Work Package 4: Final Report

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BUILD WITH CaRe
ENERGY SAVING BUILDINGS

Contents

The Interreg IVB North Sea Region Programme
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1. Overview

- The overarching objective of Build with CaRe (BwC) was to promote energy-efficiency in urban and rural communities through the marketing of energy-efficient buildings to meet carbon reduction commitments. The ambition of BwC back in 2007 was not just to create a successful network for the duration of the project but to have a continuing impact after the end of the project.

- This Work Package has more than fulfilled its ambitions – as described in the following Sections. The transnational cooperation stimulated by WP4 and made possible by BwC has enabled the development in Norwich of the most ambitious passivhaus project anywhere in the UK and the initiation of a major new passivhaus building at the University of East Anglia. An outcome from these new projects will be learning about passivhaus technologies and construction by hundreds of enterprises in the East of England. These projects, and several others now being undertaken for the UK Government, would not have happened without BwC. Along with other work we have undertaken, these projects ensure that BwC will not only have continuing impact in the East of England but will help shape the promotion of low-energy construction across the UK and more widely in the N Sea region as transnational cooperation continues.

- Similarly for refurbishment, resulting from the same transnational cooperation that made the new-build projects possible, an innovative energy-efficiency project for existing homes, with up to C80 ambition (80 per cent reduction of carbon emissions from energy use), is now nearing completion in Norwich. This ERDF-supported work, which would not have happened without BwC, will likewise lead to learning across multiple enterprises and help develop refurbishment policy and practice in the UK.

- We have created the evidence base to underpin the development of both low-energy new build and also the major task of refurbishment of existing buildings across Europe. This evidence, and major reports that describe and discuss it, have been promoted to policy makers in Brussels and elsewhere. We identified significant and persistent barriers to progress in energy efficiency in Europe that were made visible during the debate surrounding the recent passing of the Energy Efficiency Directive. The work undertaken by this Work Package will be prominent in helping overcome these barriers.

- Monitoring of energy use, environmental parameters, and occupant perceptions, in passivhaus and other low-energy buildings in Germany, Sweden and the UK has provided abundant evidence of the planned-for energy efficiency and also of

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very positive occupant perception and well-being. This evidence from monitoring has likewise been widely promoted.

- We have engaged with financial players promoting more urgent activity in low-energy construction to ensure awareness of the evidence base we have created. In addition, through the networks created, private-sector funding of new passivhaus projects has been achieved. The virtual agency created will have increasing positive impact as these developments made possible by BwC mature and gain attention and influence.

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2. Evidence Base

It became clear near the beginning of the project that there were significant barriers to progress in energy efficiency in general, and to low-energy buildings, in particular, across the EU. These barriers existed across a wide spectrum and could be summarised as political and structural barriers (to do with political ambition, regulation etc), industry barriers (lack of ambition or willingness to change, for example), and social barriers (lack of awareness of the benefits of low-energy homes and buildings, for example). The clearest evidence for these barriers was the lack of progress in energy efficiency across the EU. While progress towards the EU mandates of twenty per cent reduction (relative to 1990) in greenhouse gas emissions and twenty per cent proportion of renewables in energy supply by 2020 was good, only half the twenty per cent target for energy efficiency relative to 1990 was being achieved.

Making buildings much more energy efficient is the biggest step change that can be made to achieve the wider energy efficiency targets. The generic barriers to progress in energy efficiency reflect a similar set of barriers that are inhibiting progress in energy efficient buildings. In other words, political, industry and social barriers are the biggest problem preventing BwC from achieving its overall objective. By comparison, lack of awareness of technical and lifecycle data is a minor issue. Because of this awareness, while we did not neglect the assembling of technical data, the whole BwC project agreed that progress would most effectively be made if the barriers were identified and means by which they had been tackled could be highlighted by this Work Package. Such a study is particularly appropriate for a transnational project such as BwC because an effective body of evidence can only be gathered from study of activities in several Member States and regions.

There is considerable documentation on the benefits of passivhaus living from the Passivhaus Institut and others including BwC partners in Germany. Nevertheless, the penetration of passivhaus standards for new build homes, even in Germany and Sweden where low-energy construction has been strongly pursued, is only a very small proportion of the total. Rather than a standard that can be achieved cost-effectively now, passivhaus has been seen in all countries primarily as something expensive today and only for the future – an example of the institutional barriers that exist.

The supposedly high cost of passivhaus compared to traditional methods of construction was one significant barrier, emphasised in Germany, for example, by a recent report: *Passivhaus, Effizienzhaus, Energiesparhaus & Co: Aufwand, Nutzen und Wirtschaftlichkeit (Passive House, Energy Efficient House, Energy Saving House etc: Costs, Benefits and Economics)* by Dietmar Walberg (in German) which received wide attention in Germany in 2010 and 2011.

According to Walberg, building a new house to passivhaus standards compared to German 2009 standards would cost, on average, an additional 30 per cent. He highlighted that this additional capital cost could never be regained through lower

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annual heating bills. This figure was widely assumed by the building industry in Germany to mean that passivhaus and similar highly energy efficient low-energy construction was not cost effective and would only be adopted by enthusiasts who would be responsible for only a few per cent of overall activity.

In fact, this 30 per cent figure is very debatable but very little evidence was easily available to present an alternative perspective. For example, the costs of items such as passivhaus windows and doors have come down since the study was made, and the work does not take into account the cost reductions that can be made if a passivhaus building design is value-engineered to optimise performance while reducing cost.

It was very clear that without identification of the barriers – either real, or asserted as by Walberg - and demonstration of how they could be overcome, progress towards low-energy buildings would be far slower than was either possible or desirable. While there was general awareness of the existence of barriers, many were not explicit. There was no clear description of them or how they impacted on progress in low-energy construction. Hence, as noted, with the support of all partners, the development of the evidence base focused on these barriers and how to overcome them with evidence from BwC partners prominent.

This work resulted in two definitive reports which have had and are having major impact across the region.

2.1. Refurbishing Europe

The first of these reports was *Refurbishing Europe: An EU Strategy for Energy Efficiency and Climate Action Led by Building Refurbishment*, Bruce Tofield and Martin Ingham, February 2012 (see http://www.buildwithcare.eu/news/231-refurbishing-europe for background and links to report, summary report and press releases).

Refurbishing Europe was a centre-piece of the BwC final seminar in Brussels, 7 March 2012 (see Section 4.5.3), and was distributed to MEPs, EU Commission officials, NGOs, and others in Brussels concerned with energy efficiency and low-energy buildings. The report outlined in detail why energy efficiency was so important if long-term climate change targets were to be met and how building refurbishment to low-energy standards was the single most important action that was essential if the necessary progress in energy efficiency was to be made. Key barriers were highlighted and examples of how these could be overcome were given. BwC projects highlighted including bauraum Bremen, building refurbishment in Västra Götalandsregionen and in Roosendaal Holland (see 2.3 below), and skill formation in AZB Hamburg.

Simultaneous press releases: *Call for tough new targets on EU energy reduction (Upprop för strängare mål för EUs energibesparing)* were issued by the University of East Anglia[1] and Västra Götalandsregionen and received wide attention in the press

[1] https://www.uea.ac.uk/mac/comm/media/press/2012/February/EU-energy-efficiency.

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and media. In the UK, ITV News broadcast a very well-received item covering both the benefits of living in a new passivhaus (filmed at Wimbish – Section 3.5.3) and also work on refurbishing an old Victorian home to energy efficient standards (see Section 4.5.6).

The report helped to firm up views among MEPs about the importance of energy efficiency and strong action on low energy buildings, and hence helped the passing of a stronger Energy Efficiency Directive than might otherwise have happened. Jean Lambert MEP, a Build with CaRe Ambassador, issued a press release (with the BwC logo prominent) following the BwC seminar in Brussels where she had addressed the meeting: *Green MEP demands tougher efficiency targets for Europe's buildings at final Build with CaRe conference*, Press Release, 8 March 2012[2]. Hence it is likely that the impact of BwC will be experienced in a positive manner across the EU for decades to come.

2.2. Delivering a low-energy building

The second report is *Delivering a low-energy building: Making quality commonplace*, Bruce Tofield, August 2012 (in draft). While a final version is still to be issued, a draft has been widely circulated and has received very favourable response and helpful comment from those outside the project in the UK who are also concerned to promote low-energy buildings.

While *Refurbishing Europe* focused in particular, as its title implies, on the low-energy refurbishment of the existing building stock across the EU, *Delivering a low-energy building* focuses, in particular, on new-build construction using particular examples to show how, with the appropriate quality approach from design through construction, passivhaus construction need be no more expensive that building to conventional codes and standards.

We identify the principal barrier preventing the necessary transformation as the "traditional construction model" where the quality in design and construction necessary to deliver a low-energy building cannot be delivered. Cost is not the principal problem but a change in attitude and approach is essential. We provide examples of how low-energy buildings have been delivered to no extra cost and identify the process steps that are essential.

In particular, we note that the new build apartments in Norwich designed to passivhaus standard (see Section 4.5.4) – that were conceived as a result of the BwC project - will be funded by private capital because the lifetime costs are seen to be lower than for conventional construction. This is a hugely important breakthrough – made possible by BwC introducing key people in Broadland Housing Group to passivhaus construction - and provides the foundation for future engagement with social housing and private sector developers to accelerate the introduction of passivhaus developments. Similar arguments apply also to private sector funders, especially where building for rent. We

[2] http://www.jeanlambertmep.org.uk/news_detail.php?id=769.

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anticipate this development will make possible a very substantial acceleration in passivhaus and low-energy construction in the UK and, we anticipate, across the NSR as a whole.

We highlight the 'performance gap', identified in a number of studies in the UK, where buildings thought to be 'leading edge' and of above-average energy efficiency almost always show much higher actual energy use for heating and cooling than the design estimates and energy performance certificates (EPCs) have indicated. The 'performance gap' is only revealed by detailed post-construction evaluation, but its existence means that, without a step-change in quality of design and construction, it will be impossible to meet energy efficiency and hence also climate change targets.

This failure to meet energy efficiency and climate change targets would be extremely serious, but will happen 'under the radar' if current attitudes and processes persist, no matter what building codes or standards might say. This is because, at present, there is very little post-construction evaluation undertaken. The existence of the 'performance gap' highlights the importance of the monitoring and evaluation work undertaken within this work package of BwC (see Section 3).

