An exploration of the challenges facing developers of affordable dwellings following low carbon and ecological principles, in rural Locations in Wales

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Summary

This paper discusses the challenges in developing ecological, low carbon and affordable dwellings in rural areas of Wales; since much of the funding in the UK is often focused on urban development. The Welsh Assembly Government (WAG) is committed to the aim that the construction of new homes moves towards zero carbon as soon as possible. There is a need to ensure that this strategy recognises that one size does not fit all; and understanding and addressing these issues will be fundamental if WAG objectives are too achieved in rural areas. This paper discusses a three year research project, which commenced in autumn 2010 in collaboration with the University of Wales Institute Cardiff (UWIC) and Pembrokeshire Housing Association (PHA), a registered social landlord and developer of affordable dwellings; to create a development model for affordable, low carbon, ecological rural dwellings to achieve WAG targets. This paper will be of use to rural developers, designers and architects.

Keywords: affordable, rural development, ecological, low carbon, dwellings, Wales.

1. Background

This paper begins by identifying how an understanding of economics at a regional level can inform our knowledge of the challenges facing rural communities. Pembrokeshire, in west Wales, is used as a case study. Pembrokeshire's rural amenities (a national park and extensive coastline) mean that the county attracts in-migrants from England and urban areas of Wales and many of its dwellings are owned as second homes by people whose main residence and employment is outside the county raising property prices and making dwellings unaffordable for many local people. In addition, the market for construction service is less competitive in Pembrokeshire leading to higher tender returns than in urban areas and raising the cost of new-build dwellings. Despite these issues the Welsh Assembly Government (WAG) does not provide additional funding for housing associations in Pembrokeshire or other rural areas of Wales.

WAG has set an objective for the construction of new homes to move towards zero carbon as soon as possible. In support of this accelerated timeline towards zero carbon since September 2010 all new dwellings in Wales have been required to meet level three of the Code for Sustainable Homes (CfSH) to receive planning permission. Control of the Building Regulations in Wales is set to be transferred to Welsh Ministers from 31 December 2011 and as a first step towards zero carbon, an improvement of 55% over the 2006 edition of ADL1 of the Building Regulations will be imple-

mented in 2013. Meeting the challenge of raising the performance of the dwellings to achieve these standards will mean developing new skills for many contractors and developing suitable methods of construction. A potential lack of products and skills for the Welsh construction industry could result in low carbon dwellings that have substantially higher capital costs than dwellings built using traditional construction techniques, at least in the short term.

2. Development of Affordable Dwellings

In rural areas of the UK construction firms are characterised by their small size and the dispersed nature of their market both in terms of suppliers and clients and there are questions about how well rural construction firms can adapt to delivering low and zero carbon dwellings. Issues about rural supply chains meant that PHA's original attempts to build level four of CfSH dwellings were found to be unaffordable within the budgets that they had available from WAG. To overcome this PHA utilised the fabric design of their level three dwellings, with the addition of photovoltaic panels to meet code CfSH level four. The paper identifys that supply chain issues could be overcome by drawing on the economic and sustainability benefits that could be gained from encouraging greater locality of supply of primary products. The paper also considers how local sourcing of products could utilise the agricultural capacity of the rural economy to produce construction materials.

There are a number of factors acting on the affordability of dwellings in rural areas such as in-migration; the purchase of second homes; and planning restrictions. These factors have affected development of rural areas by creating a shortage of affordable dwellings. The continuing influence of theses factors combined with the uplift in house prices associated with low carbon homes will compound the current shortage in affordable dwellings in many rural areas of Wales if the issues are not addressed. The recent recession has had little impact on the affordability of dwellings in rural areas as despite falling prices; dwellings are becoming less affordable due to the current difficulties in securing mortgages for many people in rural areas.

The rural planning system in the UK has come under criticism for creating an environment in which dwellings has become unaffordable for many living in rural areas by restricting the use of land available for development. In addition, some developers have noted that local opposition to development, including social housing, is a significant factor in restricting development in rural areas. Within planning authorities there is awareness of the need for affordable dwellings in rural communities and Pembrokeshire's Planning Guidance allows 'exception sites' for affordable dwellings as means to address these issues.

