Information Paper 9/13

Lessons from AIMC4 for cost-effective, fabric-first, low-energy housing

Part 1: Introduction to AIMC4

Paul Cartwright and Christopher Gaze

This Information Paper is Part 1 in a series of four papers about the AIMC4 applied research project, which was created to research, develop and pioneer the volume production of low-carbon homes for the future that would achieve Level 4 (energy) of the Code for Sustainable Homes without the use of renewable energy.

Part 1 introduces the AIMC4 project and describes the process of translating its objectives into innovative solutions to meet the project targets. Part 2 covers the supply chain development phase of the project – the process of working with suppliers to develop products and build solutions to meet the technical specification. Part 3 focuses on developing detailed technical specifications for the homes, and Part 4 on understanding value for the end user and making the construction process as efficient as possible.

This series of Information Papers seeks to draw together the AIMC4 story in one place as a reference point for industry, government and other stakeholders. The lessons learned cover issues that are relevant to the volume production of low-energy homes, which will be important for all builders and developers as regulations develop in the future.

Introduction

The AIMC4 project has five core objectives:

- To develop a better understanding of consumers, their needs and aspirations relating to low-energy/low-carbon homes and their response to a range of possible technology solutions.
- To research and develop (interactively with the supply chain) new design approaches and build processes that will drive innovation in the existing supply chain and stimulate the emergence of new suppliers and partnerships. In parallel, this will accelerate the development of new materials, components and systems, creating a supply chain capable of delivering a range of innovative products to support a 'fabric-first' approach from within the UK to drive cost efficiencies.

Figure 1: An AIMC4 home built by Crest Nicholson

Box 1: AIMC4

AIMC4 is a unique partnership of companies, created to research, develop and pioneer the volume production of low-carbon homes for the future. It stands for 'the application of innovative materials, products and processes to meet the Code for Sustainable Homes Level 4 energy performance'.

The AIMC4 consortium was set up in 2009 to develop and apply innovative materials, products and processes to meet Level 4 energy requirements of the government's Code for Sustainable Homes, through innovative fabric and building services solutions only, thus embedding reduced carbon emissions within the performance of the dwelling.

The consortium members comprise: developers Stewart Milne Group, Crest Nicholson plc and Barratt Developments plc, which were responsible for the design and build of the energy-efficient homes; BRE, which advises on innovative solutions and evaluates the technical issues; and H+H UK Ltd, a supplier of aerated concrete (aircrete) products. BRE Scotland is analysing and evaluating both the performance of the homes and occupant responses and behaviours.

The ground-breaking project cost £6.4 million overall: £3.2 million was invested by the government-backed Technology Strategy Board with the other £3.2 million coming from the consortium members.

The key to the success of the project has been to engage with both known and new suppliers at all levels to develop design solutions and processes to deliver homes that meet Code Level 4 energy requirements through energy-efficient fabric and building services solutions, without requiring the use of renewable technologies.

Achieving this goal will not only assist in meeting the government target of zero-carbon homes by 2016, but will reduce costs, introduce new product suppliers and supply chains, generate new construction methods and ensure that homes are designed to meet consumer needs without confusing or costly technologies.

- To design and develop a minimum of 12 homes that meet consumer needs and deliver to energy standards of Level 4 of the Code for Sustainable Homes[1], with a fabric-first solution. These will be built in various locations across the UK and sold on the open market.
- To use project outcomes at all stages to broaden wider industry knowledge and capability.
- To underpin the cost-effective volume delivery of the energy-efficient homes of the future with occupant-centred design to meet government timescales.

The timeline for the different stages of the project is shown in Figure 2.

The concept

The concept of AIMC4 was born from a consensus between the consortium partners that they wanted to develop robust technical and commercial solutions to meet the energy requirements of Level 4 of the Code for Sustainable Homes using fabric-first solutions and in advance of the anticipated changes that will apply in England* to Approved Document L1A[2]. The partners had become increasingly concerned that the technical changes to home design resulting from the regulatory push did not sufficiently take into account consumer views and home occupier reactions. Unless the new low-carbon homes of the future are consumer friendly, the risk is that forecast emission reductions will not be delivered in reality.

