

460: Zero Carbon by 2011: Delivering Sustainable Affordable Homes in Wales

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Abstract

As the Stern Review on climate change reported, more than a quarter of the UK's carbon dioxide emissions come from the energy used to heat, light and run homes. In order to tackle this problem, the UK government has committed itself to achieving zero carbon standards for all new homes by 2016, the most exacting target found anywhere in the world. In February 2007 the devolved Welsh Assembly Government (WAG) announced that all new buildings funded by the Assembly will need to achieve Zero Carbon by 2011 five years earlier. The standards of the current assessment tool employed by the Welsh Assembly is still a long way short of the zero carbon goal, therefore the imminent replacement of this for the BRE Code for Sustainable Homes, signifies a step-change in housing construction in order to achieve zero carbon homes. The delivery of homes at this level by 2011 will require considerable economic and political support and will need a reinvestigation of the form, orientation, construction and materials used. It is currently unknown how the industry will respond to these changes, or if the Code for Sustainable Homes offers the best method of changing perceptions and mindsets. Through case studies the paper will demonstrate a way of achieving the integrated design of zero carbon housing in Wales through collaborative processes. Working with environmental research engineers, manufacturers, registered social landlords and government offers a holistic approach to sustainable design. This is not based on a tick-box approach to design but an understanding of all aspects of sustainability. Case studies will assess the success of this approach and offer an insight into the viability of achieving zero carbon in Wales by 2011.

Keywords: housing, zero carbon, energy

1.0 Introduction

"Climate change represents a potentially catastrophic threat, but it is within our control to address it – and address it we must."ⁱ

The Stern Review of the Economics of Climate Changeⁱⁱ demonstrated that there is overwhelming clear evidence of climate change and that it presents a serious global risk demanding an urgent global response. The review recommended strong and deliberate policy action in order to motivate carbon emission reduction. In 2004, emissions from buildings account for over half of the 150 million tonnes of carbon dioxideⁱⁱⁱ emitted in the UK. More than a quarter of this came from the energy used for running, heating and lighting homes. In order to tackle this problem, the UK government has committed itself to achieving zero carbon standards for all new government funded homes by 2016.

In February 2007 the devolved Welsh Assembly Government (WAG) announced that all new buildings funded by the Assembly will need to achieve Zero Carbon by 2011. This paper aims to examine the potential of the Welsh construction industry to respond to the political drive for zero carbon homes. Initially, drivers from government

policy will be examined, and the assessment method proposed for zero carbon assessed. Case studies from Design Research Unit Wales (DRU^w) will then be used to demonstrate a possible direction for the creation of affordable, sustainable homes in Wales.

1.1 Achieving zero carbon social housing in the UK

The UK Government has promoted three tools to achieve the zero carbon goal by 2016: National planning policy, which regulates the location and design of development; the Building Regulations, applying to England and Wales, which addresses conservation of fuel and power, health and safety, and accessibility; and BRE Code for Sustainable Homes, which measures sustainability in new build housing. The aim is to use these policies to demonstrate a clear framework in which zero carbon housing can be procured and delivered. The integration of policy into these documents and the progressive tightening of regulations will aim to gradually ramp up towards the carbon neutral target. While England is developing tools to achieve zero carbon, since the WAG announcement fast-tracking this deadline there has been no clarity in how WAG defines zero carbon, or how this is likely to be achieved.

1.2 Measuring sustainability

In April 2007 the BRE Code for Sustainable Homes was adopted as the required method for the assessment of the sustainability of new government funded housing in England. The Code is a 'whole house' environmental assessment method which contains mandatory performance levels in 7 key areas: Energy efficiency, Water efficiency, Surface water management, Site Waste Management, Household Waste Management, Use of Materials and Lifetime homes. A development is rated from levels 1 to 6 where Level 1 represents an entry level home, built to a small margin above building regulation standards, while 6 is a zero carbon home. The Code for Sustainable Homes states that 'a Zero Carbon Home is 'where net carbon dioxide emissions resulting from all energy used in the dwelling are zero or better. This includes the energy consumed in the operation of the space heating/cooling and hot-water systems, ventilation, all internal lighting cooking and all electrical appliances.'^{iv} It also states that a 'zero carbon home is required to have a Heat Loss Parameter (covering walls, windows, air tightness and other building design issues) of 0.8 W/ m²K or less, and net zero carbon dioxide emissions from use of appliances and cooking in the home on average over a year.'^{iv} It will use no more than 80 litres of water per person per day, of which a minimum 30 percent will be provided by rainwater or grey water harvesting.