The problem of the 'performance gap' also emphasises an additional but extremely important reason for building to passivhaus standards. This is that the quality standards essential to deliver passivhaus successfully provide a considerable guarantee that energy performance design targets will be met. Achieving the passivhaus quality standard can only be accomplished if the quality standards which will also remove the 'performance gap' are adhered to. While the endemic quality issues surrounding the "traditional construction model" have been discussed in various places, there has been, until now, very little discussion about their negative impact on the successful delivery of energy efficiency targets for buildings.

The quality transformation necessary to deliver new buildings that perform as they should in respect of energy use applies with equal, if not greater, force to refurbishment of existing buildings. In *Delivering a low-energy building* we highlight the fact that if the energy 'performance gap' is a major concern for new build, it will be even more of an issue for refurbishment. Hence a transformation away from the "traditional construction model" is essential not only to deliver successful new low-energy buildings but also to ensure successful refurbishment of the existing building stock to low energy operation.

The two reports, *Refurbishing Europe* and *Delivering a low-energy building* are hence complementary and should be read as a pair.

To summarise, the key aspects of this transformation to a high quality process – detailed in *Delivering a low-energy building* - that must be followed if a low-energy building is to be successfully designed and constructed are:

- The brief must be clear and appropriate
- Innovation may be necessary but building operation must be simple
- Modelling of building performance is essential

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- Teamwork throughout is essential
- Design must be finalised before construction begins
- Attention to construction detailing is essential
- Post-construction evaluation is essential

While both reports have a UK focus, they discuss generic issues that are almost certainly present across the NSR and the EU as a whole. It would have been impossible to write them without knowledge and awareness of work in BwC partner countries, regions and cities that has been gained as a result of meetings and visits with partners and to projects in partner countries.

A particularly important and relevant project that was visited by BwC partners in April 2010 was the refurbishment of apartments at Brogården, Alingsås in Region Västra Götaland managed by Alingsåshem housing association[3]. Not only were these being refurbished to passivhaus energy standards as part of a comprehensive upgrade but the quality processes followed by the contractor, Skanska, were exactly those needed to ensure that a performance gap does not arise. The "traditional construction model" was abandoned in order to create a culture of teamwork and high-quality working that avoided the proliferation of defects that normally arise in construction, that lead to the energy "performance gap" and which are so often hidden and never revealed.

Hans Eek of the Swedish passive house centre described this work in a plenary presentation[4] at the Norwich BwC conference in October 2010 (Section 4.5.1). This Work Package was pleased to be able to highlight this work to underline the transformation in approach to quality that is essential if energy efficiency targets are to be achieved. These principles are now being followed in refurbishment work now underway in Norwich (Section 4.5.6).

2.3. Modern methods of construction

The quality standards essential if low-energy new buildings are to be successfully delivered can be achieved more easily in factory conditions than on site. Hence so-called "modern methods of construction", such as panellised construction – where pre-fabricated panels are delivered to site and erected – will be important in making possible large-scale passivhaus and similar new build and also refurbishment projects.

[3] A description of the apartments and their refurbishment together with other aspects of the work and the engagement of the occupants is given (in Swedish) on the website of the housing association, Alingsåshem, http://www.alingsashem.se/index.php?page=brogardens_ombyggnad. See also Skanska Case Study 64, *Brogården, Sweden* (in English), http://skanska-sustainability-case-studies.com/pdfs/64/64_Brogarden_v001.pdf.

[4] Presentation by Hans Eek, Swedish Passive House Centre, Build with CaRe conference, Norwich, October 2010, http://www.buildwithcare.eu/downloads/Public/Annual-Conference-2010/Presentations-Thursday-21-Oct/Hans-Eek-Passivhus-Centrum-Sweden-21-Oct-2010.pdf/.

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We were able to become a partner in just such a low-energy new-build project. Norwich-based housing association, Saffron Housing Trust, built a pair of new semi-detached homes in Diss using pre-fabricated panels manufactured in Sweden. We summarised the success factors from this project in a 2009 report: *Overcoming the Barriers to Low Carbon Construction: Saffron Housing Trust's Low Energy Homes at Skelton Road, Diss*, Bruce Tofield, November 2009[5]. Monitoring of these homes is described in Section 3.5.1.

This project has led to continuing work in the region to see how such panels can be constructed more locally; it is not economic to import panels from across the North Sea on anything other than an experimental scale. There is now a very good prospect that a new factory to construct panels for passivhaus and similar construction will be established in Norfolk. Such a prospect would have been very unlikely without the network established by BwC.

Through our BwC partner at Noord-Beveland, The Netherlands, we have been able, with partners from local East of England housing associations, to visit a major refurbishment project at Roosendaal in the south of The Netherlands where pre-fabricated panels make possible very rapid transformation of apartments owned by the housing association alleewonen. We have highlighted this project, which was cost effective for alleewonen, in *Refurbishing Europe* and more detailed information was given in the presentation[6] *High energy-efficient refurbishment in The Netherlands* by architect Erik Franke at the Norwich BwC conference in October 2010 (Section 4.5.1).

Through promotion via the conference and reports such as *Refurbishing Europe*, we have been able to present innovative developments such as the Roosendaal refurbishment to a wide audience, and also to use this awareness to help develop knowledge amongst owners and potential developers.

2.4. The UK Green Deal

The UK has proposed a concept called the Green Deal to promote refurbishment of homes and other buildings to better standards of energy efficiency. The key aspect of the Green Deal is that owners can obtain a loan against the property to undertake measures that can then be repaid as an extra charge on energy bills. Unlike a conventional mortgage for house purchase, a Green Deal loan will stay with the house even if ownership changes. However, there is little new money or subsidy proposed and a feature of the Green Deal, as promoted, is the so-called 'golden rule' whereby the extra charges for the work should be balanced (at least) by equal savings in energy bills.

5 See http://www.buildwithcare.eu/articles/78-partners/134-low-energy-homes-in-diss about the project and http://www.buildwithcare.eu/images/pdfs/overcoming_the_barriers-low_energy_homes_at_diss_norfolk_jul10.pdf to access the report.

6 This presentation may be downloaded from the conference page, http://www.buildwithcare.eu/articles/66-conferences/170-build-with-care-annual-conference-2010.

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The principle is, therefore, that the homeowner should pay no more each month than before but will have a more energy efficiency home. On the assumption that energy bills will continue to rise, the proposition is that actual bills are likely to be lower, over time, than they would have been without the work being done to increase energy efficiency.

There are many concerns about how such process can actually work in practice to achieve anything like the necessary 60-80 per cent reductions in energy use and carbon emissions. It seems very questionable whether the 'golden rule' can be satisfied by anything other than the lowest cost actions such as loft and cavity wall insulation – useful by themselves but insufficient by far to yield the reduction in energy use for heating necessary to meet climate change targets.

The Green Deal and all the concerns and issues surrounding it are summarised in a report[7] by this Work Package: *The 'Green Deal' Appraised* by Martin Ingham, October 2011.

This work is an important part of the developing evidence base about financing low-energy and low-carbon refurbishment. We outline these financing issues in *Refurbishing Europe*. Evidence from extensive experience in Germany is that subsidies are required to achieve more than modest energy savings but subsidies are not part of the Green Deal proposals. The German experience was described by Tatjana Bruns of KfW Bankengruppe, Frankfurt, at the Norwich BwC conference, October 2010 (Section 4.5.1) in a presentation[8]: *Supporting the energy efficient rehabilitation of the building stock – The German experience*.

The 'Green Deal' Appraised report was the centrepiece of a Green Deal Summit at the University of East Anglia in November 2011 attended by representatives from Government and national bodies as well as by experts from local government and housing associations[9].

It is important that everyone concerned with low-energy buildings, whether politicians at national, regional or local level, as well as housing associations, developers, and those involved in construction, are aware of issues and concerns about proposed mechanisms, codes and standards, such as the Green Deal in order that inappropriate decisions can be avoided. In the development of the evidence base we have succeeded in making explicit important issues and concerns as well as ways to make the necessary progress.

7 See http://www.buildwithcare.eu/articles/78-partners/219-the-green-deal-appraised where there is a link to the report.

8 Downloadable at http://www.buildwithcare.eu/articles/66-conferences/170-build-with-care-annual-conference-2010.

9 See the UEA press release at http://www.uea.ac.uk/mac/comm/media/press/2011/November/greendealpanel.

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2.5. Low energy building database and Index of Carbon Impact

As already noted, awareness of technical issues relating to low-energy buildings is not a major issue preventing progress. The creation of yet another database to add to the several that already exist would not have been a productive use of time. However, in order to create general awareness of the information available in these diverse and disparate databases that already exist a compendium of *Low Energy Building Databases* was prepared by Martin Ingham and updated during the project (final version: Version 1.2, June 2011). This lists nineteen separate databases with information on low-energy buildings in Europe.

Similarly, it became evident that it would not be productive to pursue an Index of Carbon Impact (WP4 Activity 3) in any detail as other organisations were devoting considerable effort to such study. BwC did not have the resource to match what others were already doing.

For example, there is the RICS paper, *Methodology to Measure Embodied Carbon of Materials* (see http://www.rics.org/embodiedcarbon) aimed at quantity surveyors, building surveyors, building control surveyors and project managers. The paper sets out a practical approach by which carbon emissions during the construction of a building can be measured with the methodology developed following a successful industry-wide consultation. This work was highlighted in Brussels during European Sustainable Energy Week in 2012.

Researchers at the University of Bath in the UK have been compiling an *Inventory of Carbon and Energy (ICE)* (an inventory of embodied carbon for a wide range of materials) with regular updates. The latest version, 2.0, by Prof. Geoffrey Hammond and Dr Craig Jones, was issued as a free Excel file in January 2011 and can be downloaded from http://www.naturalstonespecialist.com/documents/ICEV2.0-Jan2011.xls. A version in book form with comprehensive notes is available[10] from BSRIA; *Embodied Carbon: The Inventory of Carbon and Energy (ICE)*, Prof. Geoffrey Hammond and Craig Jones, January 2011 (A joint venture of the University of Bath and BSRIA).