The project had three key stages. The first was the pre-construction stage involving development of the supply chain and the design/technical specification, which were interactive and iterative processes that involved not only the supply chain but also the developers' construction teams. The second stage was delivery, ie the construction phase. The third stage was as-built performance evaluation followed by a 12-month post-occupancy study. Dissemination of the findings has been a continuous process throughout the project, via technical papers, conferences, exhibitions and seminar presentations, press releases and visits to the AIMC4 sites.

* Building Regulation powers were transferred to Wales on 31 December 2011.

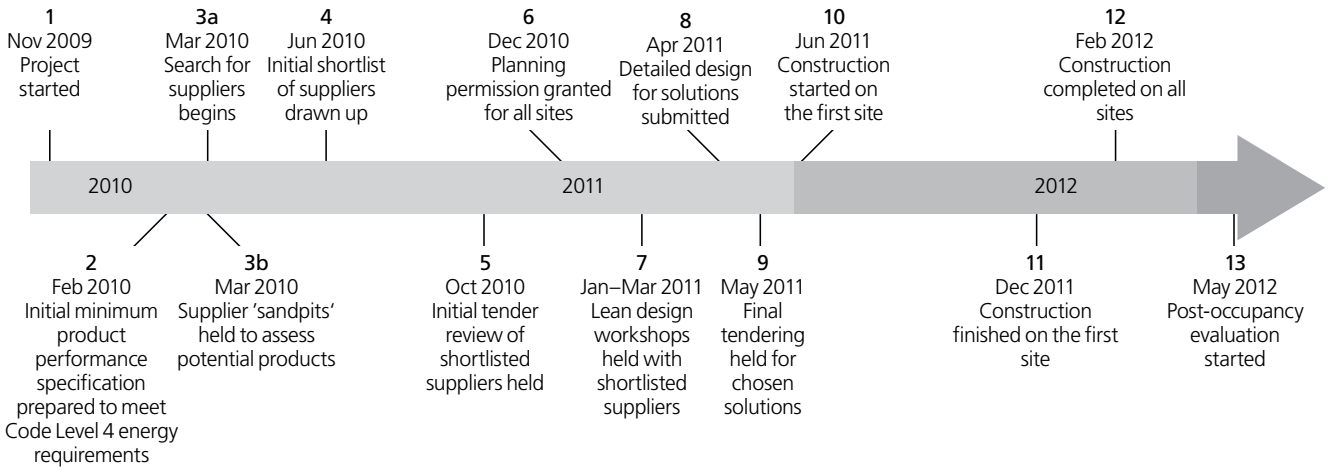

Figure 2: Timeline of key project milestones and outputs

The challenge

Figure 3 illustrates best practice understanding when the project began. Code Level 3 energy standards required a 25% reduction in carbon emissions compared with the Building Regulations 2006 (England and Wales)[3]. Code Level 4 required a 44% reduction in energy. The best result for a fabric-only approach at the time was around 35% and that was for the specification labelled 'mid-code' on the top line of the diagram. The project had to bridge this gap.

Project aims

The project has sought to develop AIMC4 homes that are easy to run, efficient and reliable, and affordable for mainstream delivery in advance of the then anticipated changes to Approved Document L1A of the English Building Regulations in 2013. The specific aims of the project were to:

- build a minimum of 12 low-energy homes for private or public sale
- test the market for such homes
- understand the performance of and customer attitudes towards the homes
- develop two (possibly three) build systems and processes
- energise the UK supply chain and develop new and existing products
- take a significant step towards producing low-energy homes in volume
- achieve significant progress towards the goal of zero-carbon homes in 2016.

The development sites and homes developed

A total of 17 AIMC4 homes were built (Table 1). Barratt Developments selected a site in Corby to build four homes: one 4-bedroom detached house and one terrace of three houses (two with two bedrooms and one with three bedrooms) (Figure 4). They were built using H+H UK's thin-joint mortar masonry system.

Crest Nicholson built five homes: one detached and four townhouses (Figure 5). They have been developed at Noble Park, the site of the former West Park Hospital in Epsom, Surrey. One of the homes was constructed using H+H UK's thin-joint mortar masonry system whilst the other four units were constructed using Kingspan TEK's structural insulated panel (SIPs) system.