All new build government funded housing in England has to be measured through the Code, and in order to receive grant funding will have to reach a certain prescribed level. This level will be gradually increased towards the deadline for zero carbon, at which time houses will have to reach Code level 5 as a minimum. To date, there are only one-off prototypes and demonstration homes, such as the Lighthouse by Sheppard Robson Architects and Barratt Homes Green House, which have achieved this high rating.

1.2.1 BRE's EcoHomes Assessment Method

While England has adopted the Code to measure the sustainability of housing, the Welsh Assembly Government currently uses the BRE EcoHomes assessment method. The predecessor to the Code for Sustainable Homes, EcoHomes is a credit based assessment, with points awarded for credits covering ecology, energy, transport and pollution. An 'excellent' rating, the highest possible, is still a long way short of zero carbon and equates to a Code level of between 3 and 4. There has been no public announcement of the replacement of EcoHomes with the Code for Sustainable Homes to date, although it is expected that the Code will be the preferred assessment method. While not yet formalised, Wales is likely to follow the lead of England and set increasing Code levels that have to be gained in order to secure funding. However, for the purposes of this paper, case studies have been assessed against current WAG policy and not using the Code.

While EcoHomes offers a useful tool for the assessment of homes, its use has been found to be problematic in some situations. Credits relating to site, amenities and transport are predetermined, but constitute sufficient percentage of the final score to be the difference between grades. This has proven to be problematic in Wales, where sites that Housing Associations can afford to develop tend to be rural or on the edge of settlements. Away from the coast much of Wales is rural in character; without any credits from the site it has proven difficult to achieve an 'excellent' rating in these locations. Although these sections of EcoHomes are useful to assess the overall sustainability of a development, the adoption of the Code, with its emphasis on energy and building fabric, will focus the assessment of new housing on zero carbon construction.

1.3 Building Regulations

The building regulations, which apply to all new buildings, will be amended to assist in achieving zero carbon housing. The Building Regulations Part L covering Conservation of Fuel and Power will feature increasingly high targets for energy reduction in the run up to 2016, achievable primarily through improvement of building fabric and through energy efficient heating and lighting. By 2010 regulations will require a 25% saving in energy use over current regulations; by 2013 this will increase to 44% and by 2016 will require net zero carbon energy production. These targets will apply to both England and Wales; the Building Regulations are not currently under the jurisdiction of WAG and in order to amend these to suit the accelerated Welsh timeframe they will need to be devolved to the Welsh Assembly if WAG intends to use them to achieve zero carbon.

1.4 Development Quality Requirements

The Welsh Assembly Government uses Development Quality Requirements to ensure minimum standards are achieved in all government funded housing. Alongside comprehensive standards covering safety, space standards and security is a pattern book of standard house types which meet all the requirements set out in the document. These are based upon traditional house types and variations from these have to be individually assessed by WAG to ensure they meet the required standards, which can be a lengthy process. Experience of working with pattern book housing shows that it is extremely difficult to convert the pattern book home into a sustainable home as significant criteria are already predetermined.

2.0 Case studies

Since 2001 Design Research Unit Wales at the Welsh School of Architecture has been involved in the design of sustainable social housing. The following case studies illustrate both the potential to deliver zero carbon housing and barriers that may stand in the way of this goal.

