LowCarb4Real

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Project title:	LowCarb4Real
Project acronym:	LC4R
Lead organisations:	UCL, Leeds Metropolitan University
Project coordinators:	Robert Lowe (UCL), Malcolm Bell (Leeds Metropolitan University)
Project duration:	January 2008 to December 2008
UrbanBuzz funding:	£120,699.72
Total CIK:	£192,635.50
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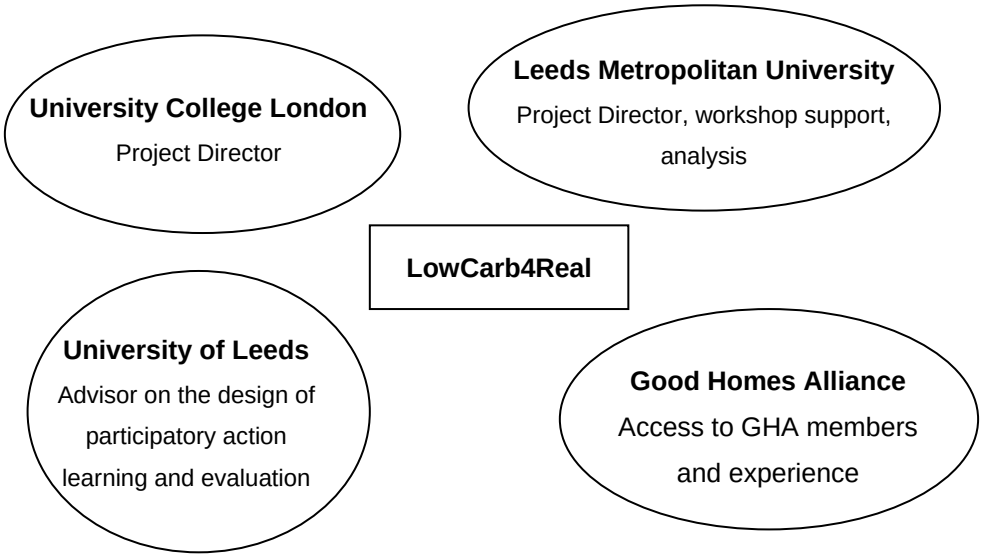
Project partners and roles:



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Context

There is growing evidence, from both academic research and initial monitoring and certification of housing energy performance (the introduction of Energy Performance Certificates in 2008) of a 'performance gap' between design and delivery of new-build homes. There are reasons for expecting the performance gap to widen as the technology used in dwellings becomes more complex[1]. This performance gap therefore has strategic implications for the Government's 2016 zero carbon target for new housing[2].

The challenges and barriers to be overcome in the move to delivering energy efficient homes are considerable. Culturally, the UK has no tradition of energy performance measurement, nor of design and production processes that follow sound manufacturing principles, in which measured performance is fed back to create system improvements. The core of the issue has been identified in a series of reports on the construction industry going back to the end of World War II – most recently in the Egan report almost 10 years ago. At a purely technical level, the problem is that too little measurement and analysis of energy performance is undertaken. Lack of data on performance is coupled with and reinforces low levels of knowledge and understanding throughout the design and construction chain in regard to the principles of effective thermal envelope and systems design, with the result that these key principles are neither well-understood nor prioritised within design or construction processes.

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[1] We offer two specific examples in support of this. The first relates to fabric performance. As levels of insulation improve, the gap in performance between insulated and uninsulated fabric increases in both relative and absolute terms. Uninsulated wall has a U value of around 1.5 W/m^2K. The 1995 Revision of the Building Regulations required wall U values of 0.6 W/m^2K. The 2006 Revision of the Building Regulations results in U values of around 0.3. The relative difference between uninsulated and insulated wall has grown from a factor of just under 3 to a factor of 5; in absolute terms, the difference has grown from around 0.9 W/m^2K to around 1.2 W/m^2K. One of the causes of underperforming insulation is the thermal bypass mechanism that was first described in detail in the course of the Stamford Brook project. Since that work was published (http://bse.sagepub.com/cgi/reprint/28/2/161) significant thermal bypasses have been discovered in all major forms of domestic construction (load-bearing masonry, timber framed and steel framed).