Useful papers and presentations by Dr Jones (now at the carbon reduction company, Sustain Ltd) include *Embodied Carbon: A Look Forward* (Sustain Insight Article: Volume I), January 2011[11], and *Embodied Carbon in Construction*, April 2012[12].

The University of East Anglia (UEA) research group also conducting the occupant studies at the Wimbish passivhaus homes in Essex (Section 3.5.3), has published a comparison of lightweight timber construction (modern methods of construction – see

[10] At https://www.bsria.co.uk/bookshop/books/embodied-carbon-the-inventory-of-carbon-and-energy-ice/.

[11] At http://www.sustain.co.uk/resources/briefing-documents-and-reports/embodied-carbon-a-look-forward-insight-report.aspx.

[12] http://www.sustain.co.uk/resources/articles-and-presentations/embodied-carbon-in-construction.aspx.

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Section 2.3) compared to conventional masonry construction of a typical UK home[13]. Compared with traditional methods of construction, the modern methods of construction house resulted in a one-third reduction in embedded carbon, with concrete being the most significant material in embodied carbon terms.

These studies of embedded carbon all note that it can take several years, sometimes even decades, of energy saving to overcome the carbon 'embedded' in new-build construction – an important reason why low-embedded carbon methods of construction are important. However, there are important issues to bear in mind – the decisions are not always clear cut.

Thus different materials can be used in quite different ways. For example, a small weight of steel can have a similar function, structurally, to a much bigger weight of timber. The whole system must be considered (including re-use at end of life), not just embedded energy per unit weight of material.

Also, how energy is used can significantly influence outcomes. Thus a study by researchers in Gothenburg and Malmo has analysed[14] conventional Swedish homes relative to passivhaus homes at Lindås (see Section 3.4) and elsewhere. Because the Lindås passivhaus homes use electricity for their heating needs, the authors conclude that from a global warming perspective (as well as most other environmental parameters) these homes perform no better than conventional homes in Sweden warmed by district heating. As in all buildings, also, the behaviour of occupants in terms of their energy use can have an impact that is far greater than differences in embodied energy of construction.

This is why we have focused on operational energy in our papers *Refurbishing Europe* (Section 2.1) and *Delivering a Low-Energy Building* (Section 2.2). Reducing embodied energy and embodied carbon is always an important objective but it must be borne in mind that in the majority of situations the energy consumed during the occupation of a building is likely to dominate savings in embodied energy. Hence creating a building where occupants are easily able to minimise their occupational energy use is always the priority objective.

Such issues have recently been discussed with respect to commercial office buildings by Low Carbon Workplace, a subsidiary of the UK Carbon Trust. A recent report, *Less embodied carbon, more value? The relative impact of operational and embodied carbon on the value of commercial office stock*, a paper[15] by Low Carbon Workplace Ltd, September 2011, notes that:

> *"Even if the building's lifetime were as little as 25 years, embodied carbon would account for only 20% of the building's whole life carbon emissions. In*

[13] *An embodied carbon and energy analysis of modern methods of construction in housing: A case study using a lifecycle assessment framework*, J. Monahan and J.C. Powell, Energy and Buildings, 43 (2011) 179-188.

[14] *Illustrating limitations of energy studies of buildings with LCA and actor analysis*, Birgit Brunklaus, Catarina Thormark and Henrikke Baumann, Building Research & Information, 38 (2010) 265-279.

[15] Available at http://www.lowcarbonworkplace.com/EmbodiedCarbon.aspxje.

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practice, building lifetimes are very much longer than 25 years. With this is mind, it is more realistic to expect embodied carbon to account for between 10% and 15% of a building's whole life emissions, with operational carbon accounting for between 85% and 90% of emissions."

Construction companies are indeed beginning to address embodied energy and, as with quality standards in refurbishment (at Brogården – see Section 2.2) Skanska have pioneered measurement of embedded carbon in new build construction. One Kingdom Street is a twelve storey state-of-the-art office building (24.490m^2 of open-planned office space) in Central London completed by Skanska in February 2008. Using the Bath University database (see above, this Section), the total construction footprint of One Kingdom Street was calculated[16] to be 24,815 tonnes of CO_2 equivalent with the steel frame and concrete works responsible for 35 per cent and 18 per cent respectively.

In discussion, Skanska have noted that this total embodied energy represents about 20 per cent of the total lifetime carbon footprint. Given that Skanska were consciously attempting to reduce embedded carbon wherever possible during the construction of One Kingdom Street, it would appear that there is some inconsistency between this estimate of the proportion and that of Low Carbon Workplace (see above) where 10-15 per cent is said to be typical. Evidently, however, the actual proportion calculated will very much depend on the assumed lifetime of the building.

We must bear in mind, however, that this proportion is committed up-front before and during a building's construction whereas operational energy is consumed over a period of decades. Given the urgency to act now to tackle potentially dangerous climate change (see Section 2.1) it is clear that reducing embodied carbon during building construction is an important challenge. The new passivhaus Enterprise Centre building at UEA (Section 4.5.5) will be constructed out of low-embodied carbon and natural materials and will be an important demonstrator for the construction of a low-energy building that not only has very low operational energy but also very low embodied energy.

Where consideration of embodied energy and carbon are of especial interest is in the major task of refurbishing existing buildings to higher energy standards (as discussed in *Refurbishing Europe*, Section 2.1). The issues have been comprehensively reviewed by Anne Power of the London School of Economics in a recent paper[17]. Professor Power concludes that:

"Refurbishment offers clear advantages in time, cost, community impact, prevention of building sprawl, reuse of existing infrastructure and protection of existing communities. It can also lead to significantly reduced energy use in buildings in both the short and long term. ... Since the case for demolition

16 See *One Kingdom Street, UK*, Skanska Case Study 36, http://skanska-sustainability-case-studies.com/pdfs/36/36_OneKingdom_v001.pdf.

17 *Housing and sustainability: demolition or refurbishment?*, Anne Power, Proceedings of the Institution of Civil Engineers, Urban Design and Planning 163 (December 2010) Issue DP4, 205–216.

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on energy grounds is not clear cut, higher refurbishment standards for existing homes using known methods (including under-floor and solid wall insulation) offer better value and potentially greater gains more quickly and cheaply than demolition and replacement building."

This conclusion supports the ambitions of BwC. We have outlined in detail (Section 2.1) the Evidence Base for low-energy and low-carbon refurbishment of the EU's current building stock. Given the immediate impact on carbon emissions of embodied carbon in such an ambition, it will be important to minimise embodied carbon during refurbishment and doubly important to minimise operational energy during use.

2.6. Renewable Wilhelmsburg

The International Building Exhibition (Internationale Bauaustellung), Hamburg (IBA Hamburg) is one of several partners from Hamburg that bring to BwC, and hence to the wider audience in the NSR and beyond, the ambition of the Hamburg region to create a vision for the European city of the 21st century[18].

Within the theme Cities and Climate Change, IBA Hamburg is developing scenarios to demonstrate how a city district is able, over time, to reduce its energy-supply-related carbon emissions to zero. The focus is on the Elbe islands in the middle of Hamburg of which Wilhelmsburg, with 55,000 inhabitants from about forty different countries, is the largest and most heavily populated.

In this work package, work has been undertaken to understand the costs and benefits of the Klimaschutzkonzept Erneuerbares Wilhelmsburg (Climate Protection Concept Renewable Wilhelmsburg). Implementing the goal of the carbon-neutral Elbe islands will require considerable investment in building refurbishment to improve energy efficiency as well as in renewable energy generation. Can the necessary investment be matched by the savings that result?

The results of this work contributed to the IBA volume *Energy Atlas. Future Concept: Renewable Wilhelmsburg*[19], and in particular to the chapter *Costs and Gains of the Future Concept Renewable Wilhelmsburg* by Joost Hartwig.

Different scenarios trigger the need for investment in building improvement at different rates, but, overall, the strong conclusion is very positive: *"The economic perspective shows that the costs incurred through the IBA Hamburg are not inconsequential but they are more than compensated for by future savings"*. This is an important conclusion, not just for Hamburg but for all cities across the NSR and the EU where the majority of the population now live. It is cities that will drive the innovation necessary to achieve a sustainable and low-carbon lifestyle – as we highlighted in *Refurbishing Europe*. This work also supports the more general conclusion of Professor Power (see

[18] See http://www.buildwithcare.eu/partners/iba-hamburg and http://www.buildwithcare.eu/good-examples/93-care-magazine/196-a-necessary-leap.

[19] by IBA Hamburg (Jovis Verlag, 2011).

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previous section) that refurbishment of existing buildings to high levels of energy efficiency is almost always to be preferred to demolition and building new.

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3. Monitoring of low energy buildings

Building Performance Evaluation (BPE) is extremely important but is undertaken on a far less comprehensive basis than is desirable. In the UK, BPE has revealed the 'performance gap' with its extremely serious implications (Section 2.2).

This Work Package has conducted monitoring and evaluation of low-energy buildings in Germany, Sweden and the UK and shown that, in each country, low-energy and passivhaus buildings work effectively and are also comfortable, pleasant to live in, and productive to work in. This is a major piece of work that moves the debate a great deal further forward.

3.1. Building Performance Evaluation

The importance of BPE has been detailed in a report[20] from UEA, *Building Performance Evaluation: Why and How*, by Martin Ingham and Bruce Tofield, March 2012. While the examples in the report are taken from the UK, the principles outlined apply to any building in any country. We are not aware of any other report that describes these principles so effectively.

3.2. Schleswig-Holstein

Passivhaus homes, now occupied for ten years, and also, recently, a new primary school, have been evaluated both with respect to energy use and also in respect of occupant perceptions. The physical condition of the homes has also been studied.

Overall, as expected, energy use in the homes shows a wide variation, but, for most homes, the energy use for heating and hot water is within the limit calculated for a passivhaus and the average total primary energy consumption across all the homes studied is less than the passivhaus limit. In particular there is high occupant satisfaction with living in a passivhaus and nearly all inhabitants would recommend passivhaus living to others.

The survey noted that even in Germany there was little awareness among construction companies of passivhaus standards. It was recommended that the very low heating costs should be more widely advertised. As everywhere, the quality of work necessary to achieve the passivhaus quality standards is high and training of craftsmen on site is important.

