Institution: University of Lincoln

Unit of Assessment: 16 Architecture, Built Environment & Planning

Title of case study: Putting research into practice in the design and construction of low carbon buildings

1. Summary of the impact

It is widely acknowledged that conventional approaches to planning and development exacerbate environmental problems with consequential negative social and economic impacts. This award winning research proposes alternatives by examining the systems and techniques used in the design of autonomous eco-building in order to identify best practice in the procurement of low carbon buildings. The research findings were first tested and subsequently validated, through the design and construction of a community building in Lincolnshire. This building has won multiple awards for innovations in sustainability and the underpinning research has impacted at regional, national and international level through direct application to design, changes to professional practice and through enhanced public awareness

2. Underpinning research

The underpinning research began in 2005 through an externally funded Knowledge Transfer Partnership project (KTP) and is ongoing. Its quality is such that it was rated as being "outstanding" on completion in 2007. In 2009, the research was awarded the national award for the Best Application of Social or Management Science by the Knowledge Transfer Partnerships programmes. In addition, the Community Building itself is a recipient of the Lord Stafford Award for Innovation for Sustainability (2009) and the Green Apple Award for the Built Environment and Architectural Heritage (2009). In 2011, the building won the Sustain Award for Construction given by *Sustain Magazine*.

2.1 Context of the research: The construction industry is a major contributor to climate change, as it is responsible for almost half of the global greenhouse gases and consumes 40% of the materials entering the global economy. In response to the challenge of climate change, the UK has introduced new stringent codes and standards in order to reduce the energy consumption of buildings and to make them carbon neutral in future. The debates around sustainability are becoming increasingly sophisticated and there is recognition that considering environmental sustainability alone, without considering broader economic and social contexts, is likely to frustrate any attempts to achieve realistic levels of sustainable development.

2.2 Current research gaps and how this research addresses them: Although the construction industry is gradually moving towards more sustainable practices due to a range of regulatory and voluntary initiatives, there are both gaps in knowledge and shortcomings in current practice that need to be addressed. Crucially, a holistic approach to sustainability that ensures that all stakeholders work together towards common goals is missing. This research supports the thesis that such a holistic approach can be achieved only by addressing the social, economic and environmental aspects of sustainability simultaneously. It emphasizes the necessity of the collaboration of all stakeholders to quantify and interpret environmental impacts of buildings throughout the building lifecycle as a key indicator of responsible use of resources and energy, and offers an exemplar of this philosophy in practice. Among the main objectives of the research are;

1. To identify the drivers for sustainability
2. To identify the content for sustainable buildings
3. To identify the process for development of sustainable buildings.

2.3 Research methodology: This research has used an inductive research methodology in order to understand the factors influencing sustainability in the built environment. This "Action Research" approach is common in design-based applied disciplines as it is close to the iterative approach used in the design of buildings. The literature review has centred on sustainability, life cycle analysis and legislation in the UK.

2.4 Key research findings: The research findings are diverse and address aspects of both planning and development. In addition to the purely theoretical, the research findings were also applied and validated through the design and construction of an award winning building project. (See section 4). Among the research findings are:

- That a balanced view should be sought to address all aspects of sustainability including social, economic and environmental.
- That focusing on driving down operational impacts alone is inadequate as this ignores both the increasingly important, in percentage terms, initial and end of life impacts of buildings.

- That in order to ensure a truly sustainable building, the construction industry must support the provision of robust data and facilitate design teams in accessing it to inform decision making in the design process.
- That a collective approach should be sought involving all stakeholders and actors from early stages of building procurement to ensure the attainment of sustainable buildings.
- That the establishment of a comparative market in CO_2 emissions that enables comparisons between different stakeholders to be made will help to drive down the impact of the industry as a whole.