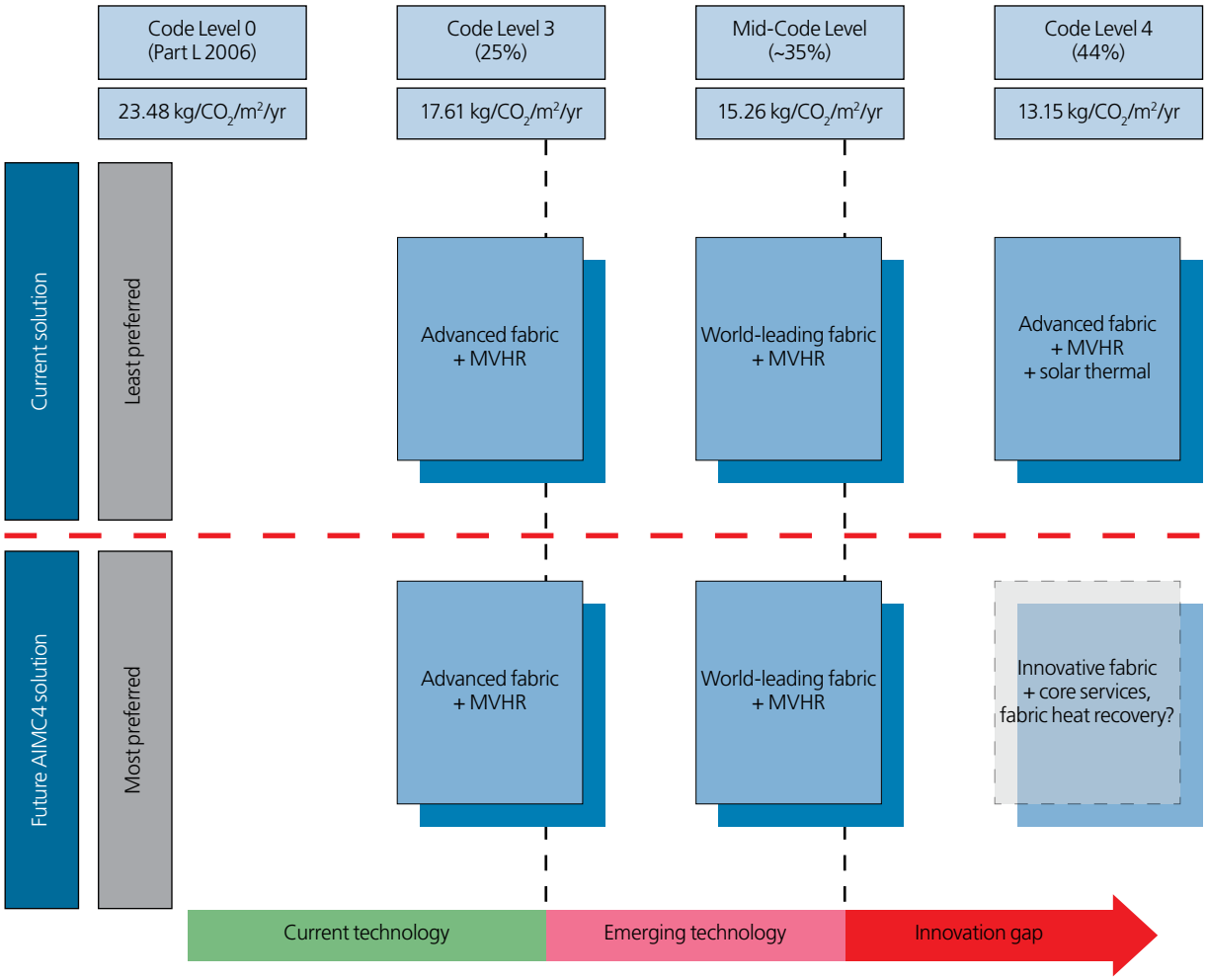

Figure 3: Best practice understanding at the beginning of the project in 2009 showing a potential 'AIMC4 solution' compared with the 'current solution'
MVHR – Mechanical ventilation with heat recovery.