3. Conclusion

From the literature review it is apparent that there is little current information on the rural Welsh construction industry, as demonstrated by the fact that key sources of information on the Welsh and UK rural construction industry have not been updated since 2004. This lack of recent information on the current rural Welsh construction industry underlines that little research has been conducted on how rural developers have been adapting to meets the challenges, set by WAG, of producing low carbon rural housing. In addition, WAG did not provide funding for monitoring the in-construction or post occupancy thermal performance of low carbon dwellings; to assess whether low carbon design has translated into low carbon construction and operation in rural areas.

This paper sets the background and context for a doctorate research project that commenced at UWIC in November 2010 to develop a best practice model for low carbon, ecological and affordable dwellings for rural parts of Wales, U K and provides a comprehensive review of literature specific to rural dwelling development in Pembrokeshire. The outcomes of the research are expected to be relevant to the design of low carbon rural dwellings, the development of methods and methodologies for improved environmental performance. This research will also provide a framework for future development by rural Welsh housing associations for low carbon, ecological housing development addressing issues such as procurement, design, local resources and the ongoing affect of the occupants on building performance.

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Summary

This paper discusses the challenges in developing ecological, low carbon and affordable dwellings in rural areas of Wales; since much of the funding in the UK is often focused on urban development. The Welsh Assembly Government (WAG) is committed to the aim that the construction of new homes moves towards zero carbon as soon as possible. There is a need to ensure that this strategy recognises that one size does not fit all; and understanding and addressing these issues will be fundamental if WAG objectives are too achieved in rural areas. This paper discusses a three year research project, which commenced in autumn 2010 in collaboration with the University of Wales Institute Cardiff (UWIC) and Pembrokeshire Housing Association (PHA), a registered social landlord and developer of affordable dwellings; to create a development model for affordable, low carbon, ecological rural dwellings to achieve WAG targets. This paper will be of use to rural developers, designers and architects.

Keywords: affordable, rural development, ecological, low carbon, dwellings, Wales.

4. Introduction

This paper discusses and illustrates some of the research, which is part of the first author's doctorate project, which commenced in November 2010 in the Ecological Built Environment (EBERE) group at UWIC, in collaboration with PHA; both organisations are situated in Wales, UK. This work is to develop and test a best practice model for ecological, low carbon and affordable dwellings that could be constructed in rural areas of Wales, UK. This paper reviews the challenges in developing low carbon affordable dwellings in rural Wales and begins by reviewing the background literature to support the research, which includes the economic context for rural development in Wales; the challenges presented by the Welsh Assembly Governments' (WAG) decision to push for the development of low carbon dwellings ahead of England in as near to 2011 as possible; the nature of the rural Welsh construction industry; the problems of affordability of dwellings rural areas; and the issues surrounding the dwellings planning system in rural areas. The proposed methodology for the research project is discussed as are the expected outcome. The paper concludes by offering possible directions to addressing the issues surrounding the development of low carbon dwellings in rural areas of Wales, UK.

5. Background and Context

5.1 The challenges of the Rural Economy in Wales

In the report entitled 'The New Rural Economics', Kilkenny [1] outlined how the challenges faced by rural communities have been explored by economists and refers to the economist Edgar Hoover, who identified three foundation stones to the understanding of economics at a regional level:

> "To sum up, an understanding of spatial and regional economic problems can be built on three facts of life: (1) natural resource advantages, (2) economies of concentration and (3) cost of transportation and communication." [2]

These Hoover and Giarratani, (referred to H&G hereafter) (1999) 'facts of life' identify many of the challenges facing rural communities in Wales and understanding the effects of these factors it is possible to identify the difficulties of developing affordable dwellings in rural areas. By applying these H&G [2] factors to a single county (Pembrokeshire) in Wales the authors believe that building development can be influenced from the macro-economic level down i.e. the regeneration and development of cities to the micro-economic level i.e. the construction of individual dwellings.

Taking Pembrokeshire, in west Wales (UK), as an example it is possible to examine the issues raised by its natural resources advantage, characterised by the county's rural amenities, which include 243 miles squared of national parkland and an extensive coastline. A consequence of these rural amenities is that the county attracts many in-migrants from the from urban areas of England, termed counter-urbanisation, and many of its dwellings are owned as second homes by people whose main residence and employment is outside the county raising property prices and therefore making dwellings unaffordable for many local people [3]. In addition, the rural attractions of Pembrokeshire mean that there are tight planning controls over the location and appearance of new buildings, restricting development and further raising the price of dwellings. These restrictions on development are particularly strict in the Pembrokeshire Coast National Park [4-5].