Air tightness tests seven to ten years after construction show some degradation compared to the as-built results but are still excellent compared to conventional building standards. It was noted that the higher the quality of the as-built home (in

[20] See http://www.buildwithcare.eu/news/237-low-energy-in-reality about BPE and to link to the report.

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respect of excellent air-tightness) the better the result also after several years, highlighting the importance of high quality workmanship during construction.

Public buildings as well as homes have been studied. A sports hall at Neuberend has shown excellent performance over several years. It has been remarked that in hot weather the internal environment is excellent and far better than found for conventionally built halls where high temperatures and humidity result from the activities.

The internal air quality is likewise excellent in a passivhaus school at Ulzburg-Sud. A major and poorly publicised problem with naturally ventilated schools (the great majority), in all countries, is the high CO_2 levels that frequently arise in occupied classrooms. Work in the UK and elsewhere has shown that such poor air quality can have a negative impact on student attention and performance. Passivhaus buildings have a clear additional benefit beyond very low energy costs in that air quality is also excellent. Good ventilation equals smarter kids! We have noted other work describing problems with air quality in naturally ventilated schools in *Delivering a low-energy building* (Section 2.2)

The following papers describe the work in Schleswig-Holstein:

> *Long-term Evaluation of Passive Houses in Schleswig-Holstein*, Dr. Winfried Dittmann and Dr. Klaus Wortmann, April 2010;
>
> *Passivhäuser 10 Jahre im Betrieb - luftdicht und komfortabel?*, Dr Winfried Dittman and Dietmar Walberg, November 2011 (in German) (*Passive houses operating for 10 years - airtight and comfortable?*)
>
> *Passivhäuser in Schleswig-Holstein: ...bis zu 10 Jahre danach: Untersuchungen, Erfahrungen und Erkenntnisse*, Dr. Winfried Dittmann, Dr. Klaus Wortmann, Dietmar Walberg, Jürgen Depner and Michael Selk, February 2012 (in German) (*Passive houses in Schleswig-Holstein: ...after 10 years: research, experience and results*)
>
> *Monitoring Passivhaus Grundschule Ulzburg-Süd*, Frau Siw Wrobel, Frau Sonja Scher, Herr Jan Zimmermann and Herr Dr. Winfried Dittmann, February 2012 (in German).

3.3. Hamburg

Passivhaus buildings constructed in Hamburg have been evaluated by BwC partner ZEBAU. 12 projects with 156 dwellings, including apartment blocks, detached and terrace houses have been studied as well as two commercial units. These were the first passivhaus buildings in Hamburg, mainly built between 2002 and 2005 and this work represents a very important long-term evaluation.

Just as in Schleswig Holstein, the evidence is very positive. Even though several of the buildings were not originally planned to be passivhaus, the observed energy use for heating was mostly close to the passivhaus standard. Occupants noted a very

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significant reduction in energy use (and hence also in bills!). 87 per cent of respondents were satisfied with the heating systems and the great majority were likewise comfortable in winter.

In one or two buildings there was evidence of overheating in summer. This evidence shows that not only must design and construction be done to avoid heat gain but that occupants need to be helped with advice and information to minimise heat gain by use of blinds and leaving windows closed during hot days for example. These conclusions apply to passivhaus buildings in all countries in the NSR. As with heating systems, the majority of occupants found the ventilation system no problem to operate and were satisfied.

With the exception of one or two buildings, the majority of occupants were satisfied or very satisfied with life in a passivhaus. These situations have provided important information about what can be improved in design, especially in apartment blocks. Knowledge and awareness is now much more widespread and costs have come down significantly. As always, the importance of the quality process – for design, for construction and for ventilation systems, was emphasised.

The following paper describes this work:

> *Evaluation of Passive Houses in Hamburg*, Jan Gerbitz, April 2010.

In addition, there is a paper jointly from partners in Hamburg and Schleswig-Holstein describing passive houses in the two regions:

> *Passivhäuser in Norddeutschland - 20 Beispiele aus Hamburg und Schleswig-Holstein*, August 2010 (in German).

3.4. Västra Götalandsregionen

Just as in Schleswig Holstein, the first passive houses in Sweden were built just over ten years ago at Lindås Park near Göteborg, and these and other more recent homes have been evaluated as part of BwC activity by Västra Götalandsregionen and the Swedish Passive House Centre. Such evaluation, ten years since the first homes were occupied in 2001, provides very positive confirmation of responses obtained when homes are newly occupied – and supports similar, but quite separate, conclusions from the work in Schleswig Holstein (Section 3.2).

The owners are pleased with their homes, in particular the low energy use, simple maintenance and indoor air quality. As is the case everywhere, it is important to provide simple to understand information about the operation of the ventilation and heating system and about the principles of passivhaus living. Based on previous experience in conventional homes, occupants will not necessarily be aware of how best to optimise conditions in a passivhaus.

With the odd exception, for example where a mechanical failure was maintaining a damper in the open position, energy use remained excellent, and as planned, and about half the total energy use in a conventional Swedish home. As the reports note,

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monitoring of energy use can be very helpful to indicate when a mechanical or similar problem has arisen. Overall, it is the simplicity of operation that is noted and appreciated by occupants.

The following papers describe this work:

Evaluation of Swedish Passive Houses, Svein H Ruud, April 2010,

Erfarenhetsåterföring från de första passivhusen - innemiljö, beständighet och brukarvänlighet, Eva Sikander, Svein Ruud, Kristina Fyhr and Owe Svensson, June 2011 (in Swedish, English Abstract)[21]

Experience and evaluation of ten-year-old passive houses – indoor environment, durability and user convenience, Eva Sikander, Svein Ruud, Kristina Fyhr and Owe Svensson, March 2012 (this is a summary report of the longer Swedish language paper).

3.5. The East of England

Given the issues and concerns detailed in the BwC report *Delivering a Low-Energy Building* (Section 2.2), it is especially important to be able to demonstrate for a UK audience, as well as across the NSR, that high-quality construction practice, as necessary to deliver buildings to the passivhaus standard, is practical and viable. To this end, within this Work Package, UEA has devoted considerable resource to low-energy building evaluation. The results have been impressive and important and add to the positive evidence from partner regions in other countries discussed in the earlier sections.

We have pursued study of three low-energy home developments of different structural types and of new and existing low-energy buildings at the University of East Anglia itself. We discuss these in turn. Together, they demonstrate that excellent low-energy buildings can be delivered – in the UK as well as in any other country – and that occupant satisfaction is high, not just because of the low bills but because internal air quality and living environments are also excellent. The educational buildings at the University demonstrate that similar outcomes can be achieved for large buildings as for homes with an additional benefit that productivity is perceived also to be high.

We discuss the link between a low-energy building and productivity in the final Chapter of *Delivering a Low-Energy Building* (Section 2.2). We summarise there the likely financial benefits of low-energy office and other buildings that seem to extend far beyond low energy bills:

> *The key factors of teamwork and simplicity that lead to excellent building fabric and low-energy operation lead also to creation of an excellent internal environment. Together, these factors can generate a sense of*

[21] Available at http://nyheter.vgregion.se/upload/Milj%c3%b6sekretariatet/Milj%c3%b6%20%c3%b6vrigt%20i%20till%20pressmeddelanden/SP%20Rapport%202011_26%202011-06-09.pdf.

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comfort and well-being that seem, fairly conclusively, to lead to enhanced productivity.

The financial benefits of low-energy buildings seem very likely to extend far beyond low fuel bills to lower maintenance costs, healthier occupants, less cost to society of ill-health, better rents and occupancy levels in commercial and office buildings, and more productive work environments. Such benefits are likely to outweigh the costs of making the transition to quality many times over, while the costs to society at large of not creating quality and foregoing the ability to deliver low-energy buildings will be huge.

3.5.1 Low energy homes built using panellised construction

We have monitored new two new low energy homes built by Saffron Housing Trust at Diss, Norfolk, since they were occupied in 2009. This pair of semi-detached homes was constructed using pre-fabricated panels manufactured in Sweden (see Section 2.3). The homes were not designed to perform quite to the passivhaus standard, but such modern methods of construction permit accurate detailing and rapid erection to weather-tightness compared to traditional on-site methods.

A description of the benefits of this method of design and manufacture was given in a 2009 BwC report: *Overcoming the Barriers to Low Carbon Construction: Saffron Housing Trust's Low Energy Homes at Skelton Road, Diss*, Bruce Tofield, November 2009[5].

The monitoring of one of this pair of houses in particular demonstrates excellent energy efficiency. The homes are all-electric with no renewable energy systems installed so that monitoring total energy use is straightforward. One home, occupied by a family of three, has maintained an annual primary energy use below the passivhaus limit of 120kWh/m^2. This is an extremely impressive outcome and is a consequence of the excellent insulation and air tightness for the property achieved during erection.

The homes and the monitoring activity are described in detail in the BwC report: *Skelton Road Building Performance Evaluation – Interim Report*, Martin Ingham, April 2011[22].

3.5.2 High Thermal Mass New Home

In contrast to the lightweight timber-frame construction of the homes in Diss, we hoped also to monitor in detail a high-thermal mass new home where temperature control is achieved in both winter and summer through massive concrete construction with high levels of insulation. As with a passivhaus, heating is largely via solar gain and the house has a south-facing aspect to facilitate this. Unlike a passivhaus, where

[22] See http://www.buildwithcare.eu/articles/81-economic-benefits/206-bwc-monitoring-confirms-small-bills with link to report at http://www.buildwithcare.eu/images/pdfs/interim_report_v04d.pdf.

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mechanical ventilation with heat recovery is standard, this home is naturally ventilated via trickle vents.

There were not the funds available within the project for the monitoring equipment required for this building in addition to the others being studied but we were fortunate that, because of the interest in the results, equipment was donated by Trend Control Systems Ltd and installed free of charge by ECS Power & Control Ltd.

A certain amount of data was collected but financial problems with the construction meant that it became increasingly difficult to maintain data collection and to address data acquisition problems that arose. The data collected did, however, demonstrate that the mode of construction helped maintain constant internal temperatures. Actual energy use could not, unfortunately, be measured.

