Department for Communities and Local Government

Code for Sustainable Homes Case Studies: Volume 4

A report prepared for the Department for Communities and Local Government by CAG Consultants

August 2013
Department for Communities and Local Government

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Introduction

Background

1.1. The code for sustainable homes (the code) is the national standard for the sustainable design and construction of new homes. It was introduced in England in April 2007. The code aims to reduce carbon emissions from new homes and create homes that are more sustainable. It is intended to help promote higher standards of sustainable design above current building regulations minima.

1.2. The code measures the sustainability of new homes against nine categories of sustainable design, rating the 'whole home' as a complete package. It covers:

- energy/carbon dioxide
- water
- materials
- surface water runoff (flooding and flood prevention)
- waste
- pollution
- health and well-being
- management
- ecology

1.3. The code uses a one to six star rating system to communicate the overall sustainability performance of a new home against these nine categories. The code sets minimum standards for energy and water use at each level. The code level 3 energy standard is now incorporated in the building regulations.

1.4. The code is not mandatory, nor is the code a set of regulations. The only circumstances where the code can be required are: (a) where local authorities stipulate a requirement in their local plans; or (b) where affordable housing is funded by the Homes and Communities Agency, which requires homes to be built to code level 3.

1.5. The implementation of the code is managed by BRE Global under contract to the Department for Communities and Local Government. BRE Global issues licences to both assessors and other code service providers, as well as providing training, licensing and registration of code assessors. More information on the code is available from the Department for Communities and Local Government website at https://www.gov.uk/government/policies/improving-the-energy-efficiency-of-buildings-and-using-planning-to-protect-the-environment/supporting-pages/code-for-sustainable-homes

Overview

1.6. The Department for Communities and Local Government commissioned CAG Consultants, in conjunction with Ecos Trust, to prepare eight case studies of homes built to code standards. These build on the three previously published volumes of case studies which are available on the Department for Communities and Local Government website[1].

1.7. The eight case studies in this volume have all been built to level 4 of the code. This level is of most relevance in terms of the next round of enhancements to part L of the building regulations. None of the previous case studies publications included code level 4 schemes so this helps to fill a gap in the set of case studies available.

1.8. Case studies were selected from across England and represent a range of different scales and development scenarios, as shown in table 1.1.

1.9. In addition to researching and preparing the case studies, interviews were conducted with a number of national stakeholders to explore their views and experiences of the code. The findings from these interviews have been used alongside the case study findings to inform the lessons and conclusions presented in this report. A list of interviewees is provided in appendix 1.

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[1] *The code for sustainable homes: case studies*. Available from https://www.gov.uk/government/publications/the-code-for-sustainable-homes-case-studies-volume-1; *The code for sustainable homes: case studies volume 2 – March 2010*. Available from https://www.gov.uk/government/publications/the-code-for-sustainable-homes-case-studies-volume-2; *The code for sustainable homes: case studies volume 3 – December 2010*. Available from https://www.gov.uk/government/publications/code-for-sustainable-homes-case-studies.

Table 1.1: Overview of case study schemes

Scheme	No. of scheme dwellings	Description
Roman Barn, Worth Matravers, Dorset	5	Rural exception scheme. Detached houses to meet local need. Initiated and part-funded by a community land trust.
Tattersalls, Oxford	3	Privately funded development of large houses on garden land within Oxford.
Bramble House, Ashford, Kent	5	Edge of town development of flats and a bungalow on derelict land, providing housing for people with learning disabilities.
Wood Road, Dudley, West Midlands	19	Urban infill development of council houses and apartments.
Dairy Close, Enfield	62	Urban redevelopment of derelict former dairy. Mixed tenure scheme of flats, maisonettes and houses, including 28 units for private sale.
Ravenscroft, Wimbish, Saffron Walden	14	Social housing scheme on a rural exception site. Mixture of flats and houses, all of which meet Passivhaus as well as code standards.
Bath Western Riverside	2,281	Regeneration of former industrial site in central Bath. Private sector and social housing. The case study focuses on phase 1, comprising 59 units.
Rainham House, Middlesbrough	25	Suburban infill development of two buildings providing supported housing and support for women.