This effect of middle and high income in-migrants moving into rural areas drawn by rural amenities was identified by Jonathan Murdoch in 'The Rural Economy and the British Countryside' [6]. Murdoch observed that, with regard to the built environment, the influx of middle and high incomes people leads to traditional buildings being bought and restored and local 'features of interest upheld as 'sacred goods''. Murdoch also identified that politically active middle class in-migrants are resist most types of development except those that fit the local aesthetic in the rural areas in which they reside. Murdoch used the term 'preservationism to describe the effects of these in-migrants on rural locations. A consequence of the 'preservationist' approach towards existing traditional properties is that Housing Associations in areas with high natural capital subject to in-migration, such as Pembrokeshire, are forced to focus on new-build developments as a means to meet social housing need, based on the experience on PHA [Ibid].

With regard to economies of concentration, the population of Pembrokeshire is very low at 117,300 people, or 72 people per kilometres squared (km^2) [7], compared with 227,100 people/km^2 in Swansea [8], or 601 people/km², and 300,000 people/km^2 in Cardiff [9]. The majority of residents in Pembrokeshire live in villages and across the county's 1618 km² there are five main towns: Milford Haven, Pembroke Dock, Tenby, Haverfordwest and Fishguard [7]. From PHA's experience of development in the county of Pembrokeshire, the lower population in the county compared with the other counties discussed above, in Wales means that there are fewer design and construction teams for developers to commission. Thus, the market for construction service is less competitive leading to higher tender returns than in urban areas making tender returns higher as identified Wales Rural Observatory (WRO) report 'Housing need in Rural Wales' [10].

Finally, transport routes and transport durations are much longer in rural Pembrokeshire than in urban areas, such as Cardiff or Swansea, which adds to costs, based on the experience of PHA. Despite the issues outlined above WAG does not provide additional funding for housing associations that develop in Pembrokeshire and weekly salaries are 12% lower in Pembrokeshire than the Wales average [7]. In Cardiff, residents on average earn 4.5% more per year than residents in the rest of Wales [9].

5.2 The Challenge of Delivering Low Carbon Dwellings

Wales is one of the few countries in the world to place sustainable development at the core of its constitution and Section 79 of the Government of Wales Act 2006 [11] established an ongoing requirement for WAG to promote sustainable development. This commitment has contributed to the decision of Welsh Assembly Ministers to take a lead over other regional assemblies in its their approach to meeting UK and European legislative requirements to reduce carbon emissions from the built environment set in the Climate Change Act 2008 [12] and the Buildings Directives 2002 [13] and 2010 [14]. In responding to these requirements WAG has set an objective for the construction of new homes to move towards zero carbon as soon as possible; and announced a target for this to be implemented by 2011 [15].

In support of this accelerated timeline towards zero carbon, WAG received devolved powers from the UK's national government at Westminster in November 2009. Since September 2010 all new dwellings in Wales have been required to meet code level three of the Code for Sustainable Homes (CfSH) to receive planning permission [15]. Control of the Building Regulations in Wales is set to be transferred to Welsh Ministers from 31 December 2011 [15]. The transfer will enable new building regulations (primarily involving changes to the current Approved Document L 1 (ADL1)) to be applicable in 2013 following a consultation process in 2012 [16]. As a first step to zero carbon, an improvement of 55% over the 2006 edition of ADL1 of the Building Regulations will be implemented in 2013. This accelerated programme is several years in advance of the ADL1 in England, Northern-Ireland and Scotland and presents considerable challenges for the Welsh construction industry.

One of the principle challenges faced by developers and designers of low carbon schemes in Wales is that the current low level demand for dwellings compared with England, means that many suppliers have held back on developing products for low carbon dwellings and many new products are unlikely to be available until the construction industry in England provides this demand. As zero carbon (CfSH Level five) is not due to be mandatory in England until 2016 [17] and with house builders likely to land bank planning consents for some time after that, it may not be until 2017 or 2018 that products for zero carbon dwellings will emerge into the market place that are suitable [18]. For many manufacturers the Welsh construction industry is too small to commit to substantial product development when compared to the English construction industry, which is over 22 times larger based on quarterly output from the period of November 2010 to January 2011 [19].