The second relates to heating system performance. Condensing gas boilers have a nominal efficiency in the region of 86-91%. Poorly performing condensing gas boilers have been found to have efficiencies 5-7 percentage points lower. A good electric heat pump may have a coefficient of performance (efficiency) of 300%, but typical performance is likely to be in the region of 150%, a factor of two worse. It appears likely that underperformance on this scale or greater will become increasingly common as energy conversion systems in dwellings become more complex. Work by the LowCarb4Real team suggests, for example, that it is not uncommon for solar hot water heating systems not to work at all.

[2] Members of the LowCarb4Real team are sceptical of the appropriateness of the Government's zero carbon target. Lessons from LowCarb4Real are however, as relevant to the task of constructing homes with very low emissions as they would be to zero carbon homes.

The question that arises from the above is why has a culture of measurement, feedback and product improvement that is common in other industries not developed in the construction industry? A team consisting of University College London, Leeds Metropolitan University, the Good Homes Alliance (whose members have been pioneering the construction of energy efficient homes around the country), and Leeds University have attempted to address this question through the LowCarb4Real project. This has drawn on a pioneering, six-year Participatory Action Research study of more than 700 new build homes at Stamford Brook, undertaken by Leeds Metropolitan University, which has established the existence of a significant gap between predicted and actual energy demand in new low energy housing.

Using a participatory knowledge exchange approach, the project team has worked with design and construction professionals, developers and policymakers to reflect on evidence from Stamford Brook and to develop a new model for knowledge transfer, to address gaps in technical knowledge and understanding within the industry. Evidence from Stamford Brook shows that the performance gap is more than a narrowly technical issue; the project has therefore been built around a series of five workshops that aimed to support mutual learning on three levels – technical, on-site management, and system transformation. Feedback shows that a combination of:

- clear, visual presentation of research evidence on performance, with
- opportunities to work through and discuss the issues in a workshop format, and
- examples of good practice provided by members of the Good Homes Alliance

produces significant improvements in self-reported knowledge and understanding amongst all groups of workshop participants. Recorded responses from participants also suggest improvements in awareness of the problems and their solutions, and perhaps even more importantly, of personal commitment to improve practice.

Significant insights have been gained from working on the issue of system transformation. The analysis of workshop participants' responses suggested that the difficulty of defining a business case for improved performance in the absence of higher energy prices or enforcement of regulation, difficulty in retaining skills and knowledge in individual firms against a background of extensive sub-contracting of work, difficulty in developing small, multi-skilled teams against a background of prevailing patterns of education and training and the problem of holding skilled teams together through the current collapse in new house construction are challenges facing the industry. The major lesson from LC4R is that the key to low carbon housing is not just how to facilitate learning, but how to enable industry to retain and apply it.

Key project objectives

The origins of the project lie in the recognition that knowledge exchange is a two way and multi faceted process. Valuable though the lessons and insights from Stamford Brook and the GHA experience are, their absorption, adoption and impacts are primarily determined by the culture and structure of the house building industry. To maximise the value of research and experience in the development of low carbon housing it is important that all sections of the house building industry are able to share their knowledge of the industry and of the issues and barriers that arise when seeking the sort of fundamental change that is needed to achieve the demanding targets for low carbon housing set by the government in the light of the need to mitigate climate change mitigation and achieve security of energy supply. This project seeks to facilitate an exchange of knowledge and understanding that would support such change.

The objective of the project, as set out in the Project Evaluation Plan, was to facilitate knowledge exchange based on two key areas of learning:

> key technological issues in the design and construction of low carbon housing in the mainstream, and
>
> the development of improved housing procurement and building processes designed to ensure that low carbon performance is reliably achieved.

In each area, the programme was intended to develop not only the specific lessons from the research but to tease out the underlying lessons that will enable technology and processes to be adjusted and redesigned as the industry moves towards the goal of zero carbon housing.

The project response

Programme

The project work programme is set out below:

stakeholder analysis	January, February 2008
workshop planning	March, April 2008
initial workshop	June 2008
review	June 2008
workshops 2-5	June, July, September 2008
strategic forum	October 2008

Stakeholder analysis and workshop planning

A stakeholder analysis was undertaken at the outset of the project to identify organisations that should be included in a project advisory group and to inform the process of recruiting workshop participants. The results are shown schematically below.

