Institution: University of Nottingham

Unit of Assessment: 16

Title of case study: Creative Energy Homes: Low-Energy and Zero-Carbon Housing

1. Summary of the impact

A development of six Creative Energy Homes (CEH) on the University of Nottingham campus provides a living test-site for leading firms, including E.ON, David Wilson Homes, BASF, Tarmac, Roger Bullivant and Igloo Blueprint to work with the University of Nottingham to investigate the integration of energy efficient technologies into houses. As a result of this work, Lovell homes has won a number of sustainable housing contracts, Roger Bullivant have developed and installed 30 System**First**™ foundation systems and Igloo Blueprint have built £7M worth of new homes. The research findings have informed the UK Government's "Green Deal" strategy, the Nottingham Community Climate Change Strategy and received widespread acclaim through a number of public engagement activities reaching out to over 5 million people.

2. Underpinning research

The need to reduce energy consumption and draw upon more sustainable energy sources has never been more pressing. As part of the Climate Change Act 2008, the Department of Energy and Climate Change (DECC) introduced a target to reduce UK carbon emissions, relative to 1990 levels, by 80 per cent by 2050. Domestic buildings account for approximately 27 per cent of that total, so that low energy housing solutions are an essential part of achieving the Government's target.

As early as 1999, researchers at the Department of Architecture and Built Environment at the University of Nottingham (UoN) were approached by construction firms seeking collaborations to help develop and test low-energy housing solutions.

Figure 1: The Creative Energy Homes Development

Homes were built to varying specifications to support the testing of a variety of design strategies, construction methods and technologies intended for the volume house-builder market. Sponsorship from David Wilson in 2000 (Millennium Eco House), Roger Bullivant Ltd in 2006, BASF in 2006, E.ON in 2007, Tarmac in 2008 and Saint Gobain in 2010 resulted in the six homes that comprise the Creative Energy Homes. For example, the E.ON Research House was modelled on a typical 1930s semi-detached home with the aim of using retrofit technology to achieve to modern energy standards.

The principal investigator and project manager was Professor Mark Gillott, (University of Nottingham, 1998 – present).

At one of the Creative Energy Homes, the David Wilson Millennium Eco House, Professor Saffa Riffat (Chair in Sustainable Energy, University of Nottingham, 1992 - present) supervised a project focussing on lived-in trials from 2002 to 2004 to investigate the feasibility of using ground-source

heat pumps for domestic applications. Research revealed that achieving the desired system efficiency – or Coefficient of Performance (COP) – depended on careful consideration of the system as a whole, taking ground loops, domestic hot water system and radiators, and system operation into account [2.1]. The work was further developed to consider the more economical option of using piled concrete foundations as ground source heat exchangers. The study investigated temperature changes in the foundation piles and the surrounding ground as well as operational performance of the heat pump itself. Temperature changes observed in the test plot were compared with natural temperature variations in the ground due to the seasonal climatic influence. The seasonal performance factor (SPF) of the heat pump was 3.62 (indicating a high level of efficiency), while the ground temperature five metres away from the test plot was found to follow predicted seasonal variation and to be undisturbed by the heat extraction [2.2].
Post-occupancy evaluation was also carried out in all six homes to provide accurate data on how each room was used within the building. Here radio frequency identification (RFID) was used to track the real-time location of occupants within the home, leading to a novel methodology which was applied to the data to inform future housing designs and ensure the best use of space [2.3]. Building on this methodology, further studies used wireless technologies to track energy use in real time, demonstrating intrinsic links between occupancy and energy use. A key recommendation arising from this study was that performance evaluation of domestic buildings should include occupancy monitoring [2.4].

3. References to the research

References *(The three most significant references are indicated with an asterisk);*

2.1. *Doherty, P.S., Al-Huthaili, S, Riffat, S.B., and Abodahab, N., 2004. Ground Source Heat Pump – Description and Preliminary Results of the Eco House System, *Applied Thermal Engineering*, vol 24, no. 17-18, pp2627-2641 DOI:10.1016/j.applthermaleng.2004.04.007

2.2. Wood, C.J., Liu, H. and Riffat, S.B., 2010, An Investigation of Heat Pump Performance and Ground Temperature of a Piled Foundation Heat Exchanger System for a Residential Building, *Energy*, vol. 35, no. 12, pp4932-4940 DOI:10.1016/j.energy.2010.08.032

2.3. *Gillott, M., Holland, R., Riffat, S. and Fitchett, J., 2006, Post-Occupancy Evaluation of Space Use in a Dwelling Using RFID Tracking, *International Journal of Architectural Engineering and Design Management*, vol. 2, no.4, pp273-288 DOI: 10.1080/17452007.2006.9684622, copy available on request.