2.5 Research team: The research that underpins this case study is ongoing work which was originally initiated as part of a two year (2005-07) Knowledge Transfer Partnership Programme (KTP000717, value £100,734) supervised by Prof. Sodagar, Prof. Chilton, Andy Earl and Philip Hyde (Chilton left the University of Lincoln in 2008). The KTP research associate was Bryce Gilroy Scott and the industrial supervisor was Nigel Lowthrop at Hill Holt Wood (HHW) Social Enterprise (www.hillholtwood.com). Students of architecture at the Lincoln School of Architecture, through a design competition under the supervision of Prof. Sodagar (2005-06), contributed to the research by creating the blueprint for the design of the building. The design was subsequently further developed in association with Dr Fieldson of Simons Group and Hill Holt Wood Social Enterprise for obtaining detailed planning permission for the scheme. The construction of the building started in 2008 and was completed in 2010.

3. References to the research

- Sodagar, B., Rai, D., Jones, B., Wihan, J. and Fieldson, R. (2011) *The Carbon Reduction Potential of Strawbale Housing*, Building Research & Information, January 2011, pp. 51–65, Routledge, Taylor & Francis Group, ISSN 0961-3218.
- Sodagar, B., Fieldson, R., Gilroy Scott, B. (2008) *Design for Sustainable Architecture and Environments.* The International Journal of Environmental, Cultural, Economic & Social Sustainability, Common Ground Publishing Pty Ltd, Vol. 4, Number 4, pp73-84, ISSN 1832-2077.
- Sodagar, B., Fieldson R. (2008) *Towards a low carbon construction practice,* Construction Information Quarterly (CIQ), Chartered Institute of Building (CIOB), Vol. 10, Issue 3, October, pp 101-108, ISSN 1469-4891.
- Sodagar, B., Chilton, J., Gilroy Scott, B., Lowthrop, N. and Fieldson, R. (2007) *Design Development for a Community Hall: the architecture of a sustainable building in Lincolnshire,* Construction Information Quarterly (CIQ), Chartered Institute of Building (CIOB), Vol. 9, Issue 1, March, pp 12-20, ISSN 1469-4891.

Key grants

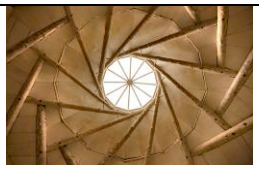
- Knowledge Transfer Programme (KTP), funding body: former Department of Trade and Industry, £100,734.
- Construction of the Community Hall Building, grant provided by Waste Resources Environmental Network (WREN), £157,500.
- Construction of the Community Hall Building, grant provided by Lincolnshire Enterprise, £100,000

4. Details of the impact

The impacts of the underpinning research have affected a wide range of audiences and beneficiaries at regional, national and international levels. These impacts may be categorised as follows:

Direct impact on design: The underpinning research, through investigation into autonomous eco-building systems and techniques, identified and developed a range of best practice and innovative novel systems for low-carbon buildings. The research findings were applied and validated through the design and construction of the award winning Sustainable Community Building. The building, as one of the main outputs of the research, has been used as a model for education and replication by different actors in the built environment. The building has not only demonstrated the practical potential of low carbon construction techniques, whilst challenging conventional wisdom, but has also influenced mainstream architectural design practice by showcasing the economic, cultural and environmental potential of low carbon construction. Selected images are included

below depicting the building and its construction process.

			
Rammed earth walls under construction	Interior view of the double timber frame reciprocal roof	Public visit to the building while under construction	View of the completed building

Key findings from the research were presented at a number of national and international events, including