We had hoped to demonstrate the excellence of internal air quality and the benefits of this mode of construction in minimising pollution from spores and dust mites. However, while we believe that internal air quality is likely to be good in a building of this type if it is operated correctly, we could not directly pursue this aspect of the study. The owner, who also managed the building construction, had agreed to undertake this aspect of the work as he was medically qualified, but the problems he faced in bringing the project to completion meant that the work was not done.

These problems encountered during construction are however instructive in that they indicate that this specific method of construction is very unlikely to become a cost-effective alternative to conventional masonry construction (as with the passivhaus homes at Wimbish described next) or to modern methods of construction using factory-manufactured panels (as at the low-energy homes at Diss described in the previous Section). Hence, such a high-thermal mass approach does not seem likely to be a route to the over-arching BwC ambition of mainstreaming low-energy buildings.

From an architectural perspective, however, the house impresses, and it has featured in the UK Channel 4 television series Grand Designs. A programme in October 2010 outlined[23] the concept and the increasing financial problems in bringing the house to completion. A follow-up clip[24], March 2012, shows, in brief, the house after completion.

A summary BwC report describing the design and the data that could be collected was issued:

> *Radian House, Boxford: Building Performance Evaluation – summary*, Martin Ingham, October 2010.

[23] Information at http://www.channel4.com/programmes/grand-designs/episode-guide/series-7/episode-5 where a link to play the programme is available.

[24] See http://www.channel4.com/programmes/grand-designs/articles/ipswich-radian-house-video-tour-series-7-ep-5.

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3.5.3 New passivhaus homes at Wimbish, Essex

As a consequence of UEA's ongoing monitoring work at the Skelton Road homes (Section 3.5.1 above) and our promotion of BwC within the East of England region, we were asked to become involved with new passivhaus homes being built at Wimbish near Saffron Walden in Essex by Hastoe Housing Association. Funds had not been made available within this project for monitoring but we were able to assist Hastoe with a successful submission to the UK Government's Technology Strategy Board (TSB) for monitoring as part of the TSB's Building Performance Evaluation Programme (this TSB Programme is outlined in *Building Performance Evaluation: Why and How* (Section 3.1)).

These fourteen houses and flats are of lightweight masonry construction and built using traditional craft methods. Passivhaus certification has been achieved, and a BwC report (also submitted to the TSB) detailing results from the first eight months of occupation was issued in March 2012:

> *Wimbish Passivhaus: Building Performance Evaluation Interim Report – March 2012*, by Martin Ingham[25].

This report provides detail about the homes and their construction as well as on energy use, environmental monitoring and on occupant perceptions. Once again, the work demonstrates the value and importance of building performance evaluation. Without it, the very low energy consumption could not have been easily verified and neither could the excellent air quality nor the very favourable occupant perceptions of living in a passivhaus. With the data – which continues to be collected beyond the end of BwC – then Hastoe can demonstrate the benefits of passivhaus construction and these benefits can be promoted to a much wider audience – as per the BwC ambition.

Indeed, the Wimbish project won the UK Passivhaus Trust Residential Award for 2012 and the presentation at the awards ceremony in July made reference to the BwC report. This work is another way in which the activity of BwC becomes known to everyone involved with low-energy construction in the UK.

Hastoe has also won a Green Apple Environment Award, for its Wimbish scheme, in the national Green Apple campaign to find Britain's greenest companies, councils and communities. The award will be presented in November 2012 at the House of Commons. The Hastoe press release notes that: *"The post occupancy monitoring is demonstrating very real energy and fuel cost savings for the tenants and occupants."*

As was noted in the evaluation of passivhaus homes in Sweden and Germany above, occupants are not necessarily fully aware of the differences between a passivhaus home and a more conventional home of the kind that they will have lived in before. Hence the provision of appropriate information is important if best results by occupants are to be obtained.

[25] See http://www.buildwithcare.eu/news/238-energy-data-in-a-non-technical-manner for a description of the work and a link to the report at http://www.buildwithcare.eu/images/pdfs/wimbish_passivhaus_interim_report_march_%202012.pdf.

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A UEA PhD student was identified to study this aspect of the handover process as well as to gain an insight into subsequent living. As elsewhere, this aspect of occupant awareness and behaviour was shown to be an important area where improvements might be made. The PhD is not yet complete but initial findings are given in the Interim Report.

Our sense from discussion with partners in all regions is that this area of information provision to occupants in easy to understand ways - which is linked to low-energy behaviour in general - is one that has perhaps been neglected relative to the more technical aspects of how to design and construct a low-energy building. Yet occupant behaviour can have a very large impact on energy use even in a low-energy or passivhaus home. If energy efficiency and climate change targets are to be met, effective ways of engaging with people and influencing behaviour will have to be developed and to be more targeted than they are at present. This is an important general area for future work across the NSR.

3.5.4 The Thomas Paine Study Centre at UEA

The Elizabeth Fry Building at UEA was opened in 1995 and was widely acknowledged as one of the most successful low-energy buildings in the UK[26]. It uses Swedish Termodeck principles and high thermal mass to minimise energy use and to maintain a comfortable internal environment across all seasons.

We revisited the Elizabeth Fry Building as part of BwC to examine whether it was still performing well after fifteen years of intensive occupation (it was - see next section). We have used the example of the design and construction of the building to demonstrate how to deliver a low-energy building that operates as it should (*Delivering a low-energy building*, Section 2.2).

The success of the Elizabeth Fry Building encouraged UEA to use similar design and construction principles in a series of new buildings in succeeding years. These have been outlined in a BwC paper produced for the BwC Conference in Norwich, October 2010 and the Conference visit to UEA:

UEA Low Energy Buildings, Martin Ingham, October 2010[27].

The Thomas Paine Study Centre (TPSC) is the newest of UEA's Termodeck buildings and was under construction during BwC (opening in 2009). Hence it was at an ideal stage to act as a Demonstration Building within BwC. A number of features in the initial design were upgraded to ensure low-energy operation and are part of UEA's contribution to BwC.

[26] See, for example, *The Best Building Ever? PROBE Team's verdict on the Elizabeth Fry Building*, Building Services Journal, April 1998.

[27] See http://www.buildwithcare.eu/images/pdfs/first_page_downloads/uea_low_energy_buildings-bwc-oct2010.pdf.

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The upgrades included:

- Upgrading the air handling units to models with higher heat recovery efficiencies and lower fan power demands
- Improved use of thermal mass in the lecture theatre
- Employing displacement ventilation
- Additional zoning, enabling greater control
- Additional occupancy sensors and air quality sensors in the main lecture theatre, to adjust air supply to suit demand.

The overall performance of TPSC has been detailed in a BwC report[28]:

Thomas Paine Study Centre: How it Works, Martin Ingham, March 2012.

It is encouraging that energy use for heating seems to be stabilising at a similar value (per m^2) to that observed for the Elizabeth Fry Building and the ZICER Building (UEA's second Termodeck building) which were both studied intensively to understand energy use and optimum control measures.

Occupant perceptions of comfort, overall satisfaction, and productivity are outstanding, just as they were for the Elizabeth Fry Building a few years after it opened. In July 2011, two years after TPSC opened, a majority of staff in the building responded to a detailed questionnaire by Building Use Studies Ltd and the results place TPSC within the top ten per cent of the several hundred office and commercial buildings on the Building Use Studies Ltd database.

The TPSC was a highlight of the BwC CARE Magazine produced by Region Västra Götaland as part of its WP1 activity. The front cover of the Magazine is a picture of TPSC.

We have made one further important advance at UEA, as part of our work on TPSC, which can help all users of large buildings understand energy use and get involved in helping to promote energy efficiency.

Users and occupants of large office and educational buildings typically have little or no opportunity to understand energy use in the building or to help reduce it. Such buildings are controlled by building management systems (BMSs) that acquire information from, often, hundreds of sensors across the building and make decisions to control environmental parameters and to maintain comfort. Even facilities managers often have little detailed knowledge of how a building is actually performing energy-wise – the focus is on maintaining occupant comfort and satisfaction as far as possible. Accessing the BMS data is difficult and, even if this can be done, the data will not usually be in a form that is easily interpreted.

[28] See http://www.buildwithcare.eu/articles/78-partners/236-how-to-capture-energy-use-data-for-large-buildings where there is a link to the report.

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Such a situation makes it difficult for facilities managers to be aware when energy use may be higher than ideal or to understand why this might be happening, and impossible for occupants of buildings to have any engagement at all with building energy use or to help promote energy efficiency in any meaningful way.

What BwC has done has been to develop software that will access, interpret and display building energy use data from TPSC and other UEA buildings on the University-wide BMS system. This work is described in a report[29]:

An Energy Display System for UEA Buildings, Andrew Courtenay, March 2012.

The report shows a picture of historic energy use data on display at the Reception Desk of TPSC and Figures in the report show, for example, how this data could be compared with similar data for other University buildings on the BMS. This work represents a major advance in the ability to capture and display energy use data for large buildings and could potentially be adopted very widely to assist energy efficiency projects and the promotion and evaluation of low-energy buildings not just in the UK but across the NSR.

The monitoring and evaluation of TPSC is continuing with a UK Government Technology Strategy Board funded project (Section 4.5.7).

3.5.5 The Elizabeth Fry Building, UEA

As noted in the previous section, the Elizabeth Fry Building (EFB) at UEA, opened in 1995, is widely acknowledged as one of the most successful low-energy buildings in the UK. It uses Swedish Termodeck principles and high thermal mass to minimise energy use and to maintain a comfortable internal environment across all seasons. An occupant survey by Building Use Surveys Ltd in 1998 identified the building as one of the best of any building surveyed to that date in respect of perceived occupant comfort, satisfaction and productivity.

But a successful low-energy building is not just one that demonstrates good performance in year one or two. It must be capable of maintaining good performance over many years. This means that it must be simple to operate and robust. Such features will result from good design and care in construction.

As part of BwC, we revisited EFB to understand energy use, air tightness and occupant perceptions over fifteen years after it was first occupied. In that time it has been intensively used with up to 800 people in the building at any one time and three lecture theatres often fully used.