2.1 Cydwelli, Carmarthenshire

Design Research Unit Wales was asked by Gwalia housing Association to assess an 18 unit housing scheme in Cydwelli, South Wales with a view to increasing its environmental credentials. The proposed scheme was planned as a cul-de-sac around which a mix of one bed flats and two bed and three bed houses were clustered. DRU^W assessed the scheme to reduce its environmental impact, to increase the EcoHomes rating, to increase levels of prefabrication, and to improve the overall design quality.

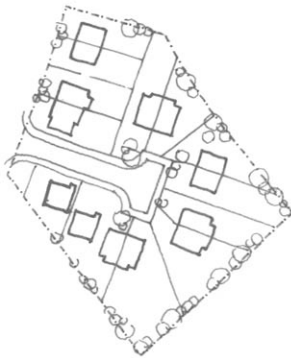


Fig 1: Cydwelli: Original pattern book site layout

When a pre assessment was carried out on the original scheme it achieved an EcoHomes rating of 'good' with projected dwelling emissions, derived from a SAP rating, of less than or equal to 24kg/m²/year. It was also suggested that this original scheme would not meet the minimum recommended airtightness of less than or equal to 1.3 W/m²/k. The emissions rate is a key factor in striving towards zero carbon and a significant part of the energy credits in the EcoHomes assessment.

The scheme had been designed to a standard cul-de-sac layout which did not maximise the benefits of orientation and form to achieve a passive environmental strategy. DRU^W studied the potential for improving the orientation of the dwellings to maximise solar gains. The existing semi-detached houses were grouped into terraces to minimise external wall area.



Fig 2: Cydwelli: Rationalised site layout

The original scheme was designed as an open timber frame with a brick external skin, both to be constructed traditionally on site. The

programmatic benefits of using timber frame, such as the potential for faster on site construction, are negated by the use of a wet trade such as brick. This affects airtightness, as there are numerous component connections to be made. It was suggested that a panellised system such as a closed or advanced timber panel be used with an increased stud depth from 140mm to 200mm to increase insulation as well as an insulated render as external cladding. This offers benefits of increased airtightness due to the construction of larger panel sizes to finer tolerances, which minimises the potential for air leakage. This would aim for a dwelling emission rate of less than 18kg/m²/yr.

Daylighting internal spaces within the house plan is important both for the well being of the occupants as well as to reduce the energy load by reducing the need for electrical lighting. The windows on the original scheme had a fairly small overall area, particularly at the kitchen where a daylight factor of 2% is suggested for occupant comfort. Key windows were adjusted in size as much as possible within the restrictions of the planning approval, to maximise the amount of natural light across the dwelling.

There was an interest from the developer to improve the overall energy rating of the scheme by offsetting energy consumption with renewable resources such as solar water heating and rain water harvesting.

2.1.1 Outcome

Due to grant funding procedure and planning approval on the original scheme, the overall layout, orientation and density could not be significantly altered. This meant that a strategy that was more conducive to passive strategy could not be developed. As Housing Associations have limited funding for all of their developments this has an impact on how a scheme can be improved. Due to the cost implications of the increase in wall depth and insulation and the implementation of an off site technology and the lack of experience of the developer these changes were not realised. Unfortunately as is the case with many housing associations, the cost of renewable technologies and the difficulty in getting extra funding mitigated their use on this scheme and only rainwater harvesting remained to store water for use in the gardens.

Negotiations with WAG could not secure the funding necessary to improve the environmental credentials of the scheme, and minimal changes were made to the design. Throughout the process the main barrier to change was cost but the lack of knowledge of new construction systems and renewable energy technologies also played apart. However, minor alterations were made, such as the use of Warmcell recycled newspaper insulation, Accoya treated timber windows and modified fenestration layouts to maximise solar gain.

It is clear from this project that the design and construction of social housing will need to be reassessed in order to achieve a cost effective zero carbon solution. The step change can not be achieved by merely applying renewable technology to pattern book housing, as was tried here, but needs to be a reinvestigation of form, orientation, construction and materials. This will have to be implemented from the start of a project, as it was evident with the Cydweli case study that trying to alter the design at a later date increases the costs exponentially. It is currently unknown how the industry will respond to these changes, or how the distribution of Social Housing Grant funding will reflect the increasing standards required by WAG.