Code scoring

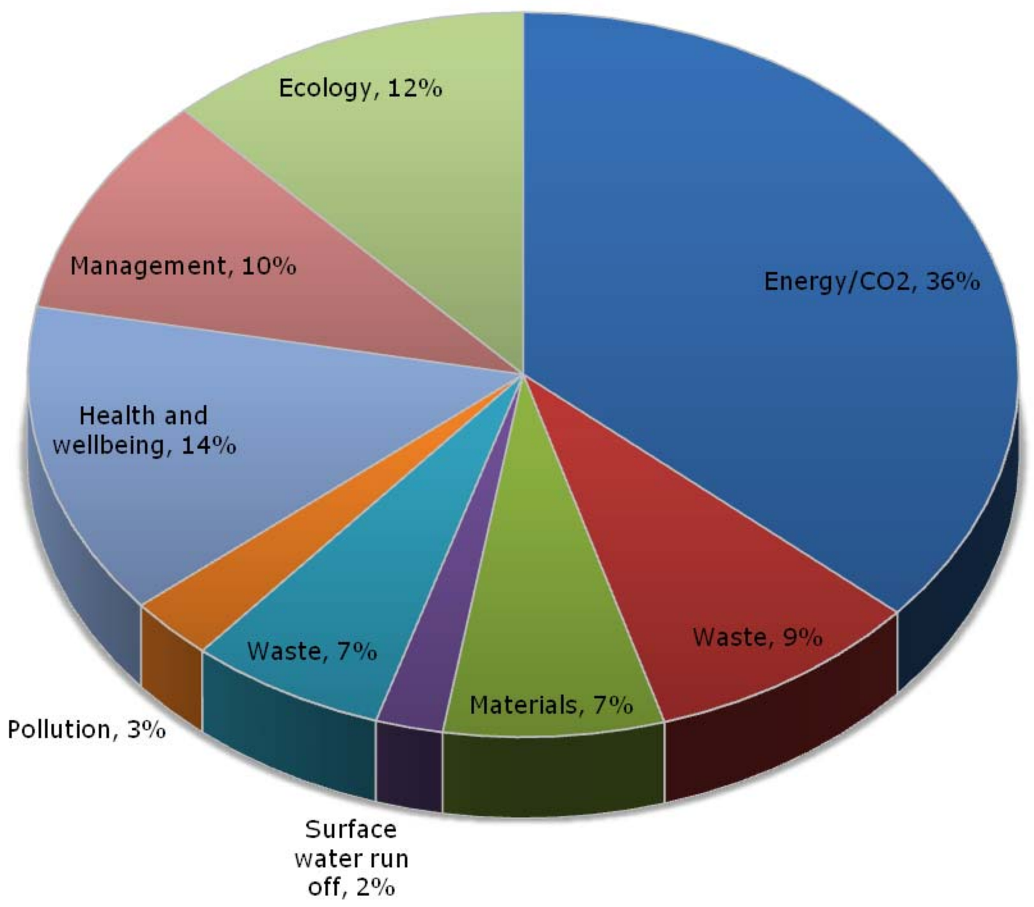
1.10. Code points are generated from achieving credits within the nine categories of the code, each of which has a different weighting attached. The credits available for each of the issues in the code and their weighted value is summarised in tble 1.2. 68 points are needed to achieve code level 4, compared to 57 for code level 3.

Table 1.2: Code categories, issues and credits (November 2010 version)

Category/Issue	Credits available	Weighted value of each credit
Energy/CO2 emissions (Ene)	**31**	**1.17**
Ene1 Dwelling emission rate	10	
Ene2 Fabric energy efficiency	9	
Ene3 Energy display devices	2	
Ene4 Drying space	1	
Ene5 Energy labelled white goods	2	
Ene6 External lighting	2	
Ene7 Low and zero carbon technologies	2	
Ene8 Cycle storage	2	
Ene9 Home office	1	
Water (Wat)	**6**	**1.50**
Wat1 Indoor water use	5	
Wat2 External water use	1	
Materials (Mat)	**24**	**0.30**
Mat1 Environmental impact of materials	15	
Mat2 Responsible sourcing of materials – basic elements	6	
Mat3 Responsible sourcing of materials – finishing elements	3	
Surface water run-off (Sur)	**4**	**0.55**
Sur1 Management of surface water run-off	2	
Sur2 Flood risk	2	
Waste (Was)	**8**	**0.80**
Was1 Storage of non-recyclable waste and recyclable household waste	4	
Was2 Construction site waste management	3	
Was3 Composting	1	
Pollution (Pol)	**4**	**0.70**
Pol1 Global warming potential (GWP) of insulants	1	
Pol2 NOX emissions	3	
Health & wellbeing (Hea)	**12**	**1.17**
Hea1 Daylighting	3	
Hea2 Sound insulation	4	
Hea3 Private space	1	
Hea4 Lifetime Homes	4	
Management (Man)	**9**	**1.11**
Man1 Home user guide	3	
Man2 Considerate Constructors Scheme	2	
Man3 Construction site impacts	2	
Man4 Security	2	
Ecology (Eco)	**9**	**1.33**
Eco1 Ecological value of site	1	
Eco2 Ecological enhancement	1	
Eco3 Protection of ecological features	1	
Eco4 Change in ecological value of site	4	
Eco5 Building footprint	2	

1.11. Figure 1.1 shows the percentage of the overall points available for each of the categories, taking the weighting factor into account.