There was great interest in the prospect of gaining this new and important information among the businesses that were involved with the design, construction and initial evaluation of EFB. These included Andy Ford, lead engineer for the EFB and, at that time, President of CIBSE (the Chartered Institute of Building Services Engineers),

[29] See http://www.buildwithcare.eu/articles/78-partners/236-how-to-capture-energy-use-data-for-large-buildings where there is a link to the report.

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BSRIA (who undertook the initial air-tightness testing), Willmott Dixon, the contractors that built EFB, and Bill Bordass and Adrian Leaman of Building Use Studies Ltd who conducted the original occupant questionnaire and the energy monitoring and analysis.

CIBSE, BSRIA and Willmott Dixon all contributed financially to enable a repeat of the air-tightness testing[30] in September 2011 (by the same BSRIA team that studied the building in 1998) and a repeat occupant survey in July 2011. Building Use Studies Ltd undertook an energy analysis and analysed the repeat occupant questionnaire that was answered by a majority of the building's occupants. BwC at UEA initiated the project, organised all the work, and arranged the handing out and collection of the questionnaire forms.

The results were extremely encouraging. Air tightness was as good as measured in 1998[31] and occupant perceptions placed EFB still within the top quartile of all the several hundred buildings on the Building Use Studies Ltd database. Energy use has increased slightly, possibly because of the greater use of ICT equipment today.

The results of all the studies conducted during the revisit have been published[32]:

> *Test of Time*[33], Bill Bordass and Adrian Leaman, CIBSE Journal, March 2012, pp30-36.

The benefits of the quality approach to design and construction are now observed in the comments that Bill and Adrian make at the end of the article:

> *"Now that UEA has many more buildings to look after, it is a credit to the robustness of Elizabeth Fry's design and fine-tuning and to UEA's maintenance and cleaning that its performance remains good. Twenty years after it was designed, why have so few newer buildings caught up?"*

Why indeed have so few newer buildings caught up? Sadly, the quality approach used by UEA and its partners in the delivery of the Elizabeth Fry Building have not become standard practice. The "traditional construction model" (Section 2.2) is still pervasive. This is why we highlight EFB as an exemplar low-energy building in *Delivering a Low-Energy Building* (Section 2.2).

It becomes clear from the occupant survey studies of the Elizabeth Fry Building and the Thomas Paine Study Centre that there is a correlation between the successful construction of a low-energy building and occupant satisfaction and comfort. We have highlighted the reasons for this in the final chapter of *Delivering a Low-Energy Building* (Section 2.2). We note there that the key factors of teamwork and simplicity that lead

30 Pictures and description at http://www.buildwithcare.eu/articles/78-partners/217-elizabeth-fry-building-still-as-good.

31 Described in *Elizabeth Fry - ageing gracefully?*, Roderic Bunn, BSRIA Delta t Magazine, February 2012, pp8,9 (subscription required; also available as *Does a building lose its airtightness over time?*, Roderic Bunn, April 2012, http://www.bsria.co.uk/news/elizabeth-fry/).

32 See http://www.buildwithcare.eu/component/content/article/233-revisit-to-the-elizabeth-fry-building.

33 Available at http://www.buildwithcare.eu/images/pdfs/cibse%20journal%20e%20fry%20revisit%20mar12.pdf.

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to excellent building fabric and low-energy operation lead also to creation of an excellent internal environment. Together, these factors can generate a sense of comfort and well-being that seem, fairly conclusively, to lead to enhanced productivity in the workplace.

We highlighted the fact that the financial benefits of low-energy buildings seem very likely to extend far beyond low fuel bills to lower maintenance costs, healthier occupants, less cost to society of ill-health, better rents and occupancy levels in commercial and office buildings, and more productive work environments. Such benefits must outweigh the costs of making the transition to quality, low-energy construction many times over, while the costs to society at large of not creating quality and foregoing the ability to deliver low-energy buildings will be huge.

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4. Continuing activity resulting from Build with CaRe

The ambition of BwC and WP4 was not just to fulfil particular objectives during the lifetime of the project but to have, in particular, a lasting impact beyond the end of the programme. There was a desire for a "virtual agency" – a partnership of institutions, agencies and other organisations – and to maintain the evidence base and network and to continue work on market transformation beyond the project end date.

It is very pleasing that these ambitions are being met. In each partner country there is on-going activity and, of particular satisfaction, is the continuing transnational engagement and partnership that could not have happened without the existence of BwC. We note here a few of the on-going activities and highlight the on-going engagement between partners and individuals in the partner BwC countries. BwC continues!

4.1. Schleswig-Holstein

The Schleswig-Holstein Society for Energy and Climate Protection (Gesellschaft für Energie und Klimaschutz Schleswig-Holstein GmbH, EKSH[34]) was founded in November 2011 to take over this aspect of the work of the BwC Partner Schleswig-Holstein Innovation Foundation (Innovationsstiftung Schleswig-Holstein, ISH). Dr Winfried Dittmann continues his work in the new organisation. Of particular relevance to BwC is the new Schleswig-Holstein Energy Efficiency Centre (Schleswig-Holstein Energieeffizienz-Zentrum, SHeff-Z[35]) in Neumünster which opened late 2011.

SHeff-Z is built as a passive house with a photovoltaic array on the roof and was visited while under final completion by Bruce Tofield and Martin Ingham of UEA during a study tour to Hamburg and Schleswig-Holstein in July 2011. The concept of SHeff-Z was developed by Dr Dittmann and colleagues when at the ISH, assisted by the BwC project and, for example the very successful bauraum Bremen[36], also a BwC partner. SHeff-Z will help individuals and businesses in Schleswig-Holstein learn about energy efficiency appliances and passivhaus construction on a much wider scale than has been possible in the past.

34 http://www.eksh.org/.

35 http://www.sheff-z.de/.

36 http://bauraum-bremen.de/.

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4.2. Hamburg

Jan Gerbitz and colleagues at ZEBAU continue their work promoting and supporting passivhaus technology in Hamburg. Of especial transnational interest has been the interaction with the East of England.

Britta Stein of TUHH, a BwC partner, visited UEA and West Suffolk College in June 2011 and gave presentations about passivhaus developments in Germany to architects and others from interested businesses as well as to University staff. This visit helped strengthen the commitment with Norfolk to passivhaus projects as noted below.

Following the study tour by Bruce Tofield and Martin Ingham of UEA to Hamburg and Schleswig-Holstein in July 2011, further visits were made to Hamburg passivhaus projects in November 2011 and to Christine Reumschüssel of DR-Architekten, Hamburg. Christine was the architect for the first passivhaus in China at the Shanghai Expo in 2010 and of an apartment complex for the disabled in Saarlandstrasse, Hamburg, that we visited in July 2011.

UEA then arranged for a visit by Christine to UEA and the East of England in February 2012. Christine spoke at a regional event in Cambridge attended by over fifty architects and others from the construction industry across the region, and to teams from the UEA and from Broadland Housing Group and its partners from the construction industry, and provided advice on passivhaus issues to both organizations[37]. She was also able to see the competing designs for the new passivhaus Enterprise Centre to be built at UEA (Section 4.5.5).

This visit was especially helpful to implant awareness and support for passivhaus principles within the University's Estates Department who will have responsibility for overseeing delivery of the new Enterprise Centre. Neither this awareness within the University, nor the passivhaus concept for the Enterprise Centre, would have been possible without the impact of BwC.

Similarly, the contact with Broadland Housing Group enabled transfer of knowledge (see Section 4.5.4) of hitherto (in the UK) problematic issues such as how to construct a balcony without thermal bridging. Balconies are a feature of the apartment complex for the disabled in Saarlandstrasse, Hamburg, designed by Christine.

In March 2012, Lars Beckmannshagen of ZEBAU spoke at the BwC Brussels Seminar[38] on *Funding System of energy efficient & plus-energy houses in Hamburg and Germany* (see Section 4.5.3).

37 See *German passivhaus architect visits UEA*, http://www.buildwithcare.eu/component/content/article/232-german-passivhaus-architect-visits-uea.

38 See http://www.buildwithcare.eu/news/235-seminar-in-brussels.

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4.3. Region Västra Götaland

BwC has supported the work of the Swedish Passive House Centre (Passivhuscentrum Västra Götaland[39]) and it has been reported informally that the proportion of passivhaus homes constructed in Region Västra Götaland now exceeds the proportion in Sweden as a whole.

Architect Hans Eek of the Passivhuscentrum is one of the original developers of the passivhaus concept and introduced the technology into Sweden. He has been especially helpful within BwC and his expertise has been of great assistance in creating new and viable projects in Norfolk (Section 4.5.4).

Hans is also the architect principally responsible for overseeing the refurbishment to passivhaus standards of early 1970s apartments at Brogården in Alingsås in the south of Sweden. This project was visited by BwC in April 2010 and the quality principles followed by the workforce, led by Skanska, were of particular note (see Section 2.2). These are being followed in a low-energy refurbishment project now underway in Norwich that would not have taken place without the impact of BwC (see Section 4.5.6).

As a result of this awareness, Hans Eek gave a plenary presentation[40] at the BwC Conference in Norwich, October 2010 (see Section 4.5.1) in which this work at Brogården was emphasised. This association of Norfolk with Hans Eek has grown since 2010 and he has worked with architects in Norwich and Norfolk to advise on passivhaus principles and methods. This relationship has greatly helped develop local confidence and the ambition that has now led to the UK's largest passivhaus project (Section 4.5.4).

4.4. West Suffolk College

UEA has worked closely with West Suffolk College (WSC) to promote learning from BwC. Bruce Tofield gave a presentation, *Mass Refurbishment – the EU experience* at The Retrofit Challenge conference[41], April 2011, at WSC, attended by over one hundred representatives from the construction and energy industries in the region as well as from the UK Government Department of Energy and Climate Change.

Bruce Tofield and Martin Ingham both presented at the final BwC event[42] at WSC, March 2012. Bruce Tofield gave the plenary presentation, *Local passivhaus solutions - Where do we go from here?*, showing how the evidence provided and the capability

39 http://www.passivhuscentrum.se/.

40 Presentation by Hans Eek, Swedish Passive House Centre, Build with CaRe conference, Norwich, October 2010, http://www.buildwithcare.eu/downloads/Public/Annual-Conference-2010/Presentations-Thursday-21-Oct/Hans-Eek-Passivhus-Centrum-Sweden-21-Oct-2010.pdf/.