Approaching zero carbon building is more successful when approached from the outset of a scheme. Taking into consideration site topography, orientation and required density of the development gives an effective starting point where passive strategies may be employed from the beginning enhancing the environmental strategy of the scheme. To achieve zero carbon a holistic approach needs to be taken where everything from maximising daylighting to the airtightness of the building fabric to renewable energy sources are all considered as part of a complete package of measures. The following case studies will investigate how this may be achieved.

2.2 SHIP housing, Gorseinnon,

For a long time Gwalia Housing Association has been leading the development of zero carbon housing in Wales. In 2003 Design Research Unit Wales was approached by the Association to partner on a research and pilot project for low energy housing funded by the Welsh Assembly Government's Social Housing Innovation Programme (SHIP). The intention was to combine the latest passive and active systems with new or prefabricated construction methods to provide a best practice, repeatable project for Wales and the UK.

The site for the scheme was a remediated brownfield in Gorseinnon, outside Swansea in South Wales. The proposal of houses off east-west oriented mews lanes offered the opportunity to maximise passive design. Instead of a traditional street arrangement of houses facing across the street, houses are all oriented to allow south facing gardens and living rooms, while car parking and entrance are to the north. Three terraces of houses are arranged in this manner; there are no detached or semi detached houses, in order to minimise external wall area. This allows the house to 'wrap up warm and face south'; the northern elevation is characterised by small openings into service areas, minimising heat loss. In contrast, the southern elevation is almost fully glazed and uses a solar buffer to assist heat retention in winter and for passive stack ventilation during summer months. Good

levels of daylight are provided to habitable rooms through side-lighting where possible and to the core through top-lighting. Both active and passive modes of ventilation are used depending on seasonal requirements.

The housing is based on a rationalised house plan founded on a spatial and technological system commonly used in office design of shell, core and fit-out. The spatial zoning allows for clear distinction between served and servant spaces and these constructional distinctions allow flexibility in room arrangements and a range of levels of fit-out can be offered through 'late configuration'. All materials for the house are sourced from within thirty miles of the site, and it aims to be a 100% recyclable construction through dry bolted or screwed construction and use of 'green' wires and cables. Wet trades are avoided as much as possible to both maximise recyclability and to reduce time on site.



Fig 3: SHIP house type, showing rationalised ground and first floor plans

Facades are clad in locally grown timber with a standing seam roof to maximise the potential time savings of dry construction. The house type developed for Gorseinnon was approved under Development Quality Requirements after extensive discussion with WAG Housing Directorate. Although the house types were 20% over the recommended floor area, it was agreed that the passive strategy necessitated this addition, and that it would not function effectively if reduced.

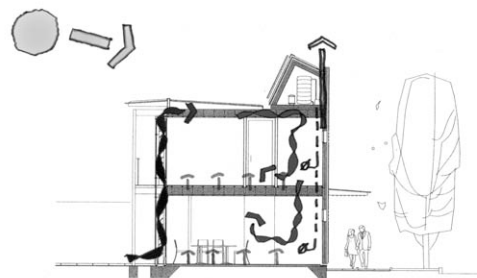
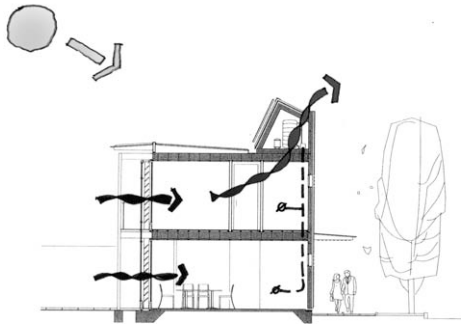


Fig 4: SHIP sustainable strategy: summer



A Fig 5: SHIP sustainable strategy: winter to provide a zero energy or at least carbon neutral response. The prefabricated module can carry a combination of solar water heating, photovoltaic cells, local wind-turbines, and heat exchangers, as well as providing storage of rainwater and grey-water management. In addition rainwater harvesting and treatment and reuse of grey water minimises reliance on mains water service.