Figure 1.1: Percentage of overall code points available per category



1.12. As well as achieving 68 points for code level 4, mandatory requirements need to be met for some elements. In relation to the dwelling emission rate (Ene1), a 25 per cent improvement is needed above code levels 1 to 3 (only compliance with Part L of 2010 building regulations is required at these levels of the code). There are other mandatory requirements for fabric energy efficiency (Ene2), indoor water use (Wat1), environmental impact of materials (Mat1), surface water run off (Sur1), storage of waste (Was1) and Lifetime Homes (Hea4). Further information on the assessment system can be found in the code technical guide[2].

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[2] *The code for sustainable homes technical guide, November 2010*. Available from http://www.planningportal.gov.uk/uploads/code_for_sustainable_homes_techguide.pdf.

1.13. Half of the case study schemes have been assessed against the most recent (November 2010) version of the code, with the other half assessed against the previous (May 2009) version. The key change between the 2009 and 2010 versions is a move towards a greater emphasis on building fabric. This was achieved through adopting a fabric energy efficiency standard in place of a heat loss parameter in Ene2 and through moving credits from Ene1 (dwelling emission rate) to Ene2. For a fuller description of this and other changes, see the Department's summary[3].

[3] *Summary of changes to the Code for Sustainable Homes technical guidance 2010*. Available from http://www.communities.gov.uk/publications/planningandbuilding/codeguidesummary2010.

Chapter 2

Case study 14: Roman Barn, Worth Matravers, Dorset

Overview

Location	Roman Barn, Worth Matravers, Dorset
Developer(s)	C.G. Fry (Design & Build contract)
Client	Synergy Housing Association
Code Assessor	C.G. Fry
Architect	ARCO2 Architecture Ltd, C.G. Fry
Date of completion	April 2012
House type(s)	Social housing development, approved as a ‘rural exception scheme’ to meet housing need, comprising: 3 x 2-bedroom detached houses (92 m^2) 2 x 3-bedroom detached houses (104 m^2)
Funding	Homes and Communities Agency, Synergy Housing Association, Worth Community Property Trust
Post-construction code level	4 (2010 version)

Introduction

3.1. Five detached houses were built to code level 4 in a rural setting at Worth Matravers in Dorset. The homes have green roofs and are designed to be modern but unobtrusive within the picturesque local setting. The site is off-gas so heating is provided by air source heat pumps.

3.2. The Worth Community Property Trust initiated the process of raising funds for the site and obtaining planning permission, using an innovative straw-bale design developed by a small sustainability consultancy. But the Community Property Trust needed to bring in the Homes and Communities Agency to help fund the scheme. They and their agents eventually agreed a change of direction, bringing in Synergy housing association and CG Fry, who were able to meet Agency requirements through a design and build contract. CG Fry redesigned the interior using more conventional construction methods, but retained the external envelope of the original design to avoid having to obtain new planning permission.

Construction details

Methods of construction

3.3. The houses are detached timber frame dwellings with beam and block floors. The exteriors are finished with render and cedar weather boarding. They have mono-pitched roofs covered with sedum planting (see right).

Key materials utilised

Walls	Render or weatherboard on 100mm concrete blockwork, lined with heat reflective membrane, 60mm internal cavity, 140mm timber frame, with insulation between timber studs, 50mm polyisocyanurate (PIR) insulation, then two layers of battens (at right angles to each other to reduce thermal bridging), then internal plasterboard.
Floors	63mm reinforced screed on 160mm thick insulation; on radon barrier; on 150mm concrete joists (suspended) with 150mm concrete block infill
Windows	Double-glazed, sealed units in painted timber frames
Doors	Timber, with double glazed panels on rear doors
Roofs	Timber deck, warm roof construction, with waterproof membrane and extensive sedum planting on top.

Technologies utilised

3.4. The original design aimed to have high-levels of glazing on the two-storey south elevations, and lower levels of glazing on the single-storey north-facing elevations. The original intention had been to have a ‘suntrap’ feature facing south. The emphasis was on meeting sustainability objectives through fabric energy efficiency, rather than the use of renewable energy. The roofs slope to the north, rather than the south, and were insulated using a sedum roof, which also had ecological benefits. A further benefit of the sedum roofs was to camouflage the development within the landscape.

3.5. The developer/architect felt that the original straw-bale design would not meet Homes and Communities Agency requirements for social housing, owing to the need for an 80 year design life, and insurance issues. The replacement design and construction details incorporated high levels of insulation and air tightness. Care was taken to minimise thermal bridging.

3.6. There were various reasons for choosing air source heat pumps as the main source of heating: the site is off-gas; the sloping roofs were not suitable for photovoltaic or solar thermal (being orientated to face north); and a central biomass boiler would have required a separate building. Smaller biomass boilers would have required manual handling, which was inconsistent with achievement of the Lifetime Homes concept. So, external air source heat pumps were chosen to power the wet central heating system. Daikin units were used, as the client had previous experience of using them.