41 See http://www.buildwithcare.eu/articles/78-partners/204-the-retrofit-challenge-conference-bury-st-edmunds-england.

42 See http://www.westsuffolkcollege.ac.uk/news-and-events/events/77/Build-with-CaRe-Event.

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created as a result of BwC activity could lead to a dramatic advance in low-energy housing construction not just in the East of England but UK-wide.

Martin Ingham presented information on the evaluation of the Wimbish passivhaus homes (see Section 3.5.3), *Building Performance Evaluation: Wimbish PassivHaus Study*.

Of especial interest in respect of continuing skill formation is the launch[43] of the Milburn Energy Centre at WSC in May 2012. The Centre is designed to demonstrate a range of 'green' technologies and to provide a training resource for College students as well as employers, public sector partners and the local community. It comprises a demonstration area, a teaching/conference room and a heat exchange boiler training facility where installers are trained in partnership with Daikin UK.

The Milburn Energy Centre was inspired by the BwC visits to BwC partners AZB Hamburg and bauraum Bremen in 2009 and had funding support from BwC. It will help facilitate learning and skills formation necessary to progress the passivhaus ambitions in Norwich and elsewhere and hence links very directly to other regional initiatives flowing from WP4 activities (Sections 4.5.4 to 4.5.6). It has been highlighted[44] in the *Leading the Way*, the Green Economy Pathfinder manifesto 2012-15 of the New Anglia Local Enterprise Partnership for Norfolk and Suffolk.

43 See http://www.westsuffolkcollege.ac.uk/news-and-events/latest-news/199/Official-opening-of-The-Milburn-Centre.

44 See http://www.newanglia.co.uk/Assets/Files/Content/2012-06-08%20New_Anglia_Manifesto_art_lo-res.pdf, p16.

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4.5. UEA and Norwich

4.5.1 Build with CaRe Conference, Norwich, October 2010

This conference[45] was attended by a hundred delegates, over half of whom came from the region, and more widely across the UK, to hear about the exciting developments in low-energy construction being promoted by BwC. Key speakers highlighted passivhaus refurbishment projects in The Netherlands and in Sweden and support for low-energy buildings in Germany. UK speakers highlighted national issues and developments as well as local achievement. The conference was unique in placing UK ambition in the context of what was being achieved in other EU NSR countries and created a firm foundation for new initiatives in the East of England region.

The UEA Press Release[46] before the conference (*UK must refurbish one house a minute until 2050, says Build with CaRe conference*, 18 October 2012) underlined the urgency of action on low-energy refurbishment in particular, while the post-conference press release[47] from UEA (*EU must refurbish 10 homes a minute until 2050: Build with CaRe conference tackles the barriers*, 29 October 2010) identified ways in which the work highlighted by the conference could enable this challenge to be met.

4.5.2 Build with CaRe seminars, Brussels, April 2011

UEA organised key presenters for the BwC seminars in Brussels during the EU Sustainable Energy Week, 11 and 12 April 2011.

For the 11 April evening seminar[48] arranged by Andrew Duff, East of England MEP and Build with CaRe ambassador, UEA arranged for presentations by Andrew Warren, Director of the UK Association for the Conservation of Energy[49] (who had also spoken at the Build with CaRe conference in Norwich), Andrew Savage, Executive Director, Business Growth, Broadland Housing Association (on *The UK's most ambitious passivhaus development*) and David Daniels, Chairman of the Eastern Region AECB (on *Making modern methods of construction an economic reality*).

At the next day's seminar at Scotland House[50], chaired by Jean Lambert, MEP for London, and also a Build with CaRe ambassador, Andrew Savage and David Daniels

45 See http://www.buildwithcare.eu/articles/66-conferences/170-build-with-care-annual-conference-2010 which has links to all the presentations.

46 http://www.uea.ac.uk/mac/comm/media/press/2010/oct/careconf and http://www.buildwithcare.eu/component/content/article/171.

47 http://www.buildwithcare.eu/component/content/article/171-press-release-annual-conference-2010.

48 See http://eusew.eu/index.php?option=com_see_eventview&view=see_eventdetail&eventid=843.

49 http://www.ukace.org/.

50 See http://www.buildwithcare.eu/component/content/article/97-conference/190-energy-week-in-brussels.

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once again made presentations and Bruce Tofield of UEA gave a presentation: *Disruptive innovation – do we have the political will to make low carbon Europe a reality?*

This talk identified, in particular, barriers to energy efficiency in general, and to low-energy buildings in particular, across the EU, and strategies for overcoming these, and was followed by a press release[51] from Jean Lambert's office which highlighted the work of BwC: *Green MEP demands radical action for a low carbon Europe*, 14 April 2011. The Press Release was picked up by Inside Housing, an electronic newsletter for everyone interested in housing across the UK, in a news item[52] a few days later which also referred to BwC.

Through these WP4 initiatives, the work of BwC was promoted to MEPs and to organisations active in Brussels in the energy efficiency field, and was further highlighted by Jean Lambert's press release. In the next section we note a further press release by Jean Lambert MEP following the March 2012 Brussels seminar and the release of the BwC report *Refurbishing Europe* (Section 2.1).

4.5.3 Build with CaRe seminar, Brussels, March 2012

UEA helped with the arrangements of the very successful final BwC Seminar in Brussels, 7 March 2012[38], including with the text of the invitation and suggested speakers, including Adrian Joyce of Renovate Europe[53] and from Skanska[54]. In particular, UEA arranged for two speakers from Norfolk who described how new innovation and new projects were a direct and tangible result of BwC and the transnational learning that BwC had made possible.

Andrew Savage, Executive Director, Broadland Housing Group came once again to Brussels to make a presentation - about *Transnational learning – the confidence to make a change*[55] – how engagement with BwC had enabled Broadland to innovate and to develop new and important passivhaus projects in Norfolk (see Section 4.5.4).

Benedict Binns of UEA's Centre for the Built Environment to talk about *UEA Exemplar Building: Low embodied carbon, Passivhaus, BREEAM Outstanding building*[56]. As noted in Section 2.5, the passivhaus concept for this new building which will showcase natural and low embedded carbon materials, only became an option as a result of the engagement with BwC.

51 http://www.jeanlambertmep.org.uk/news_detail.php?id=665.

52 *MEP calls for Europe-wide home efficiency standard*, Louise Bawden, Inside Housing, 18 April 2011, http://www.insidehousing.co.uk/ihstory.aspx?storycode=6514539.

53 http://www.buildwithcare.eu/images/pdfs/bwc_adrian_joyce_120307.pdf.

54 http://buildwithcare.eu/images/pdfs/bwc_anna_forsberg_120307.pdf.

55 http://www.buildwithcare.eu/images/pdfs/bwc_andrew_savage_120307.pdf.

56 http://buildwithcare.eu/images/pdfs/bwc_benedict_binns_120307.pdf.

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As noted in Section 2.1, the WP4 report from UEA, *Refurbishing Europe*, was a centre-piece of the Seminar and was distributed to MEPs, EU Commission officials, NGOs, and others in Brussels concerned with energy efficiency and low-energy buildings. Jean Lambert MEP, a Build with CaRe Ambassador, who addressed the Seminar, issued a press release[2] (with the BwC logo prominent): *Green MEP demands tougher efficiency targets for Europe's buildings at final Build with CaRe conference*. It is likely that the impact of BwC will be experienced in a positive manner across the EU for decades to come.

4.5.4 New passivhaus projects in Norfolk by Broadland Housing Group

The most tangible consequence of BwC in the East of England is the construction of four new passivhaus homes by Broadland Housing Group at Fulmodeston in north Norfolk. The build process is underway and the homes – to be constructed from SIPs (structural insulated panels fabricated offsite) – will be erected in October 2012.

The ambition of Broadland Housing Group to build the majority of its new homes as passive has been articulated in the Broadland Housing Group Corporate Strategy 2012-2015 which states[57] that the Group's Environmental Strategy will be delivered, inter alia, by: *Building at least 75% of our new homes to Passive House Standards.*

This ambition is a direct consequence of Broadland Housing's contact with BwC. The confidence to embark on such an innovative policy has been enabled by the transnational learning made possible by visits to BwC partners in Germany, Sweden and The Netherlands and by work with Hans Eek noted in Section 4.3 and Christine Reumschüssel (Section 4.2). This cooperation has inspired Broadland and its supply chain to gain the knowledge and skills necessary to design and to construct new homes to the passivhaus standard.

The Fulmodeston project is just for four homes but will importantly provide experience and learning for a much bigger passivhaus project in Norwich that already has outline planning permission. This is for the construction of nearly 250 apartments in a unit near the Norwich City FC ground at Carrow Road. This is not only the largest passivhaus development underway in the UK but will also be funded by private sector investors[58]. Through their innovation, a direct consequence of BwC, Broadland have been able to demonstrate that building to the passivhaus standard is cost-effective long-term compared to current-day codes.

This demonstration of the financial benefits of building to the passivhaus standard is a major breakthrough and, as noted in the Overview (Section 1), is a key part of an effective 'virtual agency' maintaining progress and ambition after the formal end of BwC. This is the evidence base that will convince financial, insurance and mortgage

57 http://www.broadlandhousing.org/files/publications/corp_strategy/corporate_strategy_2012_2015.pdf.

58 *Bid to build UK's largest Passivhaus scheme: Broadland seeks funds for 'sale and leaseback' plan to cut fuel poverty*, Tom Lloyd, Inside Housing, 9 March 2012, http://www.insidehousing.co.uk/ihstory.aspx?storycode=6520823.

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institutions to engage with passivhaus construction. There is now a platform established in the East of England, and potentially more widely across the UK, for rapid progress in passivhaus and low-energy construction and investment that would not have been possible without BwC and without the cooperation with partners across the N Sea Region. We are currently working on plans for an event that will bring together housing associations, investors and politicians to demonstrate how the Norfolk projects could be pathfinders for national roll-out.

4.5.5 New passivhaus Enterprise Centre at UEA

As noted in Sections 2.5 and 4.2, a new Enterprise Centre at UEA[59], housed in a new building of up to 4000m^2 is set to be a major stimulus to the region's economy and to the UK low carbon sector. The new building will be passivhaus certified. Once again, as with the Broadland Housing developments, this is an ambition inspired by the information made available through BwC.