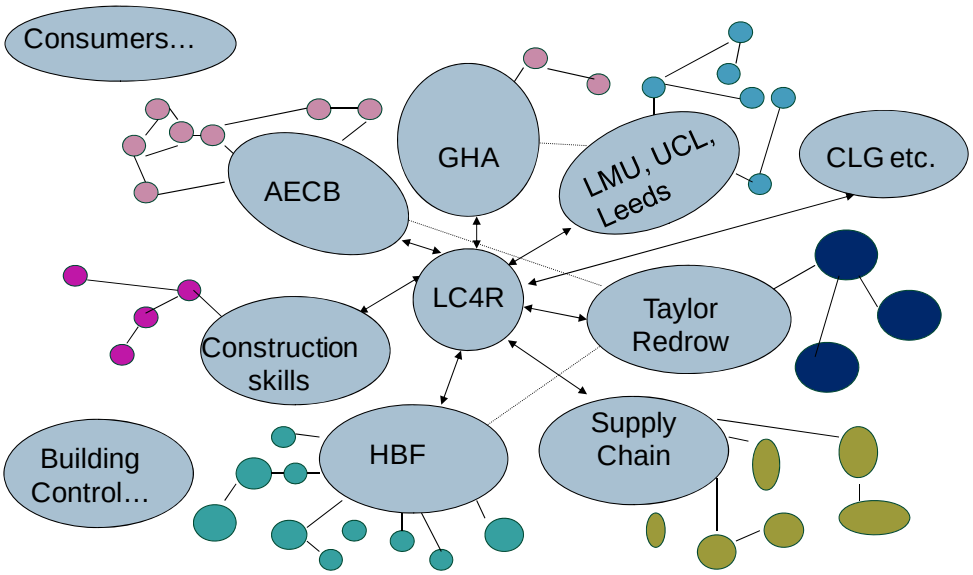

Figure 1. Stakeholder analysis.

A preliminary analysis of the problem of changing practices in the construction industry was also undertaken to inform the workshop structure and content. This resulted in the 3-level model of learning set out in Figure 1. Direct learning from Stamford Brook was primarily at levels 1 and 2, but levels 3 and 4 are also crucial to improved performance. The workshops were therefore aimed both to develop an effective approach to transferring knowledge at levels 1 and 2, and to capture views on the wider constraints of a wide range of industry professionals. These views from the workshops were then fedback to senior industry executives and policy makers at a Strategic Forum held at the end of the project.

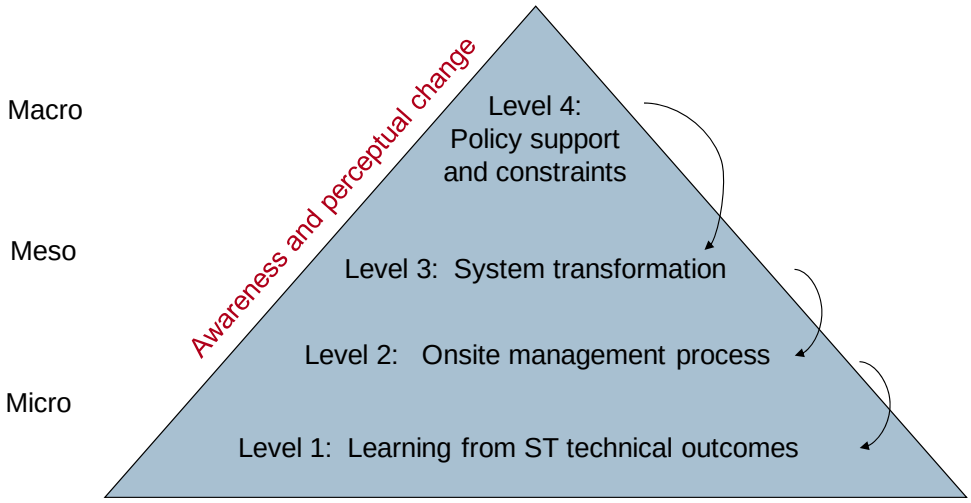

Figure 2. Learning model.