In addition to developing new products, developing new skills in the construction industry is another challenge posed by WAG's accelerated programme. The standards for low carbon, ecological homes, as characterised by the CfSH are more vulnerable to the performance of the external envelope and build quality. In addition, these standards also frequently require the installation of new technologies ranging from micro-generation technologies, including ground source heat pumps or photovoltaic panels, to the application of technologies not generally used in dwellings in the UK, such as heat recovery units. Meeting the challenge of raising the performance of the building fabric and installing and maintaining renewable technologies will mean developing new skills for many contractors [20].To compensate for the current lack of skills within the construction sector in Wales there has been a drive among some contractors and manufacturers to develop newer forms of construction, such as thin bed mortars, structural insulated panels and pre-fabricated construction to meet higher building envelope standards [18].

A consequence of this lack of products and skills is that currently low carbon dwellings have higher

capital costs compared to dwellings built using traditional construction techniques. There are a number of reports examining what the uplift in cost necessary to meet each of the levels of the CfSH when compared to a similar home built using current standards (ADL1). The figures range for uplift in capital costs vary considerably: 10% to 43% for a CfSH level five end terrace in the Communities and local Government Report [21]; 35% for a CfSH level five end terrace in the Gentoo report [20]; and 59% to 64% for a CfSH level five semi-detached house in the Lee Wakemans Report [18]. However, these reports examined theoretical dwellings built in non-specific locations without taking into account regional economics and the potential challenges of economies of concentration and transport costs outlined by H&G [2].

6. The Rural Welsh Economy

6.1 The Rural Welsh Construction Industry

In rural areas of the UK construction firms are characterised by their small size, 94% of rural firms employ ten or fewer workers with 43% employing up to two people and 20% employing between three and five employees [22]. Many rural construction firms have considerable experience in the residential sector with 37% to 60% citing domestic building installation, completion and repair as their main work [22]. In Wales; the Wales Rural Observatory Business Survey [23] outlined some of the characteristics of these small construction firms, as described below:

- They are run by local people and the most important factor influencing the decision of the directors to locate the business in rural Wales was because they were already living there. 93.8% of construction industry businesses cited this as a reason why they had chosen to locate their business in rural Wales as compared to an aggregate of 81.3% in the survey [23].
- There was a desire from many construction industry recipients to the survey to keep their businesses small. The statement: 'I would definitely like the business to grow' scored highly on aggregate (70.2%); however, only 49.5% of construction businesses agreed with this.
- With regard to customers only 26.5% of construction respondents to the survey had customers more than 100 km away from the business premises, suggesting the local nature of their market, and 50% of construction sales were generated from other small businesses against an aggregate of 27% of rural businesses [Ibid].

As discussed in Section 2.2 above, the construction of low carbon dwellings can require specialist construction techniques, especially when zero carbon is set as an objective. It is in this regard that rural construction firms can be seen as lacking because their small size and the dispersed nature of their market means that a third focus on the general building market and only 18% of firms offer a specialisation (and that was only in joinery) [22]. These results highlight a lack of skills necessary to develop zero carbon homes in rural areas. In addition, many rural construction firms do not have access to the specialist supply chains being utilised by some contractors in urban areas to over-come a lack of skill in their workforce. This lack of a specialist supply chain was apparent from the Countryside Agency report which highlighted the fact that 89% of rural contractors rely on builder's merchants as their principle source of supply for construction materials, as opposed to specialist suppliers that could provide guidance to ensure the high quality standards necessary to deliver zero carbon homes [Ibid]. In the Wales Rural Observatory business survey 78.4% of recipients from the rural Welsh construction industry said that their suppliers were located less than 30 km from their business premises suggesting very short supply chains [23].

The difficulty in building low carbon dwellings in rural Wales is confirmed by the experience of PHA building CfSH level four dwellings in Pembrokeshire under the WAG's Pathfinder Housing scheme. PHA's original attempts to achieve CfSH level four using a building fabric based approach were found to be unaffordable based on the budgets available from WAG. PHA eventually met the standard by utilising the fabric design of their CfSH level three dwellings, with the addition of photovoltaic panels to upgrade the property. The decision by PHA and its design team to using a tried and tested methodology for the building fabric, relying on a workable supply chains for west

Wales illustrates that achieving low carbon dwellings through a fabric led approach is particularly challenging in rural areas without capital investment, the development of rural supply chains or the development of specific local solutions.