3.7. The design incorporated large radiators, particularly in the bathrooms, to enable the air source heat pump to warm the homes effectively. Immersion heaters were installed to provide back-up water heating if required.

Other key features incorporated

3.8. **Ecology**: The site was of low ecological value, having been used for agriculture, and the landscape planning and ecological planting enabled the negative effect of the development to be minimised.

3.9. **Water:** Water efficient fittings were used, with the aim that the dwellings would use less than 90 litres per person per day. Water butts were installed in every garden.

3.10. **Materials:** The majority of elements scored between A+ and B in the BRE's Green Guide, and all timber came from sources certified by the Forest Stewardship Council and the Programme for the Enforcement of Forestry Certification. CG Fry have an established system for documenting the source of their supplies, as they have built up a supply system across all their developments.

3.11. **Energy:** Other features included 100 per cent low energy lighting, home office space, rotary clothes dryers and cycle storage sheds for all houses. Energy display devices were added to all the plots, to compensate for lower water scores.

3.12. **Surface water run-off:** The site is located in a low flood risk area (zone 1). Run-off from the site is handled by soakaways.

3.13. **Waste:** All homes have an internal eco-bin and composting facilities. A site waste management plan was in place throughout construction.

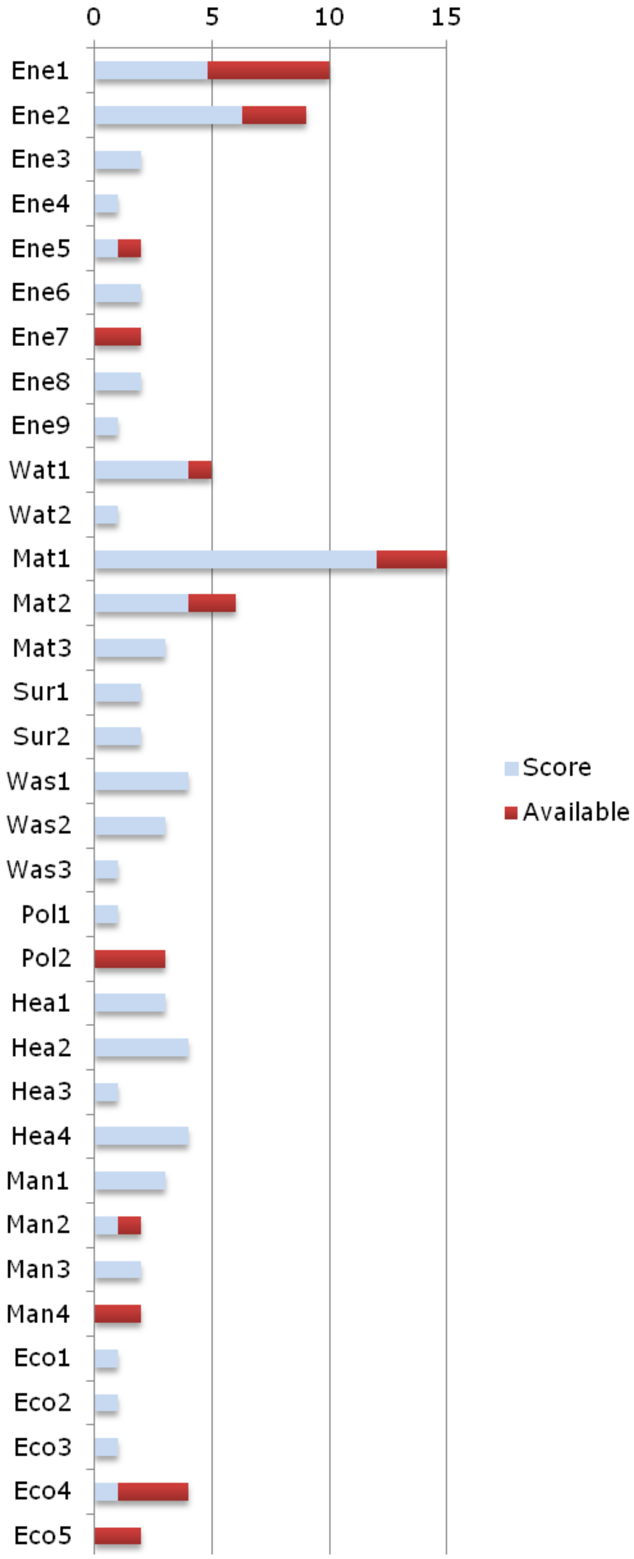
3.14. **Lifetime homes:** There was sufficient space within the external envelope of each house, possibly due to the original straw-bale design which incorporated extra thick walls, to meet the space requirement of the Lifetime Homes standard.

3.15. **Archaeological features**: The site was of considerable archaeological interest and has been thoroughly excavated. This process was initiated by the Worth Community Property Trust, ahead of development. Efforts were made to ensure that the design did not interfere with remaining archaeological features. For example, the road does not have foundations but consists of gravel 'floated' on a membrane above the soil (see right).