Table 1: Summary of sites and house types

Developer	Barratt Developments	Crest Nicholson	Stewart Milne Group
Site(s)	Meridian Park, Corby, Northants	Noble Park, Epsom, Surrey	Leathan Meadows, Portlethen, Aberdeen Athena Grange, Prestonpans, East Lothian Adelphi Road, Preston, Lancashire
Type and number of homes	One detached 4-bedroom home using H+H UK thin-joint masonry One terrace of three houses (two with two bedrooms and one with three bedrooms) using H+H UK thin-joint masonry	One 4-bedroom detached home using H+H UK thin-joint masonry Four 4-bedroom townhouses using Kingspan TEK SIPs	Two 5-bedroom detached homes using the Sigma II Build System (closed-panel timber frame) Three 2- and 3-bedroom terraced homes using the Sigma II Build System Three 2-bedroom terraced homes using the Sigma OP4 open-panel timber-frame system

Box 2: The Code for Sustainable Homes

The Code for Sustainable Homes is part of the government's programme to improve the sustainability of new dwellings, with the major aim of achieving national targets for reducing carbon dioxide emissions, but it takes a more holistic approach by considering a wide range of environmental and social impacts of new homes. It is used in England, Wales and Northern Ireland.

The Code has six performance levels – Levels 1 to 6 – and assesses both new dwellings and the development site against nine categories. The category of relevance to this project is the mandatory requirement for energy efficiency at Code Level 4, which requires an improvement in dwelling emission rates of 25% over those set out in Approved Document L1A of the Building Regulations 2010 (England and Wales)[2]; this used to be a 44% improvement over the Building Regulations 2006 (England and Wales)[3], which is roughly equivalent.

At the start of the project it was anticipated that this dwelling emission rate would be incorporated into the English* Building Regulations in 2013.

* Building Regulation powers were transferred to Wales on 31 December 2011.

Stewart Milne Group built AIMC4 specification homes on three sites: two 5-bedroom detached homes were built on a site in Portlethen, Aberdeenshire (Figure 6); a terrace of three 2- and 3-bedroom homes was built in Prestonpans near Edinburgh (Figure 7); and a terrace of three 2-bedroom affordable homes was built in Preston, Lancashire, for Communities Gateway Association (Figure 8). The five homes built in Scotland all used variations of Stewart Milne's Sigma II Build System (closed-panel timber frame) whilst the three homes built in England used the more established Sigma OP4 open-panel timber-frame system.

Structure and process for successful management and delivery

To achieve the targets set by the project, the consortium (Figure 9) has had to establish a management structure and process to ensure effective project delivery to meet both the Technology Strategy Board's requirements and, as importantly, the expectations of each of the partners for successful collaboration and delivery. The first stage of this process was to sign a collaboration agreement and establish a structure for effective consortium working.

An initial collaborative planning workshop, facilitated by BRE, accelerated the integration of the partners into a team. By mapping out key challenges across time, and assigning responsibility, a series of work groups was created (Figure 10). Each partner provided representatives for the groups including an executive steering group, and a senior manager from BRE was identified and appointed as a dedicated AIMC4 project manager.

Finally, an external stakeholder group was launched to help the consortium gauge potential opportunities and barriers as work progressed, and to provide valuable feedback and discussion on the project's findings as they emerged. The stakeholder group comprises members from a wide church of interested parties including supply chain, valuers, mortgage providers, government, regulators and insurers.

Prior to stakeholder group meetings, the partner CEOs come together to review and steer the project; both these groups are chaired by Robert Napier, the chairman of the Homes and Communities Agency (HCA). The time invested in developing this structure produced a strong collaborative process between partners, ensured tight focus for deliverables and timescales, regular communication and clarity in communicating progress.

Project delivery

The four-year project has had to achieve key milestone outputs, some of which are shown on the project timeline in Figure 2. These will be dealt with in more detail within this series of papers.