The workshops

Workshops were attended by a wide range of industry professionals. The breakdown is shown as below:

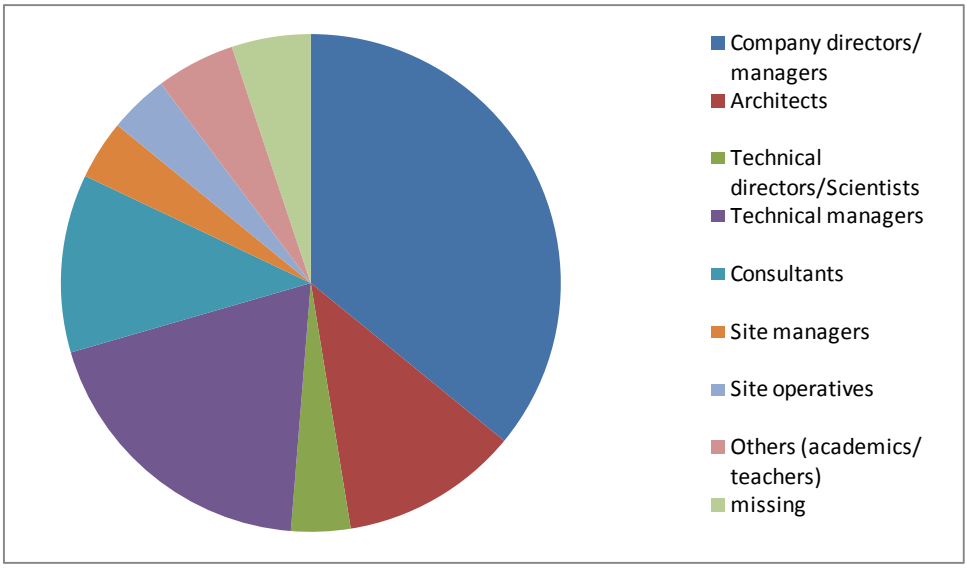

Figure 3. Breakdown of workshop participants' professional roles.

The project team found it difficult to recruit site operatives, but the small numbers that attended made valuable and positive contributions to the workshops and their evaluations were very positive.

The project programme consisted of five knowledge sharing workshops which brought together housebuilders, designers, academics, architects and a range of construction industry

practitioners. The starting point for the workshops was an explanation of findings from the Stamford Brook trial, along with insights from field experience of building low energy housing provided by members of the Good Homes Alliance. This knowledge informed a series of discussions and exercises during which participants worked their way into the problems and, through a series of exchanges and plenary sessions, developed insights into the technical issues and non-technical constraints to improved performance.

Workshop programme and content	
09:30 – 10:00	Registration & Preliminary Exercise
10:00 – 10:15	Welcome & Introduction to the Day
10:15 – 11:15	Overview of Stamford Brook Key Messages
11:15 – 11:30	Coffee Break & Posters
11:30 – 12:30	Breakout Groups – Session 1 – technical issues • thermal bridging and thermal bypasses • airtightness • systems performance
12:30 – 13:15	Lunch & Posters
13:15 – 13:45	Good Homes Alliance field experience and key messages
13:45 – 15:00	Breakout Groups – Session 2 - needs of design and construction
15:00 – 15:30	Coffee Break & Posters
15:30 – 16:30	Plenary Session – Developing A Road Map to 2016
16:30	Close

The workshop programme was changed significantly in response to suggestions from participants in the first workshop. By reducing the reliance on the series of posters produced by the Leeds Metropolitan University team and placing greater emphasis on breakout exercises and discussions, subsequent workshops became less didactic and more participatory, allowing attenders' voices to be heard.

GHA members made a key contribution to the workshops. The GHA developments presented were Bladon, a low rise scheme near Oxford and One Brighton, an apartment complex built by Kingerlee Construction, and a low-rise timber framed development at Stawell by Ecos Homes. Presentations on these schemes allowed workshop participants to place the technical information provided in the first part of the Workshops in a practical perspective, and to tease out technical, process and contextual factors that were responsible for both successes and failures. This deepened the learning of all participants, including the LowCarb4Real team.

The importance of context was powerfully demonstrated by a discussion of the preparation undertaken by Kingerlee Construction for its low-rise scheme at Bladon. To ensure that it mastered a novel construction technique using hollow clay blocks, the company took its entire construction team on a study visit to a site in Germany. There they discovered that a small, closely knit and multi-skilled team of builders were able to build the shell of a house in roughly one third the time taken in the UK. Key factors appeared to be the trust built up between members of the team and the ability of the team to retain and refine learning and skills.