Code scoring by category

Scores for Plot 1

Category	Score	Credits available
Energy/CO2 emissions		
Ene1	4.8	10
Ene2	6.3	9
Ene3	2	2
Ene4	1	1
Ene5	1	2
Ene6	2	2
Ene7	0	2
Ene8	2	2
Ene9	1	1
Water		
Wat1	4	5
Wat2	1	1
Materials		
Mat1	12	15
Mat2	4	6
Mat3	3	3
Surface water run-off		
Sur1	2	2
Sur2	2	2
Waste		
Was1	4	4
Was2	3	3
Was3	1	1
Pollution		
Pol1	1	1
Pol2	0	3
Health & wellbeing		
Hea1	3	3
Hea2	4	4
Hea3	1	1
Hea4	4	4
Management		
Man1	3	3
Man2	1	2
Man3	2	2
Man4	0	2
Ecology		
Eco1	1	1
Eco2	1	1
Eco3	1	1
Eco4	1	4
Eco5	0	2



Costs and performance

Cost analysis

3.16. The cost of the scheme was approximately £1,260 per m^2, excluding land costs, external works, and design and statutory fees. This is broken down below.

Construction elements	Cost (£)	Percentage
Sub-structure	£ 51,918	6%
Super-structure	£ 296, 299	35%
Finishes	£ 44,660	5%
Fixtures & fittings	£ 15,323	2%
Services	£ 61,675	7%
External works	£ 154,450	18%
Landscaping & fencing	£ 12,901	2%
Design contingency	£16,753	2%
Design and statutory fees	£ 52,120	6%
Management	£ 133,408	16%
TOTAL	**£839,506**	**100%**
TOTAL per m^2	**£1,716**	
TOTAL exc. external works, design/statutory fees	**£616,184**	
TOTAL per m^2 exc. external works, design/statutory fees	**£1,260**	

Source: C.G. Fry

Performance data

Item	Typical U-value (W/m^2K)
External walls	0.15
Roofs	0.15
Floors	0.15
External doors	1.50
Windows	1.40

3.17. Air permeability is 3.12-4.25 m3/(h.m^2), depending on plot.

User experiences

3.18. The scheme was only occupied in April 2012, so occupants have not yet had experience of living in the properties all year round. At the time of researching this case study they had not yet received any utility bills. One resident reported that she was very happy with her property. It took some time for her to get used to the air source heat pump. She finds the shed useful for storage but does not use it for storing their bicycle. She does use the water butt and, in fact, has installed additional butts as she is a keen gardener.

3.19. She commented on minor design issues, such as the parking spaces being the wrong side of the house from the front door. This was apparently due to the original concept of there being a French window into the house, from the same side as the parking space.

Post-occupancy and maintenance issues

3.20. There has been little experience of maintenance issues yet. Users have been briefed, before and during the move-in period, and have received a home user guide. It is not yet clear whether there will be any problems with residents' operation of the air source heat pumps.

3.21. One or two of the residents were reported to want to install wood burners. While this is not wholly consistent with the air-tight/highly insulated design concept, the developer left provision in the roof design for putting in a flue for a wood burner without creating additional penetrations to the roof.

Learning

What worked well?

3.22. The developer of this scheme is highly experienced in building social housing to code level 4 and Homes and Communities Agency requirements, and integrate code requirements fully into the design process from the outset. Their code assessor works in the same room as the designers, which helps to minimise communication problems during design.

Issues faced and how they were addressed

3.23. The developer faced design constraints in using the external envelope specified in the planning consent for this development, since the rationale for the original design had been significantly different.

3.24. The development did not achieve Secured by Design standards. This was largely due to the inappropriateness of putting in external lighting in a village which, for traditional and aesthetic reasons, has no street lighting.

3.25. The original design for the scheme would have allowed wood burners, which are the local, traditional method of heating. As noted above, one or two residents are keen to retrofit wood burners, even if this is not wholly consistent with the design strategy.

Chapter 3

Case study 15: Tattersalls, Oxford

Overview

Location	2-4 Tattersalls, Islip Road, Oxford
Contractor	Feltham Construction
Client/developer	Peter Haxworth & Yaffler Ltd
Architect	Riach Architects and Martyn Haxworth
Code assessor	McBains Cooper
Date of completion	April 2012
House type(s)	1 x 3/4 bedroom detached 2 x 3/4 bedroom semi-detached
Funding	Private
Post-construction code level	4

Introduction

3.1. Built on garden land to the rear of two properties on Islip Road in north Oxford, the Tattersalls scheme incorporates one detached and two semi-detached houses. The two semi-detached houses were built for private sale, with the detached house occupied by one of the two co-developers of the scheme. A neighbouring bungalow (now number 1 Tattersalls) and one of the Islip Road houses have also been renovated as part of the development. From the scheme's inception, both of the developers have sought to achieve the highest standards of sustainability within the commercial and cost constraints of the scheme.