2.4. *Gillott, M., Rodrigues, L. and Spataru, C., 2010, Low-Carbon Housing Design Informed by Research, *Proceedings of the Institution of Civil Engineers – Engineering Sustainability*, *(Special Issue: Engineering Sustainability),* vol. 163, no. 2, pp77-87 DOI: 10.1680/ensu.2010.163 .2.77

Grants:

- Riffat S.B., KTP007442/TSB: System**First**™ with Thermafoundation, 2010-2012 (Total Grant £124,130) Partners: Roger Bullivant.
- Riffat S., Gillott M., Micro-generation Test House, 2009-2013 (£349,600) Funded by E.ON
- Gillott M. C., Hall, M. EPSRC/E.ON EP/G000387/1, CALEBRE – Consumer Appealing Low Energy Technologies for Building Retrofitting, CI (£2,048,061) 2008-2013 Multi HEI project led by Prof D Loveday at Loughborough University
- Ford, B., EC funded project Passive-on, 'Marketable Passive Homes for Winter and Summer Comfort', EIE/04/091/S07.38644, 2004-2007 (€714,000)
- Gillott MC., EPSRC (EP/I000259/1) Reduction of Energy Demand in Buildings through Optimal Use of Wireless Behaviour Information (Wi-be) Systems, CI (£597,628) 2010-2012 Multi HEI project led by Prof L Shao at De Montfort University
- Riffat S. B., Etheridge D. W., EPSRC GR/R79968/01, PPA: Renewable/Sustainable Energy Technologies for Future Generations. (£40,100) 2002-2004
- Gillott M., Ford, B., Wilson, R., Rodrigues, L., Guzman, G., Stacey, G. Solar Decathlon Europe ten act10n (€12,000), strategic funding to support dissemination to five different target groups: children, teenagers, university students, professionals of the buildings sector and general public. Supported by Intelligent Energy Europe funding.
- Riffat S.B., KTP007443/TSB: Building retrofitting & PCM panels, 2010-2012 (Total Grant

£125,678) Partners: Mark Group

4. Details of the impact

The Creative Energy Homes project is unique among UK HEIs. Impacts from the research have been widespread and can be seen across three key areas: industry, influence on policy and public engagement.

Industry

The project has been geared towards addressing the needs of industry from the start. CEH is one of the first projects in the UK to test the national standard for zero-carbon housing delivery, the UK Code for Sustainable Homes. The businesses sponsoring the project had never designed or built these types of homes before. By working in close collaboration with UoN in a controlled and monitored environment, construction companies have been able to develop the techniques, skills and expertise necessary to meet the latest industry challenges.

As a direct consequence of its involvement in the project, in 2008, Lovell Homes (a contractor for Tarmac Homes' two CEH properties), was able to establish itself as a low-energy housing developer/contractor and secured other external contracts *"It was a fantastic research and learning experience that has enabled Lovell to gain a competitive edge in how to deliver these types of houses en mass and we are now constructing circa* [text removed for publication] *Code for Sustainable Homes level 4 homes per year informed by this experience."* The company has also designed and built around [text removed for publication] Code level 6 homes and [text removed for publication] Passive Houses within the Eastern region informed by their work on CEH [4.1].

The Midlands-based Roger Bullivant Group is one of the largest foundation engineering companies in the UK. As a result of the research into using concrete foundations as ground source heat exchangers, the company updated its trademarked System**First**™ foundation system to enhance thermal performance and reduce thermal bridges. This has been on sale since October 2009 and over 30 installations have been carried out [4.2].