The new building will host a new Centre for the Built Environment to showcase, monitor and test new sustainable products and bio-based materials from local companies. It will also house a 200-seat lecture theatre and an incubator for new start-up businesses to enhance opportunities for UEA students, graduates and staff across the NRP and will be constructed out of low-embedded carbon and natural materials.

The building will be an important demonstrator for the construction of a low-energy building that not only has very low operational energy but also very low embedded energy. As part of the condition for receiving ERDF support for the construction, over 500 small and medium-sized businesses in the region will receive learning on passivhaus methodology, and on low-energy and low-carbon construction. This learning programme is already underway[60]. The UEA ambition was outlined in the presentation by Benedict Binns as the BwC final Seminar in Brussels, March 2012 (Section 4.5.3) and progress can be followed on the CBE blog at http://adaptcbe.wordpress.com/.

4.5.6 A low-energy refurbishment project by Broadland Housing Group

As emphasised in *Refurbishing Europe* (Section 2.1), the majority of buildings that will be standing in 2050 have already been built. Refurbishment of existing buildings to a very high standard of energy efficiency is the major and essential task that must be accomplished if the EU's energy efficiency and climate change targets are to be met.

However, as we point out in *Delivering a Low-Energy Building* (Section 2.2) it is the drive for very energy efficient new build such as passivhaus that creates the capability and the supply chain to enable effective refurbishment of buildings to low-energy standards. If we cannot build new low-energy buildings with any confidence that

59 *NRP Enterprise Centre will drive low carbon jobs for the region*, UEA Press Release, 7 November 2011, http://www.uea.ac.uk/mac/comm/media/press/2011/November/Enterprise.

60 See https://www.adaptcbe.co.uk/CBE/events.xhtml.

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design energy targets will be met, then the chance of delivering a low-energy building stock via refurbishment is essentially zero - in which case EU energy and climate change targets absolutely cannot be met. The quality practices necessary for successful refurbishment will first be learned and adopted in new build construction.

This spill-over from new build quality to exceptional quality in refurbishment has already been demonstrated in Sweden where – as noted in Sections 2.2 and 4.3 - expertise in passivhaus new build construction has been applied to the refurbishment of early 1970s apartments at Brogården in Alingsås in the south of Sweden.

An ERDF- supported refurbishment project in Norwich by Broadland Housing Group is one of the first such projects to be funded in the UK. Broadland is taking a small number of homes with a good spread of different house types, each with its own problems and idiosyncrasies, from a Victorian semi in a conservation area to 1990s homes built by a developer. The object is to refurbish them up to a C80 standard[61] and to identify key issues that need to be tackled in order effectively to deliver the hoped-for improvement. Two of the homes will be refurbished up to the passivhaus EnerPHit standard[62].

This project has been made possible by the engagement with BwC in general and the visits to Brogården and to Roosendaal (Section 4.3) in particular. The processes have been informed by the quality standards demonstrated at Brogården and the technologies used by the awareness generated by the engagement with BwC partners across Germany, Sweden and The Netherlands.

The commitment and enthusiasm of colleagues in the region equally committed to low-energy construction has been essential to ensuring the successful launch of all these new projects including this one. Of particular importance has been the work of David Daniels, who was project manager for the low-energy homes being monitored at Diss (Section 3.5.1) and Andrew Savage of Broadland Housing Group (who has travelled twice to Brussels to make presentations to BwC events; Sections 4.5.2 and 4.5.3).

The expertise developed in Building Performance Evaluation during BwC (Section 3.5) is proving invaluable in this new project and Martin Ingham is overseeing the monitoring of the homes once refurbished that is essential to demonstrate the performance and to highlight any problems or concerns that arise.

4.5.7 On-going Building Performance Evaluation

As already noted (Section 3.5.3), the expertise gained in Building Performance Evaluation through BwC was key to obtaining UK Government Technology Strategy Board funding for the monitoring of the new passivhaus homes at Wimbish. This work continues.

61 Reducing the carbon emissions from energy use by 80 per cent.

62 EnerPHit – the Passive House standard for old buildings, http://passipedia.passiv.de/passipedia_en/certification/enerphit.

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Two more Technology Strategy Board projects have since been won in addition to that for Wimbish. One is a study of the Broadland Housing's Carrow Road passivhaus designs (Section 4.5.4) in respect of the behaviour of the building in future decades as climate warms.

The second is an in-depth evaluation of the performance of the Thomas Paine Study Centre (Section 3.5.4). None of these programmes could have been attempted without the expertise developed through BwC. They will all – along with the monitoring of the refurbished homes in Norwich (previous Section) – provide vital information and awareness of the quality of new low-energy buildings and of any issues that must be tackled.

These projects – all run and monitored by Martin Ingham – place Norfolk at the forefront of the UK's Building Performance Evaluation capability and the results will influence and assist the successful promotion of low-energy construction across the country. As we note below, Martin has already made several presentations about his work at national events, all of which note the credit due to and importance of BwC and the transnational cooperation and learning it made possible.

4.5.8 Presentations and input at regional and national level

During the course of BwC we have made several representations to UK Government consultations, press releases on key events or issues, and presentations at important regional and national events. The press releases linked to Refurbishing Europe and the BwC Conference in Norwich have been noted above (Sections 2.1 and 4.5.1).

In September 2011, we issued a press release[63] with support from Broadland Housing Group and Hastoe Housing Association highlighting the fact that the housing market crisis in the UK presented a unique opportunity to transform the quality of housing in England, to stimulate innovation, to create new business opportunities and supply chains, and to transform skills in the construction sector.

We highlighted the success of BwC in fostering contact and learning between continental partners and housing associations and businesses in the East of England, and that new initiatives were a reality on the ground with architects, housing associations and construction companies working together to deliver passivhaus and similar very low energy construction.

Following the release of *Refurbishing Europe* (Section 2.1), Bruce Tofield wrote a blog for the Green Alliance[64], *Passivhaus buildings could transform UK energy demand*[65].

63 *From housing crisis to housing transformation*, UEA Press Release, 2 September 2011, http://www.uea.ac.uk/mac/comm/media/press/2011/September/buildwithcare.

64 Green Alliance is an influential environmental think tank working to ensure UK political leaders deliver ambitious solutions to global environmental issues, http://www.green-alliance.org.uk/.

65 Posted 8 March 2012, http://greenallianceblog.org.uk/2012/03/08/bottlenecks-and-their-solution-german-style/.

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We issued a detailed response[66] to the call for evidence on energy efficiency by the newly-formed Energy Efficiency Deployment Office within the UK Government's Department of Energy and Climate Change, DECC, issued in February 2012.

We pointed out in our response that the adoption of the passivhaus standard for new build domestic and, in many situations, for refurbishment, is the biggest single action that can accelerate the progress in energy efficiency that is urgently needed. We urged the UK Government to take the lead and to make passivhaus the default standard for domestic new build, followed by comparable standards for refurbishment. We noted that without the quality guarantee that passivhaus standards bring, the performance gap between actual energy use of new buildings and design criteria would likely remain a problem but that passivhaus quality would mean this performance gap could be eliminated (as outlined more comprehensively in *Delivering a Low-Energy Building* Section 2.2).

We highlighted that because of the widespread ignorance of passivhaus principles among the UK construction industry, appropriate investment packages that reflect the long-term benefits of passivhaus construction are rarely presented to financial providers. The funds are in principle available however, and bringing property to a very low-energy passivhaus quality is an excellent investment (as in the Broadland Housing Carrow Road project in Norwich, Section 4.5.4).

We suggested that perhaps the most important act that Government could take would be to help create the market-place where such investment in low-energy new build and refurbishment could happen. Led by social housing and funded by long-term investors, the quality of work would be assured and skill sets and capabilities would be created.

Presentations by Bruce Tofield and Martin Ingham at BwC events including conferences at West Suffolk College and Brussels have been mentioned above (Sections 4.4 and 4.5.2).

Bruce Tofield gave a presentation on Build with CaRe[67] to the ERDF External Stakeholders Group of the NRP Enterprise Centre (Section 4.5.5), emphasising the importance and urgency of low-energy construction if energy and climate change targets were to be met.

66 *Response of the Build with CaRe project University of East Anglia, Norwich, UK and East of England AECB to the DECC (Department of Energy and Climate Change) Call for Evidence, 8 February 2012, on Energy Efficiency and the role of the EEDO (Energy Efficiency Deployment Office)*, 4 April 2012, see http://www.buildwithcare.eu/news/239-submission-to-the-uk-call-for-evidence.

67 7 December 2011 at the Norwich Research Park.

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Martin Ingham has given several presentations at regional and national level about the work of BwC. These presentations have helped raise the profile of BwC and of low-energy construction at EU and NSR level, at UK level, and at regional level in the East of England.

Martin's presentations include:

Low Carbon Construction & Performance: Wimbish PassivHaus and other BwC Projects, 14 September 2011, UEA, at the UEA Low Carbon Innovation Centre/InCrops/BwC event on Passivhaus developments in the region,

UK 'Green Deal' Appraised - an Opportunity?, 1 December 2011, at the John Innes Centre, Norwich Research Park, at the Norfolk - Constructing the Future Conference,

Wimbish Passivhaus, Meeting with Technology Strategy Board, 17 January 2012

UK 'Green Deal', Energy Company Obligation, FiT & Building Regulations, Broadland Housing Group event, 2 February 2012

Breaking down silos and changing attitudes across Europe: the role of research, 30 May 2012, National Energy Action conference[68] on *European Energy Policy: Saving the Environment and Cutting Costs*, Victoria Park Plaza, London.

Wimbish Passivhaus: Building Performance Evaluation, 12 June 2012, at Good Homes Alliance Wimbish site visit, see http://www.goodhomes.org.uk/events/111,

Cost and Performance of Passivhaus and Low Carbon Buildings, Centre for Built Environment seminar, 5 July 2012 (see Section 4.5.5).

Bruce Tofield and Martin Ingham
September 2012
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[68] See: http://www.nea.org.uk/Resources/NEA/Campaigns%20and%20Events/Documents/European%20Energy%20Conference%20slides.pdf for all the presentations; *Breaking down silos* is at slides 39-70.

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