Construction details

Methods of construction

3.2. Although originally designed with traditional cavity wall construction, the three dwellings were eventually constructed with single leaf blockwork, finished with rendered external insulation. This resulted from an exploration of different options by the architect, code assessor and clients to find the most cost-effective approach to meeting the requirements of the build.

Key materials utilised

External walls	200mm lightweight aerated concrete blocks, finished with polystyrene insulation batts and external render
Ground floors	Beam and block floor with expanded polystyrene infill blocks
First floors	Standard beam and block
Second floors	Chipboard
Windows	Composite aluminium and timber
External doors	Composite aluminium and timber
Roofs	Plain clay tiles

Technologies utilised

3.3. The scheme incorporates a ground source heat pump with an 85 metre vertical pipe bore. The option of air source heat pumps was explored but the efficiencies were found to be insufficiently high. Solar thermal was also added part way through the contract, not because it was necessary to achieve code requirements but because of client choice and a belief that it would add value to the properties. Each property includes a mechanical ventilation system with heat recovery (see right).

Other key features incorporated

3.4. **Energy:** The scheme achieved good insulation levels although the levels of roof insulation were limited to some degree by the need to incorporate roof dormers. Cycle storage was provided for the detached house within the retained garages on the site. Space for home offices was provided within each of the properties.

3.5. **Ecology:** An existing yew hedge was retained, which helped with the ecology credits, and also provides an element of screening for the detached property.

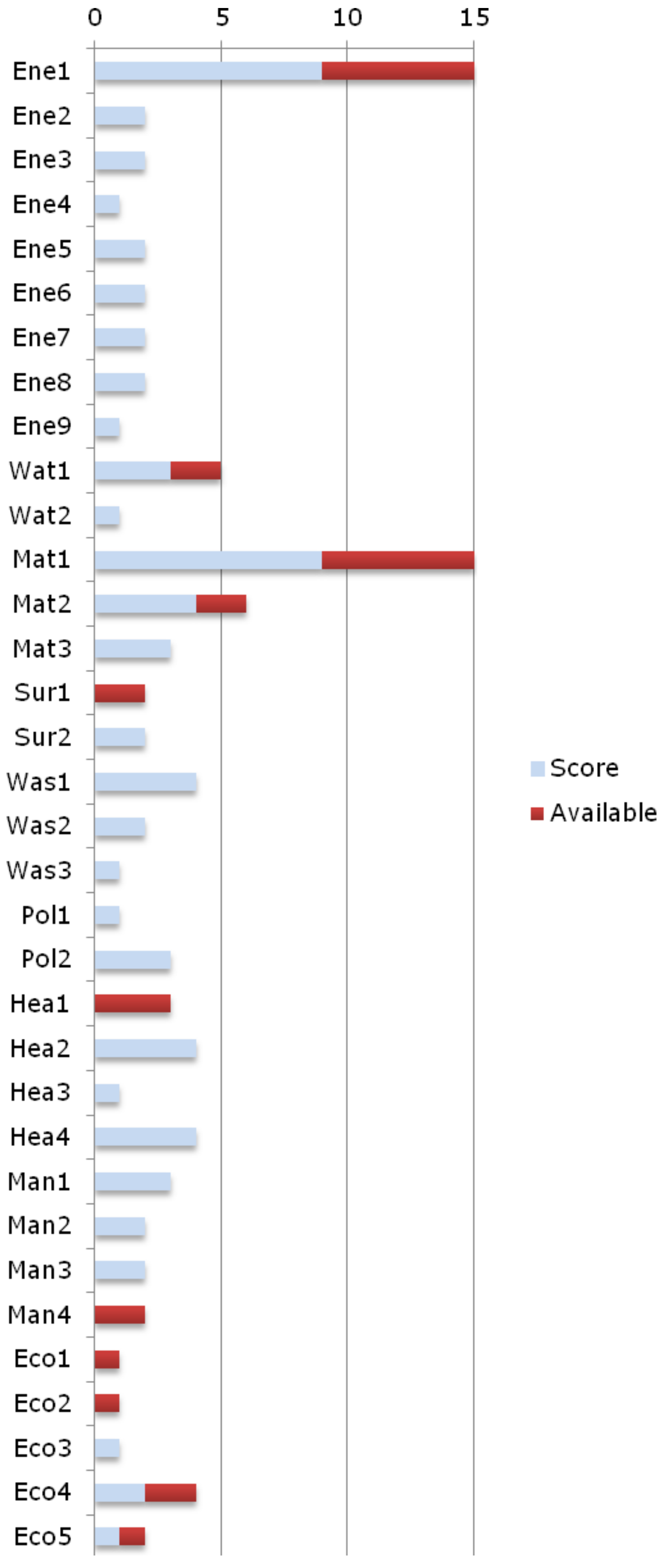
3.6. **Waste:** The scheme included space for recycling bins and compost bins were provided.

