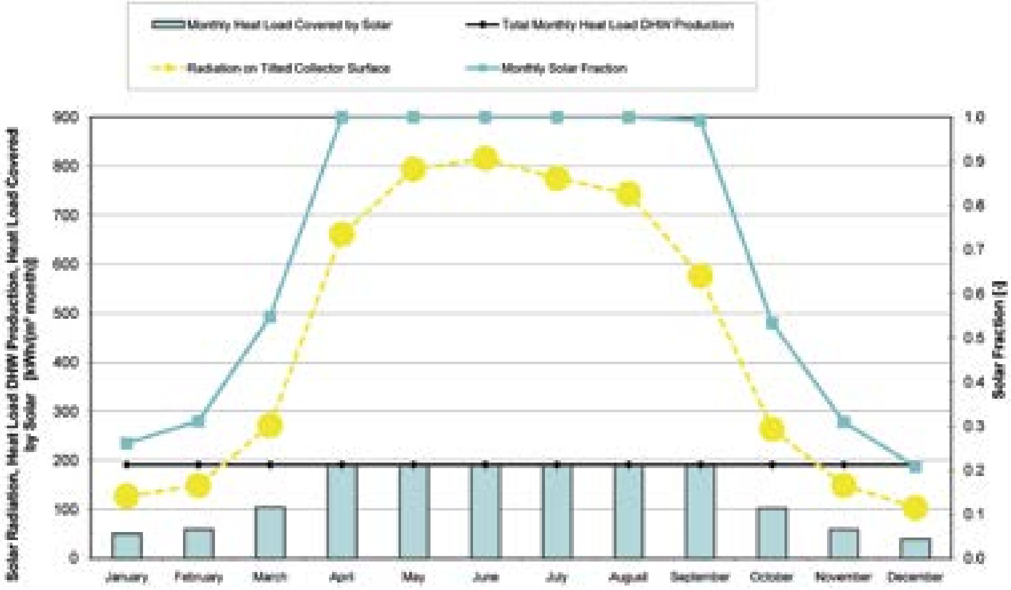
It should be noted that SAP calculates kg CO_2/m^2/annum to include only the emissions as regulated under UK Building Regulations – Part L i.e. heating, hot water, pumps and fans, and fixed lighting. The Passivhaus Planning Package (PHPP) calculates kg CO_2/m^2/annum to include both 'regulated emissions' as above, and the remaining 'unregulated emissions' i.e consumer electronics and household appliances.
Larch House was designed to be truly zero carbon, for both regulated and unregulated emissions.

The homes were initially used as showhomes for one year, acting as an educational resource for visitors to the Ebbw Vale site. In September 2011, United Welsh took control of the two dwellings and it is proposed for tenants to occupy the homes before December 2011.

Operational monitoring of the two homes is being measured by the University of Cardiff. Both homes are currently operating in line with their design specification, and consumption of energy is as anticipated. The PV array has reportedly been performing well, with electricity generation at between 4.5 kW and 4.7 kW on sunny days.

Dwelling	CO_2 emissions from an equivalent Part L 2006 compliant dwelling (kg CO_2/year)	CO_2 emissions reductions		Net CO_2 emissions (kg CO_2/year)	Percentage reduction in CO_2 emissions from LZC technologies
		Solar hot water (heat generation)	Solar PV (electricity generation)		
The Larch House	2668.63	382.38	2178.03	139.87	94%
The Lime House	2352.79	351.30	929.70	1103.44	53%

Summary table showing the reduction in carbon dioxide emissions from LZC technologies in Passivhaus dwellings
Data sourced from bere:architects (SAP Design Assessment reports)



Lessons learnt

Technological issues:

Achieving truly "locally" sourced materials can be challenging, due to imported components.

It has been recommended that in order to accurately design Passivhaus dwellings suitable for particular local UK environments, a close matrix of weather station data is required due to the large variations in local weather conditions over short distances. Consideration should be given of the true benefits of designing to adverse weather conditions compared to average conditions at an early design stage of the project. Experience gained from Ebbw Vale confirms German experience that Passivhaus buildings can safely be designed to average weather conditions.

When selecting SHW systems, a study should be made to assess the comparative advantages of installing a larger SHW system (i.e. 100% of hot water demand) with a mixer valve to prevent scalding, over installing a smaller system (e.g. to meet 65% of demand) with no mixer valve.

Financial lessons:

After construction of The Larch House, it was decided to save money in the Lime House, by reducing the size of the windows, compensating by other fabric measures to achieve Passivhaus certification. The difference between the two approaches was highlighted by using worst–case weather data and this decision significantly reduced the build cost of the second house. With normal weather data, the difference between the two approaches would be less marked.

Awards and Achievements

- The Larch House is the first Welsh social housing dwelling to achieve Passivhaus certification;
- Winner of Sustainability Category at the Royal Institute of Chartered Surveyors (RICS) Wales 2011 awards;
- Winner at Constructing Excellence Wales Awards 2011;
- Selected as Constructing Excellence Wales Exemplar, 2011;
- Shortlisted in Sustainable Housing Awards 2011;
- Currently shortlisted in RICS National Awards 2011;
- Currently shortlisted in Energy Awards 2011;

- Currently shortlisted in UK Constructing Excellence Awards 2011; and
- Finalist in Increasing Environmental Sustainability category at Welsh Housing Awards 2010.

References and Acknowledgements

Justin Bere, Director, bere:architects

Further information

Low Energy Buildings Database
www.retrofitforthefuture.org/

Sharp Solar Centre at
www.sharpmanufacturing.co.uk/sukm
Filsol Solar at www.filsol.co.uk/

These case studies are presented to show examples of how buildings can be designed and built to be low carbon and incorporate renewable and low carbon technologies. This case study is part of a series of case studies supporting a separate practice guidance document on low carbon buildings. **For further information see www.wales.gov.uk/planning**

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