Modelling of the design showed that combination of building fabric improvements and the energy pack could offer a design heat loss of 1KW, making the house close to zero carbon.



Fig 6: SHIP site section with roof mounted energy packs

2.2.1 Outcome

The project suffered a loss of funding at planning stage and the majority of the sustainable features of the house were removed. The scheme was built to the house plan developed, but with tiled pitched roofs and fully rendered facades. Glazing areas were reduced considerably, and the solar buffer removed. While an improvement on standard pattern book social housing, the scheme reach none of its goals for sustainable design.

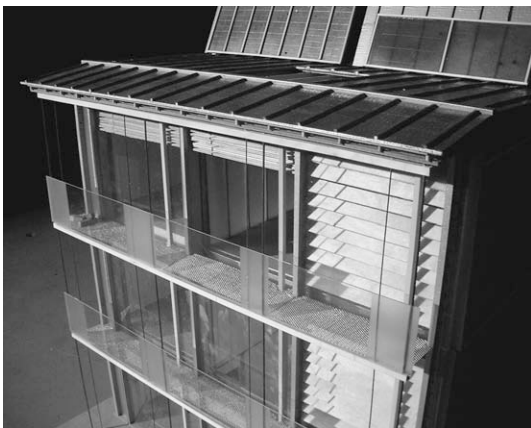


Fig 7: SHIP south façade with solar buffer

Following the SHIP housing project, Gwalia have asked DRU^w to advise on the delivery of 'zero carbon' housing on a site in Neath. This development of the SHIP house type aims to achieve the highest Code for Sustainable Homes rating achieved to date in Wales. The scheme is for 16 social houses, a mix of two and three bed houses and flats, on a difficult site on the outskirts of Neath. The site is a north facing slope and is a fraction of a larger masterplan including private houses and a hostel for the homeless. This project is under development at the present and it is hoped that the principles of the SHIP housing can be maintained, including the roof pod and rationalised construction system.

2.3 Housing at St Athan

In 2007 Design Research Unit Wales were asked by Wales and West Housing Association to develop a scheme for 17 homes in St Athan outside Cardiff. The brief required a mix of 2, 3 and 4 bed dwellings, both flats and houses. From an initial massing study using pattern book house types and footprints, rationalised site layouts were investigated that standardised all house types as much as possible into East-west terraces. The orientation of the site, with its long south aspect, offered the potential to create terraces of houses which make use of passive environmental strategies as well as offering the possibility of using renewable energy sources.

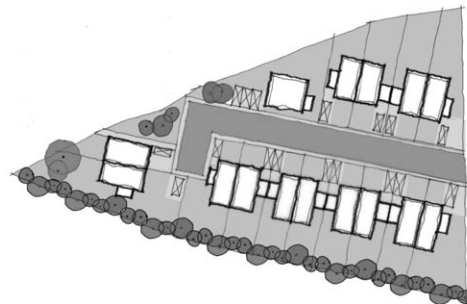


Fig 8: St Athan rationalised site plan

The site plan is based on a single access lane through the site, running east-west, with a traditional street arrangement of facing houses. A mix of terraced- and semi-detached houses line the street. These narrow aspect houses are designed to be standardised in depth across all house types, with minimal change in width between houses of different sizes. This includes the use of roof spaces in larger homes, which offers additional EcoHomes points. House types develop the SHIP house type and are designed to rationalise zoning by placing heavily served spaces such as kitchen, bathroom, and WC along a service wall. On the street, an external bin and bike store are clipped onto the house, adding EcoHomes points to the development.