Knowledge exchange

Workshop outcomes

The Workshops were evaluated by using a questionnaire designed to capture the extent of level-1 learning. Participants were asked to record rate their knowledge under ten headings on a ten-point scale, at the start and end of each workshop. The difference in scores is a rough measure of the direct impact of LowCarb4Real on knowledge of participants. Scores for nine of the categories are shown below. Knowledge shifts were statistically significant for:

- “ability to do a pen-on-section test for air barrier or insulation continuity”,
- “understanding of the principles of thermal bypassing”
- “ability to identify constructions likely to be at risk of thermal bypassing”

A breakdown of total knowledge shift by professional role showed remarkably little variation between roles – all categories of participants were able to benefit from the LowCarb4Real workshop process. It is worth noting that a number of the participants at the workshops were already knowledgable in these areas[3] and as a result had small knowledge shifts. Presence of these individuals pulled the average knowledge shifts down.

[3] They attended despite this and their evaluations of the workshops were positive, in many cases highly so.

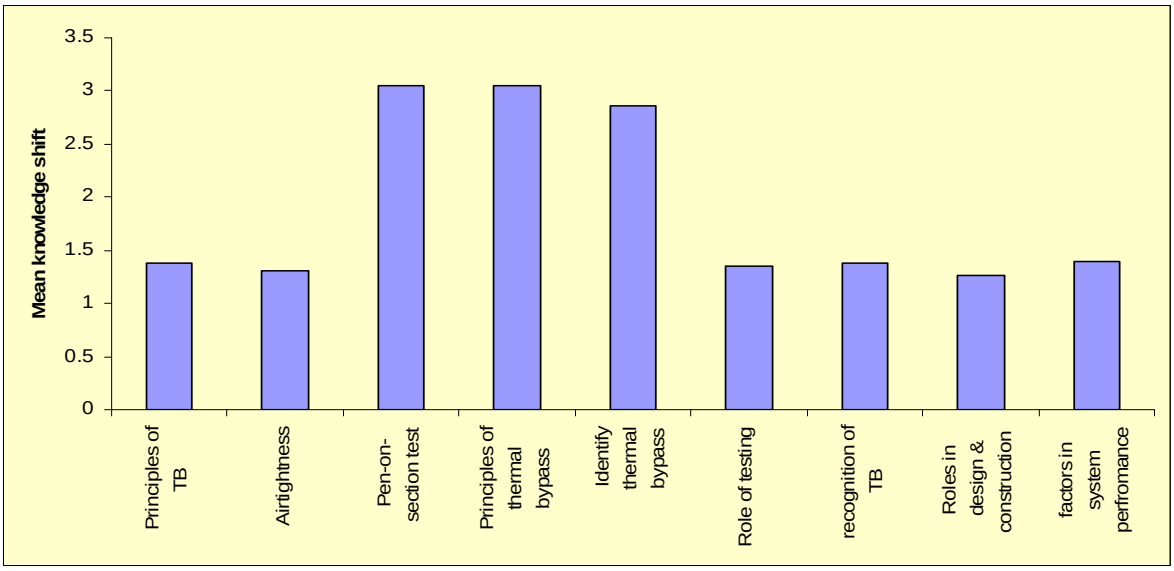

Figure 4. LowCarb4Real knowledge shifts. The vertical axis represents movement on a ten point scale on which 1 represents “no knowledge” and 10 represents “complete knowledge”.

In the second breakout session in each workshop, all participants were asked to reflect on the needs of designers and construction teams. Individual responses were recorded on more than 700 post-cards. These were analysed to identify areas in which change was needed to support improvement in energy performance, and to identify key imperatives for change shown in figure 5.

This analysis of responses from workshop participants was then fed forward to the Strategic Forum. This is discussed below, but the reader may wish to refer to the final project report for a more detailed discussion. This analysis must be taken as provisional – further analysis of outputs from both workshops and strategic forum would be needed to take this forward.