The Countryside Agency report [22] explained that significant sustainability and local economic benefits could be gained from encouraging greater locality of supply of primary products originating in rural areas such as aggregates, quarry products, timber, and blocks, bricks and tiles. However, there are a number of examples where the sourcing of local materials can been taken beyond supplying aggregates and quarry products and could go far as utilising the agricultural capacity of the rural economy to grow materials. Examples of this include the RuralZED house developed by Bill Dunster [24,25], the Modcell system [26] or Ty Unnos [27] which utilise local grown prefabricated components to achieve low carbon design. By utilising modular prefabrication based on renewable resources (especially wood) these systems can overcoming skills shortages. The Centre for Advanced and Renewable Materials identified that Wales is well placed within the UK to exploit this emerging technology of locally grown prefabricated construction systems through strong links with agriculture, access to R&D capabilities and a wide portfolio of funding sources [28].

6.2 Affordability of Dwellings in Rural Areas of Wales

As discussed in Section 2.1 above, there are a number of factors acting on the affordability of dwellings in rural areas such as in-migration and the purchase of second homes has been one of the most influential factors rural and coastal tourist areas of Wales. As a result between 1997 and 2003 house prices in the nine rural authorities in rural Wales increased by an average of 82.9% compared to an all Wales increase of 73.2% [10]. The report identified the continuing effect of theses factors combined with the uplift in house prices associated with low carbon homes would compound the current shortage in affordable dwellings in many rural areas of Wales.

Since the publication of the Wales Rural Observatory survey in 2006, there has been a recession causing house prices across the UK to fall between January 2008 and March 2009, and this has affected Wales by producing an overall decrease in the need for affordable dwellings [29]. A study conducted by Wales Rural Observatory [29] revealed that the recent downturn in the dwellings market has had little impact on the affordability of dwellings in rural areas as despite falling prices, dwellings are becoming less affordable due to the difficulties in securing required mortgages and it is now more difficult for new entrants and those on low incomes to enter home ownership [29].

6.3 Planning as an Obstacle to the Development of Rural Housing

The rural planning system in the UK has come under criticism for creating an environment in which dwellings has become unaffordable for many living in rural areas. In his book ‘Low Impact Development: Planning and People’, Simon Fairlie [30] argued that the current system for rural planning dating back to the Town and Country Planning Act of 1947, operates to restrict the amount of land that is allocated for residential uses. Fairlie argues that the restrictions result in a scarcity of development land in rural areas; monopoly control by corporations who buy options on land likely to be allocated escalating its price; a lack of affordable dwellings and ‘massive indebtedness of a large proportion of the population with a host of other repercussions including overheating of the UK economy and the 2007 to 2008 credit crunch’ [Ibid].

While many people would not go so far as to level the cause of the credit crunch on the UK planning system there is certainly a belief that it is an obstacle to addressing dwellings need in rural Wales by some developers. A criticism levelled at the planning system is that its policies tend to reflect UK and WAG policies rather than local preference [10]. Conversely, some RSL developers have noted that local opposition to development, including social housing, was a significant factor in restricting development and ‘ruralness’ with its associations with landscape and beauty often made planning an emotive subject [Ibid].

Within planning authorities there is awareness of the need for affordable dwellings in rural communities and Pembrokeshire's Planning Guidance [31] allows, affordable dwellings to be built in or near a settlement 'in exceptional circumstances where there is proven local need'. However, there is still some debate as to how successful these 'exception sites' have been for providing affordable dwelling and to what extent the planners should intervene to ensure that land that would not otherwise be permitted for dwellings should enable dwellings to be built at an affordable price [10].

Fairlie [30] argues that more fundamental change to the planning system is required to address issues of environmental degradation and provision of affordable dwellings. People should be allowed to build anywhere if they conform to agreed environmental criteria argues Fairlie. This approach would eliminate the artificial prices attached to allocated land and would 'create an incentive for developers to compete with each other not by outbidding each other for scarce development sites but by drawing up projects that judged to be more sustainable than those of rivals' argues Fairlie. There is a precedent for the type of low impact development advocated by Fairlie [Ibid] in Pembrokeshire at Lammas Eco-village which was the subject of a prolonged planning process [32]. The success of Lammas' planning proposal led to the concept of low-impact development being recognised by the local Planning Authority through Pembrokeshire's policy 52 [33] and the rest of Wales through 'TAN 6: Planning for Sustainable Rural Communities' [34].