Regeneration property developer Igloo Blueprint used the research team's studies of occupant behaviour in the CEH house to inform the design of an innovative £7M housing development just outside Nottingham city centre. Nick Ebbs, the company's CEO, has remarked: "*The insight we gained on the practical delivery of Code Level 4 housing, through our discussions regarding the research results on use of low carbon technologies and post occupancy evaluation from the Creative Energy Homes project, has helped inform our own thinking in relation to the design and specification of our 'Nottingham Green Street'* (Figure 2) *development of 38 Code Level 4 homes… the learning journey we have been on with the University is also shaping our larger developments including Trent Basin and elsewhere in group our housing schemes in Newcastle and Cardiff*" [4.3]. Phase one of the scheme was completed in spring 2012, with all 38 homes quickly sold. Phase two is already under construction and will deliver 100 more homes by the end of December 2013 [4.3].

Figure 2: Picture of the Nottingham Green Street homes

Influence on policy

CEH research findings were used to inform the setting up of the Government's Zero Carbon Hub (ZCH), the national body with lead responsibility for delivering homes to zero-carbon standards by 2016. The ZCH informs policymakers and industry and is a leading source of knowledge on sustainable housing. CEH homes form two of the 28 UK case studies the ZCH uses as exemplars for scale-up [4.4]. In July 2009 Gillott was invited by the Zero Carbon Hub to join the Post-Occupancy Evaluation Protocols Group, a team of experts assembled to formulate a national

standard for the performance evaluation of buildings formulated by the group.

The Government's Green Deal scheme, launched in January 2013, is designed to encourage business and home owners to employ more green technologies in their properties. Prior to its launch there was a lengthy consultation period, including calls for evidence on the applicability of retrofit technologies. Gillott's research findings on in-situ testing of retrofit technologies used in the E.ON research house was included in a memorandum to the House of Commons that fed into the Government's consultation of the Energy Bill submitted by the Consumer-Appealing Low-Energy technologies for Building Retrofitting (CALEBRE) research team in June 2011 [4.5]. In October 2012 Gillott was also invited to present his research findings from the CALEBRE project at DECC by the team formulating the Green Deal policy [4.5].

Locally, the CEH has informed the Nottingham Community Climate Change Strategy 2012-2020. The project is cited in the strategy document, as the homes are used as local examples of sustainable building design. *"The Creative Energy Homes project is building a number of real homes to conduct research into energy efficiency and low / zero carbon housing." [4.6]*

In January 2012 Gillott was invited to give the keynote presentation to approximately 150 politicians, industry, the general public and media at the strategy's launch event.

Public engagement

Public engagement with CEH is substantial and has maximised reach through international media coverage, including BBC Breakfast News (December 2009), Voice of America (November 2009) and on BBC Radio 4 Costing the Earth: the 'House that Heats Itself' aired on 13th March 2013. Further engagement has included the BBC programme Blue Peter (March 2011), which alone reached an audience of 370,000 people. The CEH development opened to the general public 13 years ago and between 2008 and 2012 sustained an average of 150 to 250 visitors per month, 96 per cent of whom reported that their knowledge of sustainable housing technologies had been enhanced. CEH also featured in the video 'Britain Through My Eyes', which was released by the UK Foreign & Commonwealth Office in the build-up to the 2012 Olympic Games. In addition, CEH was an award winner at the 2010 Solar Decathlon Europe competition. An independent assessment, provided by public relations firm Tonic PR, has estimated the potential audience for the research as a result of these various forms of engagement to be in excess of five million [4.7].

5. Sources to corroborate the impact

4.1. Andrew Berwick, Contracts Manager, Lovell Homes – letter dated 11/10/13 available on file
4.2. John Patch, Director, Roger Bullivant Limited – letter dated 10/10/13 available on file
4.3. Nick Ebbs, CEO, Igloo Blueprint – letter dated 3/12/12 available on file
4.4. Zero Carbon Hub Profiles Gallery
http://www.zerocarbonhub.org/examplepdfs/Profile007-Tarmac_20091025_113237996.pdf
http://www.zerocarbonhub.org/examplepdfs/profile014-BASFHouse.pdf
4.5. CALEBRE briefing notes
http://www.publications.parliament.uk/pa/cm201011/cmpublic/energy/writev/m34.htm
4.6. Nottingham Community Climate Change Strategy (see page 26)
http://www.nottinghamcity.gov.uk/CHttpHandler.ashx?id=33519&p=0
4.7. Tonic PR 2010, Saint-Gobain and the Nottingham H.O.U.S.E. – press coverage evaluation, available on file.