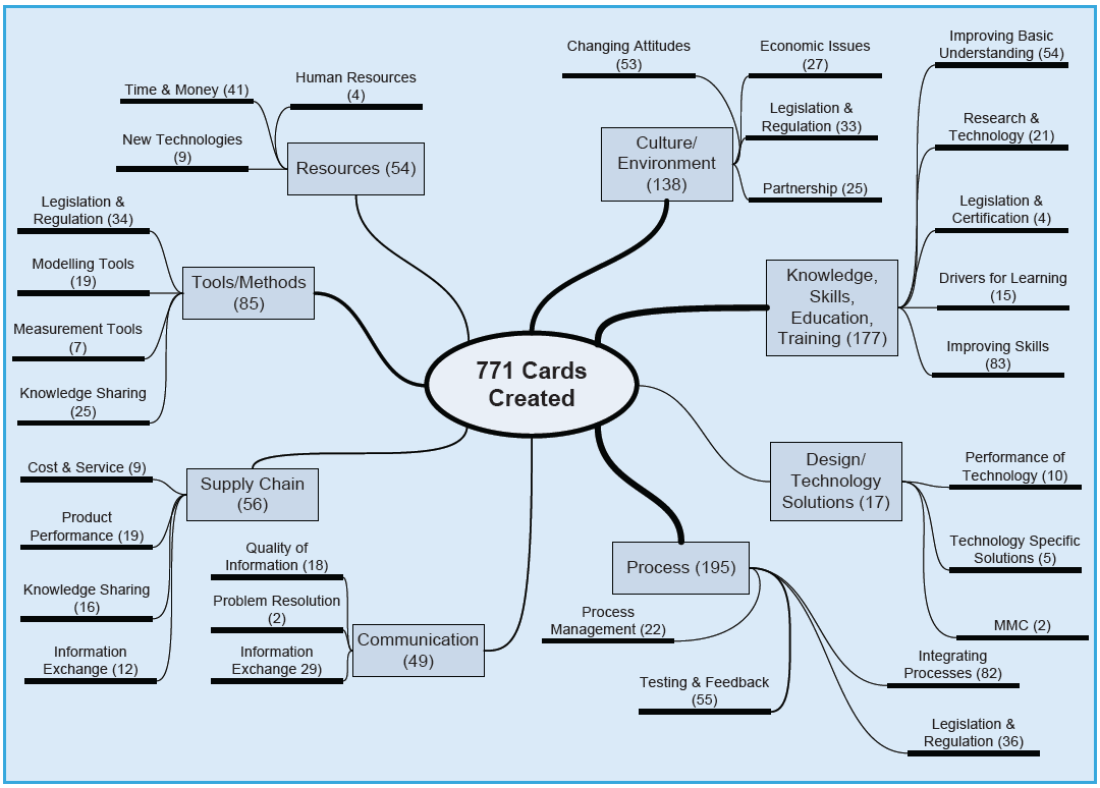

Figure 5. Identifying change categories.

The strategic forum

The final evaluation workshop was held at UCL on 30th October 2008. Titled “Closing the Gap: A Strategic Forum on the Energy Performance of New Housing” an invited audience of policymakers, industry professionals and other influential stakeholders evaluated the implications of the outcomes from the previous workshops for the development of policy for re-engineering the industry and its regulatory framework in a Low Carbon world.

The Strategic Forum took a similar format to the workshops. Outcomes and issues raised at workshops were presented by the LowCarb4Real team. Workshop participants, a small builder, an architect and a major developer, presented their reflections on LowCarb4Real and the learning model it represents. Breakout groups then discussed potential actions and ways forward with respect to a number of change categories, and raporteurs presented potential responses by Government, industry and other stakeholders to reduce the gap between as-designed and as-built performance in a plenary discussion. The Forum continued the analysis of issues identified in workshops, but with somewhat limited success in terms of developing potential solutions. This perhaps highlights the possible lack of drivers, resources and incentives for implementing change, together with the pressures of the Building Regulations review on senior industry figures and civil servants, and the profound impact of the economic downturn.

Education and training

The LowCarb4Real advisory group included Construction Skills – it is expected that output from the project will feed into developments in training through this route. LowCarb4Real has demonstrated successful knowledge transfer in three key areas – thermal bridging, airtightness and thermal bypassing and it is likely that the approach developed by the project will be widely used in training and education in these areas.