7. Research Methodology

With regard to developing a methodology for the research programme, the literature review has identified the following weaknesses in existing literature:

- There is little current information on the rural Welsh Construction industry, as demonstrated by two key sources of information on the Welsh and UK rural construction industry, which have not been updated since 2004 [10, 22].
- This lack of recent information on the current rural Welsh construction industry underlines that little research has been conducted on how rural developers have been adapting to meets the challenges, set by WAG, of producing low carbon rural housing.
- There is a lack of information on the experience of designers, developers and builders in Wales building low carbon dwellings what they consider as the most effective means of achieving affordable, low carbon dwellings in rural locations.
- The question about the development of experience is especially true of the dwellings built through the WAG's pathfinder programme and at the time of writing (March 2011) there is still no information on how successful the pathfinder houses have been in achieving their objectives. This lack of information is exacerbated by the fact that WAG has not provide funding for monitoring the in-construction or post occupancy thermal performance of low carbon dwellings to assess whether low carbon design has translated into low carbon construction and operation.
- There is little information on the availability of the specialist skills, supply chains, materials and components required for building low carbon ecological rural Wales.

Table 1 Project work plan

Work Packages	Description
WP1	**Literature review on appropriate rural dwellings systems/monitoring** WP1 develops a conceptual framework for the research project and literature review. The literature review includes legislative and policy drivers; ecological building fabric approaches; renewable energy systems; research techniques used in interviews and monitoring environmental performance in dwellings; and procurement methods.

WP2	**Monitoring – post occupancy evaluation, physical monitoring and analysis** WP2 investigates the success of the strategies adopted by rural developers in achieving CfSH Level three and Level four with the aim to obtain information, using energy monitoring and questionnaires on the following: existing energy use; factors which influence energy use; attitudes toward energy efficiency.
WP3	**Analysis of qualitative and quantitative data from case studies** WP 3 will evaluate the performance of case study houses and identify factors influencing thermal performance, resource use and occupant comfort and behaviour.
WP4	**Production of a draft rural model for ecological and low carbon Dwellings Communities** WP 4 undertakes analysis and interpretation of factors influencing thermal performance, energy use and occupant comfort and behaviour to aid development of a best practice model.
WP5	**Development of Best Practice Model for Rural Ecological and Low Carbon Dwellings Communities** WP5 will apply and test the best practice model design guide approach on vacant sites as part of Pembrokeshire Housing Association's landbank.
WP6	**Dissemination of research outcomes** WP6 will bring the research together in a format that will make it readily usable by the rural developers. The project is due to be completed in October 2013.

The overall aim of the first author's doctorate project is to develop a best practice model for the development of low-carbon, ecological, low rise rural dwellings, for a 21st century Wales. To achieve this objective the work plan above has been prepared (Table 1) highlighting the various work packages.

The outcomes of the research are expected to be relevant to the design of low carbon rural dwellings and the development of methodologies for improved environmental performance. This research will also provide a framework for future development by rural Welsh housing associations for low carbon, ecological housing development addressing issues such as procurement, design, local resources and the ongoing affect of the occupants on building performance.

8. Conclusion

The paper has set the background and context for a doctorate research project that commenced at UWIC in November 2010 to develop a best practice model for low carbon, ecological and affordable dwellings for rural parts of Wales, UK. The paper has provided a comprehensive review of literature specific to rural dwelling development in Pembrokeshire, Wales. The key findings arise from recognition that WAG's targets presents a considerable challenge to for the Welsh construction industry especially in rural areas with short supply chains and a shortage of skills. The decision by PHA and its design team to construct its dwellings relying on a workable supply chains for west Wales illustrates the difficulties of building affordable low and zero carbon dwellings in rural areas without support whether through capital investment or planning support such as 'exception sites'. Potential exists to utilise the rural economy to develop new supply chains; however, it could be argued that capital investment would be required to release this capacity. This literature review when assessed in terms of H&G [2] facts of life suggests that within the emerging eco-economy of the twenty-first century Wales there lies the potential for the first factor, natural resource advantages, to offset the disadvantages of the second and third factors, economies of concentration and costs of transportation and in doing so revitalise rural areas.

The key challenges facing the doctorate have been discussed and include a lack of recent information on the rural Welsh Construction industry and how successful attempts to develop the knowledge base of designers, developers and builders in rural Wales have been and based on their ex-

perience to date. The methodology for the research project have been discussed and will include post occupancy evaluation, physical monitoring and analysis and development of a practice model design guide. The outcomes of the research are expected to be relevant to the design of low carbon rural dwellings and the development of methods and methodologies for improved environmental performance. This research will provide a framework for future development by rural Welsh housing associations for low carbon, ecological housing development addressing issues such as procurement, design, local resources and the effect of the occupants on building performance.

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