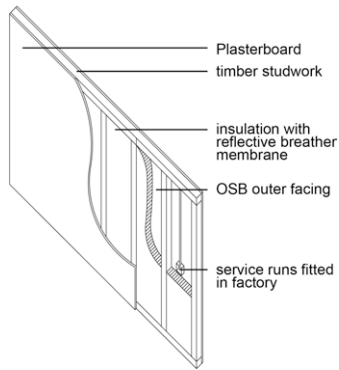


Fig 9: Advanced timber panel

An initial pre-assessment by an independent assessor suggested that CO₂ emissions of between 15-18g/m²/yr could be achieved. This relates to Code level 3. This can be achieved primarily through building fabric improvements with a suggested 6% improvement to Building Regulations target U values. Increasing the airtightness of building fabric to 3m³/h/m², as well as this improvement over target U values significantly improves the heat loss parameter to a proposed target of less than 1.1kg/m²/kwh. The client expressed a preference for using an advanced timber frame construction system, which offers the potential benefits of increased airtightness, reduced waste, and decreased time on site. A super insulated advanced timber panel using a reflective building paper was chosen as the preferred construction method. Using this advanced panel system where the envelope of the building arrives on site as large panels with internal services and finishes as well as the possibility of external finishes means that there are less connections to be made, reducing the amount of possible gaps within the construction. This method will improve the efficiency of the building fabric; in addition carbon consumption will be further offset using certain efficient renewable systems such as solar water heating and photovoltaic cells. This offers the potential to reach an EcoHomes excellent rating.

2.3.1 Outcome

The aim of the project has been to achieve a high environmental performance while driving as much construction as possible off site. A low energy design has been achieved primarily through improvements in building fabric, form and renewable energy. All these items have a cost implication associated, which needs to be recognised by government funding bodies. While the scheme is currently at planning stage, the scheme has secured Social Housing Grant for all the proposed measures and discussion to deliver a Welsh advanced timber panel is ongoing.

This case study demonstrates that sustainable housing is achievable in Wales in a form that should be acceptable to both the public and funding bodies. While still a long way from zero carbon, this project demonstrates a direction for a

repeatable housing type that offers an integrated strategy for sustainable design. Although costs are higher for these measures, it is inevitable that in order to reach zero carbon by 2011 projects will have a higher capital cost, but will potentially offer lower whole life costs than pattern book housing.



Fig 10: St Athan development perspective view

3.0 Conclusion: Opportunities & barriers to achieving zero carbon

The case studies demonstrate that a whole house design strategy can offer a complete package of both passive and active measures to aim for zero carbon. Without a holistic strategy from inception of a new development any attempts to reduce carbon emissions and increase energy efficiency are likely to fail. The use of an assessment system such as the Code for Sustainable Homes with its emphasis on point scoring may lead to sustainability being seen as an add-on, rather than being integral to housing design. These case studies have shown that it is important to start with suitable site identification and a study of optimum orientation and density of a new development. This will maximise the potential for passive environmental strategies to be employed. It will then be imperative to choose the appropriate construction system and building fabric to achieve best performance. Through experience it has become evident that utilising prefabricated components can help to improve building fabric performance significantly. Once these steps have been considered it can then be valuable to consider micro renewable technologies which can offset the remaining energy demand.

There is considerable political drive to achieve zero carbon in Wales, but as yet there are no prototypes, guidelines or definitive targets set to create the necessary step change in the house building industry. Furthermore, the need to achieve higher environmental credentials has the potential to increase the cost of housing provision. Funding bodies will need to recognise the increased cost associated with the higher specification needed to achieve Code levels required. While the goal of zero carbon is government policy, there is currently little additional guidance or funding to enable this to be achieved. While cost remains a barrier to zero carbon housing, with increased demand for products and systems it can be hoped that economies of scale will reduce these costs and they will no longer be add-on's but become an integral part of housing design.

4.0 References

ⁱ HM Government, (2005) 'Securing the future. The UK Government Sustainable Development Strategy'.

ⁱⁱ HM Treasury (2007) 'Stern Review: Economics of Climate Change.'

ⁱⁱⁱ Communities and Local Government, (2007) 'Building a Greener Future: Towards Zero Carbon Building'

^{iv} BRE (2006) 'The Code for Sustainable Homes: A step Change in Sustainable Home Building Practice'

^vCLG (2008), 'Code for sustainable homes technical guide'