Output from the LowCarb4Real project has already fed into the development of a Low Carbon Housing Learning Zone, part of Leeds Metropolitan University's participation in the Construction Knowledge Exchange (a network of 22 centres of knowledge exchange activity to support higher education institutions working with business and the wider community) in conjunction with AECB (The Association for Environment Conscious Building). Workshop materials are publicly available on-line and this material feeds into a number of courses at Leeds Metropolitan University.

University College London Energy Institute and Loughborough University have recently won £5.8 million to establish a Doctoral Training Centre in Energy Demand Reduction in Buildings. LowCarb4Real outputs will feed into the development of an MRes course which will provide the taught element of doctoral training at this centre.

Project impact

Given that the LowCarb4Real project began with the Stamford Brook project, it is perhaps worth summarising the key lessons from that project. These were that:

- Technical change and improved performance are possible. Dwellings at Stamford Brook had roughly half the air leakage of typical dwellings of the time, and around half the heat loss. This conclusion was particularly important in the light of the view, widespread in the early years of this decade that site-built load-bearing masonry construction could not be improved and represented a technological dead end.
- Unless performance is measured, it is hard to make and sustain change. This was most clearly visible in respect of air leakage, which demonstrated a robust tendency to drift upwards between campaigns of pressurisation testing.
- Change does not stick unless cultural and structural issues are dealt with. Note that this lesson was fully corroborated by GHA contributions to the LowCarb4Real workshops and was not disputed by any of the workshop participants.
- The construction industry is complicated and academic support for change works best in a participatory framework. The best illustration of this is that the technique used at

Stamford Brook to make walls airtight was proposed and demonstrated not by the academic, but by the developer partners in the project.

LowCarb4Real built on these lessons in a number of ways, but the real contribution of both projects has been to reveal the technical, social, cultural and structural complexity of the housebuilding industry, and to demonstrate models of participatory, industry-based research and knowledge exchange needed to make very low carbon housing a reality.

Lessons from LowCarb4Real are being taken forward in a number of ways. UCL is currently working with Barratt Homes on an investigation of the performance of the Barratt Greenhome, one of the UK's first code 6 homes at the BRE Innovation Park and Leeds Metropolitan University is working with the Joseph Rowntree housing trust on a code 4 housing scheme incorporating heat pump technology. The intention is to use participatory techniques developed from LowCarb4Real to engage with the design and construction teams responsible and to work through issues that emerge from monitoring.

The workshops and strategic forum identified regulation as a key area for improvement, with deficiencies in the system of regulatory advice and the disjunction between Building Regulations and the Code for Sustainable Housing currently causing problems for house-builders. Lessons from LowCarb4Real have been fed into the ongoing review of Part L of the Building Regulations, through the establishment of a working group dealing with compliance and feedback.

The Future

One of the most important current developments for the UK construction industry is around proposals for dealing with the existing housing stock. The experiences gained from LowCarb4Real has enabled members of the project team to inform the agendas of a number of organisations - TSB, English Heritage, the Homes and Communities Agency, CLG, the Zero Carbon Hub, Arups - on how major refurbishment programmes should be constructed and supported, particularly with respect to the importance of engagement between industry and academia. LowCarb4Real team members have also been actively involved in activities such as the DIUS Foresight investigation into Sustainable Energy Management and the Built Environment.

It is not possible to conclude this piece without acknowledging the extraordinary situation that the housebuilding industry now finds itself in, having gone from an extended boom to the deepest recession in decades. The impact of the recession has been felt not just in a general sense. Individuals who were intimately involved in the Stamford Brook Project and who were in a position to make a major contribution to reducing energy use and CO_2 emissions from new housing have left the industry. Colleagues who are still employed in the industry are battling to keep their

companies afloat. Periods such as this have been described by the economist Joseph Schumpeter as “gales of creative destruction”. We consider that this may be an unrealistically optimistic description of what is currently happening in the UK housebuilding industry.

Further information

Further information on Stamford Brook, LowCarb4Real and related topics can be found at:

http://www.leedsmet.ac.uk/as/cebe/projects/lowcarb4real/index.htm

http://www.leedsmet.ac.uk/as/cebe/projects/stamford/pdfs/del8execsum.pdf.

http://www.goodhomes.org.uk/

http://www.cke.org.uk/

http://www.aecb.net/index.php

http://www.ucl.ac.uk/energy/