Figure 4: Barratt Developments' completed AIMC4 homes

Figure 5: Crest Nicholson's completed AIMC4 homes

Figure 6: Stewart Milne Group's Portlethen site homes

Figure 7: Stewart Milne Group's Prestonpans site homes

Figure 8: Stewart Milne Group's Preston site homes

Figure 9: The project consortium

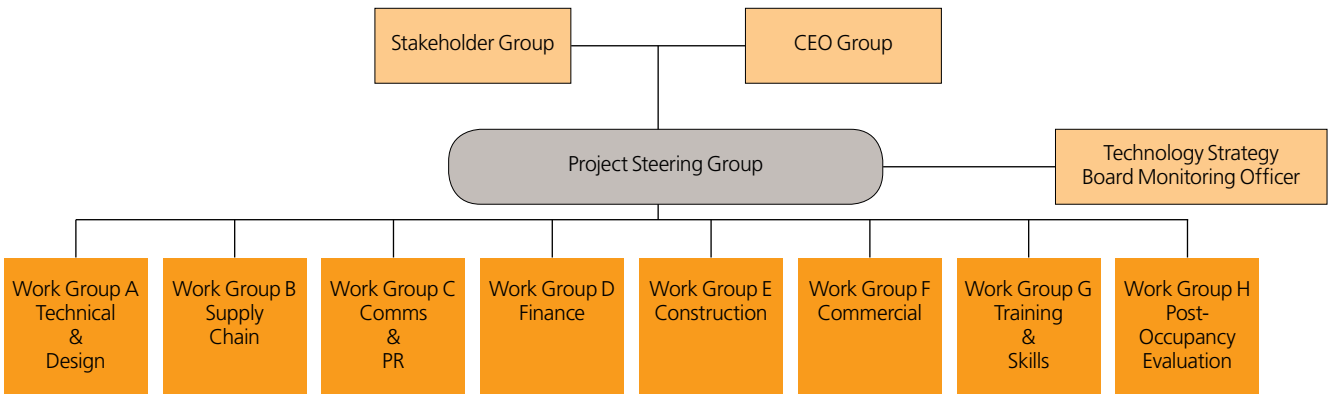

Figure 10: AIMC4 project management structure

Developing the technical specification

The first 18 months of the project involved a period of interactive technical discussions and assessments, not only within the consortium, but also with the potential supply chain. Through this process, robust baseline fabric technical specifications were developed.

Developing the technical specification required modelling using the Standard Assessment Procedure (SAP)[4, 5] to establish target technical specifications for key product types, including minimum performance levels of insulation materials for floors, walls and roofs, ventilation systems and hot water systems. The first stage of modelling established the criteria by which potential suppliers could be assessed.

Apart from the sheer difficulty of achieving these technical requirements, there were also some regulatory challenges. The main one was the delay in changes to SAP as a result of new Building Regulations when the new Approved Document Part L1A came into force in October 2010. Until the Building Regulation changes were confirmed in November 2010, a consultation version of the software had to be used, with unknown levels of variance from the final one. The consequence was that the SAP ratings could not be confirmed until a final version was released, resulting in an unavoidable delay to the project.

Supply chain

Following the development of an initial technical specification, the process of finding suppliers with the potential to develop products to meet the requirements began. This involved a novel approach to engaging with suppliers that was key to the success of the project. Ecobuild 2010 was used to publicise the search. The search focused not only on the construction industry, but also aimed to reach suppliers to non-construction sectors such as the automotive and aerospace industries.

A pre-qualification questionnaire was used to gauge interest from suppliers and to gather technical and commercial information against which capability could be assessed. The consortium was searching for suppliers who not only had the potential to meet the technical requirements, but who also shared the values of the project and could demonstrate that they could work collaboratively with others to improve value and/or drive down cost. Product assessment involved a number of stages, including a series of 'sandpits' – interactive workshops where potential suppliers worked together and developed novel approaches, partnerships and potential new products. Successful suppliers attended two sandpits. The process resulted in a shortlist of 33 suppliers who went through to the final phase of assessment, which included customer focus groups and a series of design workshops focusing on specific product groups.

The final tendering stage was in two phases. The first was against generic house types, and the second was for the 17 AIMC4 homes that were to be built. The tender process also included a vital mid-tender face-to-face discussion process to ensure good communication. By this means products were selected that would give the most cost-effective (in the medium term) whole-house solutions, whilst remaining technically robust.

The final solutions for each of the sites and their respective house types were then finalised ready for construction. This included subjecting the homes to dynamic thermal modelling to check for any risk of overheating.