- The 4th International Conference on Environmental, Cultural, Economic and Social Sustainability, 4-7 January 2008, Trengganu, Malaysia. Sodagar, B., Fieldson, R., Gilroy Scott, B. *Design for Sustainable Architecture and Environments.*
- The 24th International Conference on Passive and Low Energy Architecture (PLEA), 22-24 November 2007, Singapore. Sodagar, B., Chilton, J., Gilroy Scott, B. and Lowthrop, N. (2007) *Integration of teaching and research: design development for a range of autonomous buildings*.
- The UK-China innovation forum on sustainable building technologies, Beijing and Shanghai, 21-24 June 2011. Sodagar, B. *Overall situation of the sustainable building sector in the UK.*
- BRE East Midlands Innovation: Opportunities in Construction using Renewables, EPIC Centre, Lincoln, 9 September 2010. Sodagar, B. *Carbon reduction potential of renewable materials.*
- Low Carbon Business Network Conference; Building and living with Bio-renewables, EPIC Centre, Lincoln, 24 November 2009. Sodagar, B. *Potential for reducing GHG emissions through the use of bio-renewables.*

The research remains ongoing, but its dissemination has already demonstrated its impact potential in a number of key areas involving practitioners and professionals, as well as its environmental benefits and its impact on public opinion. In particular there have been:

Impacts on practitioners and professional services: Hill Holt Wood Social Enterprise, acting as the industrial partner for the research project, directly benefited from the research by gaining skills and expertise to establish a sustainable design and construction arm for the organisation (http://www.youtube.com/watch?v=tk-kNtEBDUo). Simons Design, part of the Simons Group, a major construction company in the region, directly benefited from the research through its collaborative work with the research programme which enabled them to be recognised as a pioneer in sustainable construction practice. This visibility resulted in the company winning prestigious contracts, and in addition the practice was awarded “Business in the Community East Midlands Region Prohelp Award 2007” for their pro bono work through the Prohelp scheme for their involvement in a number of projects, the most significant of which was the Sustainable Community Building. In addition, a wide range of architectural practices, planners, construction companies, suppliers, manufactures, and local authorities benefited from the research through accessing its findings at different platforms including visits to the building, workshops, conferences, publications and press coverage.

Impact on raising awareness of the public: The research has substantially raised the public awareness and acceptance of the potential of sustainable planning and development through a wide- ranging programme of public events, talks, workshops and visits to the building as outlined below. It has also resulted in specific changes in policy makers’ awareness and behaviours towards the role and potential of low carbon design in safeguarding the environment. For example, following the involvement of North Kesteven Council in the Sustainable Community Building, the Council commissioned social housing projects in the region built in load-bearing straw-bale construction (reference 1 in Section 3).

Impacts on the environment: The research has demonstrated significant and quantifiable impacts on the quality of built environment by highlighting the potential of low impact environmentally friendly buildings. The Sustainable Community Building has been used as a

precedent at national and international levels to demonstrate the practical application of low impact construction techniques and design. For example, *Sustain Magazine* has selected it as one of the top 10 most sustainable buildings in the UK, making it an important reference point that will underpin future developments in the field.

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5. Sources to corroborate the impact

- Sustain Award for Construction, Sustain Magazine, 2011.
- Lord Stafford Awards, Innovation for Sustainability, 2009.
- Housing Associations Green Apple Award for the Built Environment, the Green Organization, 2009.
- Green Apple Award for the Built Environment and Architectural Heritage - Champion of Champions - the Green Organisation, 2009.
- Best Application of Social or Management Science, Knowledge Transfer Partnerships Awards 2009 for Hill Holt Wood KTP research project, January 2009.

Short listed for awards

- Sustainable Project of the Year 2010 (projects under £10m), Building Magazine in association with UK Green Building Council.
- *Sustain Magazine* Award 2010 for "Design and Architecture".
- Best UK Knowledge Transfer Partnership Award 2009 for Hill Holt Wood KTP.

Professional Journals

- *Architect's Journal* (AJ), Specification: Reciprocal roofing was used by a team of academics, volunteers and social entrepreneurs for a meeting hall deep in the Lincolnshire Forest, by Kaye Alexander, January 2009.
- *Sustain Magazine*: Natural Building: 10 of the best, by Professor Tom Woolley, Volume 10, issue 06, 2009