3.7. **Water:** Low water use sanitary fittings and flow restrictors were used and water butts were provided.

Code scoring by category

Scores for 2 Tattersalls

Category	Score	Credits available
Energy/CO2 emissions		
Ene1	9	15
Ene2	2	2
Ene3	2	2
Ene4	1	1
Ene5	2	2
Ene6	2	2
Ene7	2	2
Ene8	2	2
Ene9	1	1
Water		
Wat1	3	5
Wat2	1	1
Materials		
Mat1	9	15
Mat2	4	6
Mat3	3	3
Surface water run-off		
Sur1	0	2
Sur2	2	2
Waste		
Was1	4	4
Was2	2	2
Was3	1	1
Pollution		
Pol1	1	1
Pol2	3	3
Health & wellbeing		
Hea1	0	3
Hea2	4	4
Hea3	1	1
Hea4	4	4
Management		
Man1	3	3
Man2	2	2
Man3	2	2
Man4	0	2
Ecology		
Eco1	0	1
Eco2	0	1
Eco3	1	1
Eco4	2	4
Eco5	1	2



Costs and performance

Cost analysis

3.8. The average build costs across the three houses was £1,466 per m2, excluding land costs. These costs were lower than anticipated because of a highly competitive tendering process. The developers estimate that building to code level 4 introduced an uplift of approximately £30,000 per unit compared to building regulations standards.

3.9. The developers were advised by the selling agent early in the process that building to high sustainability standards would not necessarily increase the resulting value of the properties. This appears to have been borne out in practice, with the sustainability features reportedly not incentivising the sales of the properties. The code certificates were not requested by the purchasers and did not form part of the conveyancing process.

Performance data

Item	U-value (W/m^2K)
External walls	0.18
Roofs	0.14
Ground floor	0.14
External doors	1.30
Windows	1.30

3.10. The airtightness achieved was 4.23-4.95 $m^3/(h.m^2)$.

User experiences

3.11. Peter and Anne Haxworth occupy the detached property and were interviewed as part of the research for this case study. Although the construction of the house was significantly delayed, they are delighted with the outcome, particularly the comfort and efficiency of the property.

"It's amazing to live in. There is a very steady, even temperature throughout, all year round. The heat pump works with the underfloor heating very well and the overhanging eaves ensure that we are protected from too much glare and heat gain in the summer."
[Peter Haxworth]

3.12. They estimate that they are using 16 per cent less gas than in their previous home. Since gas is essentially only used for cooking, as in their previous home, they suspect the savings are due to a more efficient hob.

3.13. The electricity savings are striking, with annual usage in their new home estimated at 36 per cent of the usage in their previous home. This in spite of some electricity in the new home being used by builders during the refurbishment of a neighbouring cottage. They anticipate that in future, annual usage will be approximately 26 per cent of the usage in their previous home.

3.14. It has not been possible to accurately calculate water savings to date because the water supply has also been used for the purposes of the cottage refurbishment next door but significant savings are anticipated because of the water saving measures fitted to the property.

Post-occupancy and maintenance issues

3.15. Problems have been encountered with the heat exchanger in the mechanical ventilation heat recovery system of the detached property. The original heat exchanger was very noisy and had to be replaced. A second unit, installed on the advice of specialist consultants, also failed. A third unit has now been installed and is reported to be running well.

Learning

What worked well?

3.16. Early consideration of sustainability issues allowed the code requirements to be integrated into the design of the scheme from the earliest stages, e.g. in establishing south-facing aspects in the plot layout and retaining some of the original garages for cycle storage.

"I have seen lots of buildings with add-ons. I wanted to make sure that sustainability was designed in from the outset."
[Tim Purrett, Yaffler Ltd]

3.17. The renewable energy installations which have been incorporated have been particularly successful, as evidenced by the electricity usage in particular.

3.18. In terms of the process of achieving code requirements, the assessor stressed the value of carrying out both the code and SAP assessments, which makes for more straightforward information flows and greater confidence that the energy aspects of the code will be achieved.

Issues faced and how they were addressed

3.19. Considerable difficulties were faced in securing planning permission for the scheme due to neighbour issues and concerns about the height of the development. A compromise was eventually reached in which the ground floors were lowered through significant excavation and through the second floors being contained within the roof space using large dormer windows. Whilst more acceptable to the planners, the use of dormers made it more difficult to achieve the requisite levels of thermal efficiency and airtightness.

3.20. Some challenges were also encountered in installing the pipe work for the ground source heat pump. The bore struck bedrock, which caused a delay to the construction process. Such a significant bore (85 metres) was also somewhat disruptive in a residential area.