Box 3: The stakeholder organisations

- British Board of Agrément (BBA)
- CITB
- Construction Products Association
- Council of Mortgage Lenders (CML)
- Department for Communities and Local Government (DCLG)
- Energy Saving Trust (EST)
- HBOS plc
- Heating and Hotwater Industry Council (HHIC)
- Homes and Communities Agency (HCA)
- Hot Water Association (HWA)
- Lloyds Banking Group
- Local Authority Building Control (LABC)
- NHBC
- Royal Institution of Chartered Surveyors (RICS)
- Scottish Government Building Standards Agency (SBSA)
- Technology Strategy Board
- Town and Country Planning Association (TCPA)
- Welsh Assembly Government
- Zero Carbon Hub
- Zurich Insurance Group

Understanding value and applying lean techniques

Understanding value begins with understanding the needs of the end user; in this case the eventual occupant of the home. Products with which the end user interacts, eg controls, ventilation systems and windows, were analysed in customer focus groups. Feedback was then provided to the manufacturers, and taken into account in the tender process.

During the final phases of supplier selection a series of 'lean design' workshops was held to confirm details of the candidate products, including how they interfaced with other products, and to establish efficient methods of delivering a highly insulated fabric structure.

The application of lean techniques continued into the construction phase with pre-start collaborative planning workshops to plan the programme and look at ways to reduce delivery time and costs. The site work was then measured with BRE's activity sampling tools CALIBRE[6] and SMARTWaste[7]. After construction, a build process evaluation was carried out to examine potential cost savings in the process through improved labour and material efficiency.

Post-construction evaluation

A critical part of the project is the post-construction evaluation in order to understand how the homes perform, not only against technical criteria, including energy efficiency and carbon emissions, but also in terms of occupant satisfaction, ie how happy the occupants of the homes are with their living environment.

The first stage of the evaluation was an as-built evaluation of the energy efficiency of the AIMC4 fabric performance. In order to understand the actual thermal performance of the fabric, co-heating and heat flux tests were carried out prior to occupation. Thermal imaging was also used during the co-heating test to identify any potential areas of thermal bridging and/or air leakage (Figure 11).

The second stage of the evaluation, which started in 2012, is the post-occupancy evaluation, measuring in-use energy performance and customer behaviours. Information is being gathered to better understand lifestyles and living habits, how occupant behaviour affects a home's performance and how well the home provides thermal comfort and effective control of the building services. Tailored home user guides have been produced for the residents of each of the dwellings, including quick-start guides for specific technologies such as heating controls and ventilation systems. The home demonstration will be particularly important and will be reviewed to allow learning opportunities.

All homes will be subject to a comprehensive environmental audit to establish what equipment is being used in the homes and the potential energy use of that equipment. Electricity, gas and water sub-circuits will be monitored. Sensors will establish indoor air quality, temperature levels and the impact of opening and closing windows on the overall energy analysis. A weather station puts energy and ventilation use in the context of external conditions.

Everyone has a personal and subjective approach to comfort, heating and ventilation in their homes. The studies will include understanding how occupants react to having energy display meters available and whether they use the meters to adjust their behaviour.

The overall success of AIMC4 homes in terms of mitigating carbon emissions depends on how occupants live in their homes and whether their behaviour works to optimise the performance of the dwellings (and reduces their energy and water bills).

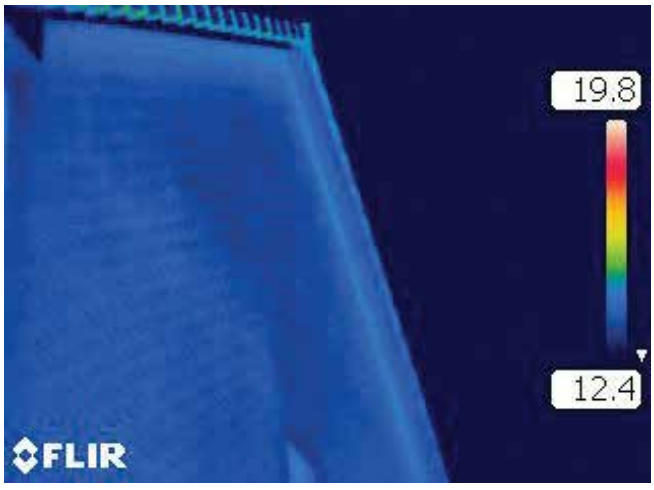

Figure 11: Thermal image of a gable end

Lessons learned

The key initial lessons learned from this project are:

- Early engagement between project partners is essential to build an effective and open collaboration with a clear project structure and clear roles, work tasks, communication and reporting channels.
- A phased approach with interactive assessment is essential to find the best suppliers and to facilitate partnering.
- The commercial challenge of achieving cost-effective delivery of homes to the energy requirements of Code Level 4 outweighs the technical challenge of the project.
- Engagement with sector stakeholders including government, trade bodies and policy influencers is essential to ensure the results of the project will be relevant not only to the project partners but also to the wider industry.
- Where projects are subject to external regulations and standards, some contingency allowance has to be made in order to allow for possible changes to them, eg the exact requirements of the Building Regulations some years ahead could not be known at the start of this project. This featured on the project's risk register, which was continuously updated.
- Research projects like AIMC4 would be considerably assisted if there were more consistency and certainty in government policy and regulations.

References

1. Department for Communities and Local Government (DCLG). Code for Sustainable Homes: technical guide. London, DCLG, 2010.
2. Department for Communities and Local Government (DCLG). The Building Regulations 2010 (England and Wales). Approved Document L1A: Conservation of fuel and power in new dwellings. London, DCLG, 2010.
3. Department for Communities and Local Government (DCLG). The Building Regulations 2000 (England and Wales). Approved Document L1A: Conservation of fuel and power in new dwellings. London, DCLG, 2006.
4. Department of Energy and Climate Change (DECC). SAP 2005: The government's standard assessment procedure for energy rating of dwellings. London, DECC, 2005, revision 3.
5. Department of Energy and Climate Change (DECC). SAP 2009: The government's standard assessment procedure for energy rating of dwellings. London, DECC, 2009.
6. Cartwright P, Brayshaw J and Hadwin P. Sustainable refurbishment of the BRE Victorian Terrace. Part 2: The construction process. BRE IP 12/11-2. Bracknell, IHS BRE Press, 2011.
7. Adams K, Blackwell M and Holt A. Saving money, resources and carbon through SMARTWaste. BRE FB 48. Bracknell, IHS BRE Press, 2012.

The project partners

The consortium members comprise developers Stewart Milne Group, Crest Nicholson plc and Barratt Developments plc, technical adviser BRE and aircrete supplier H+H UK Ltd. Stewart Milne Group also includes a timber-frame division, Stewart Milne Timber Systems, which provided the timber-frame systems for the houses that the group developed. The success of the project has to a large extent been down to investing the necessary time and resources at the beginning to build a strong consortium approach to delivering the project.

Commenting on the project, the partners said:

Our customers and our partners want low-carbon housing delivered at low cost and that is exactly what AIMC4 is delivering. By concentrating on a fabric-first solution we are driving important advances in materials, products and processes that will bring sustainable benefits to the house building industry and the UK supply chain.

Mark Clare, CEO, Barratt Developments plc

This is a ground-breaking solution to develop cost-effective fabric-first solutions to low-energy homes, with the consumer at the heart of the thinking. The collaborative approach is unique in the sector and draws in the skills and talents across the industry in one common goal.

John Slater,
Group Managing Director, Stewart Milne Homes

AIMC4 has demonstrated the value of collaboration, both between competing developers and within the supply chain. Achieving Code 4 at a competitive cost requires new product and building system solutions and new approaches to building assembly such as using lean construction techniques. It's not just about the products, but the way that they are put together and the new skills needed to achieve this.

Mark Oliver, Managing Director, H+H UK Ltd

AIMC4 is a testament to the power of collaborative research that drives the market to meet the challenges of 21st century housing. It is now paving the way for positive change in the future delivery of cost-competitive sustainable homes in the UK that are more affordable to run. The project's approach to procurement has been a key factor in its success and UK construction can learn from this.

Peter Bonfield, CEO, BRE Group

This exciting and challenging research project was exactly the bold step needed to address reduction in carbon emissions from new homes, and to drive delivery of government targets. Stimulation of innovation in the UK supply chain will yield new, cost-effective industry solutions and the wide expertise of the partners will ensure a step change to underpin the delivery of desirable, sustainable communities.

Stephen Stone, CEO, Crest Nicholson plc

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Technology Strategy Board
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BRE, Garston, Watford WD25 9XX
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