3.21. A further challenge described by one of the clients related to the building techniques needed to achieve the sustainability standards. For example, in order to achieve the necessary airtightness, very narrow mortar beds had to be used in the single leaf blockwork and tight joints were needed between insulation materials and around windows and doors. Issues with such items led to delays in the construction process and the resulting levels of airtightness were not as high as initially hoped for.

Chapter 4

Case study 16: Bramble House, Ashford, Kent

Overview

Location	Sotherton, Ashford, Kent
Developer(s)	ISG Jackson
Client	Ashford Borough Council
Architect	Hunters
Code assessor	Ashford Borough Council
Date of completion	November 2011
House type(s)	Scheme provides long-term independent living accommodation for people with learning disabilities, and comprises: 4 x 1 bed flats 1 x 1 bed bungalow
Funding	Homes and Communities Agency
Post-construction code level	4

Introduction

4.1. Bramble House comprises a block of four one-bedroom flats plus a one bedroom bungalow annexed to the main building. The site, on the outskirts of Ashford in Kent, had previously been derelict land in the corner of a residential cul-de-sac owned by the council, which had given rise to anti-social behaviour problems. With its close proximity to local facilities and bus services, it was considered an ideal site for housing development.

4.2. The dwellings have been designed to be suitable for occupants with a diverse range of housing need and are being used to provide long-term independent living accommodation for people with learning disabilities.

4.3. This development forms part of a larger phase of council-led development, made possible after the council secured funding from the Homes and Communities Agency. A total of 78 new houses, bungalows and flats have been delivered with that funding. The first ten developments were built to meet code level 3, whilst the second phase (of which Bramble House is part) has been built to meet code level 4.

Construction details

Methods of construction

4.4. The external walls of the development are constructed from fully insulated cavity masonry work (using thin joint lightweight blockwork) finished with a rendered coating. For the first six sites that the council developed, timber frame construction was used. For the second phase of developments (including Bramble House), the council specified blockwork construction for a number of reasons:

- the council's planned maintenance department reported concerns relating to the timber frame construction used on the first sites. The walls were reported to be vulnerable if residents do not use the correct fittings for wall mounting fixtures
- it was suggested that this may make the properties less likely to overheat and retain more residual energy during the heating season
- as with timber frame, the building envelope can be erected relatively quickly, allowing internal works at an earlier stage than other forms of masonry construction
- there had been an amount of media interest regarding fires on timber framed building sites, which had an influence at the early design stage

"We feel the lightweight thin joint blockwork system offers a better all round performance than timber frame construction and is more resilient. To achieve the code 4 mandatory energy requirements, the wall structure was relatively thick which may be a consideration on 'tighter' sites."
[Simon Lees, code assessor, Ashford Council]

Key materials utilised

External walls	Lightweight aerated concrete blocks with thin joint mortar and 125mm of mineral wool insulation
Ground floors	Suspended concrete beam and block formation with insulated screed topping (chosen because there was a need for a ventilated sub-floor, following site remediation).
Upper floors	Pre-stressed concrete planks with screed topping.
Windows	uPVC double glazed with low-E glass.
External doors	Solid timber.
Roofs	Pitched concrete tile with 350mm glass wool insulation.

Technologies utilised

4.5. The dwellings perform well in terms of reduced carbon emissions, through a ‘fabric first’ design approach, efficient space and water heating systems, renewable energy input and low energy lighting throughout. Photovoltaic panels on the roof contribute at least 15 per cent of the electricity demand.

4.6. On the first six sites that the council developed, solar water heating was installed to help meet code level 3. For the code 4 developments, the council chose to specify photovoltaics rather than solar water heating because it was found that many tenants find the controls for solar water heating rather complicated and therefore do not use the systems properly. The council had previously done some research with its tenants and found that they adapted to using photovoltaics very quickly, e.g. learning to use appliances at the right time to get the maximum benefit. The council also felt that it was simpler to have one technology installed on a development rather than two, and therefore chose to specify photovoltaics for the second phase of development sites. In addition, unlike solar water heating units, photovoltaics do not use up internal storage space and the feed-in-tariff which was available for photovoltaics added to the rationale.

Other key features incorporated

4.7. **Energy**: Clothes drying provision is made by way of a retractable clothes line in the shower room. The lighting of the scheme exterior and common areas is by way of low energy, controlled fittings. A large bicycle storage shed is provided close to the entrance of the property. Facilities are provided to have a home office set up in the main open-plan living area.

4.8. **Water**: Flow-rate restrictors have been installed on the showers and taps and the toilets are dual flush. Water butts have been installed to provide capacity for the communal garden.

4.9. **Waste**: The dwellings are equipped with internal recycling bins to encourage waste separation. Accessible, adequate external storage for waste has been provided within the scheme. A number of garden composters have been provided for residents to use, conveniently positioned for both them and the grounds maintenance contractors.

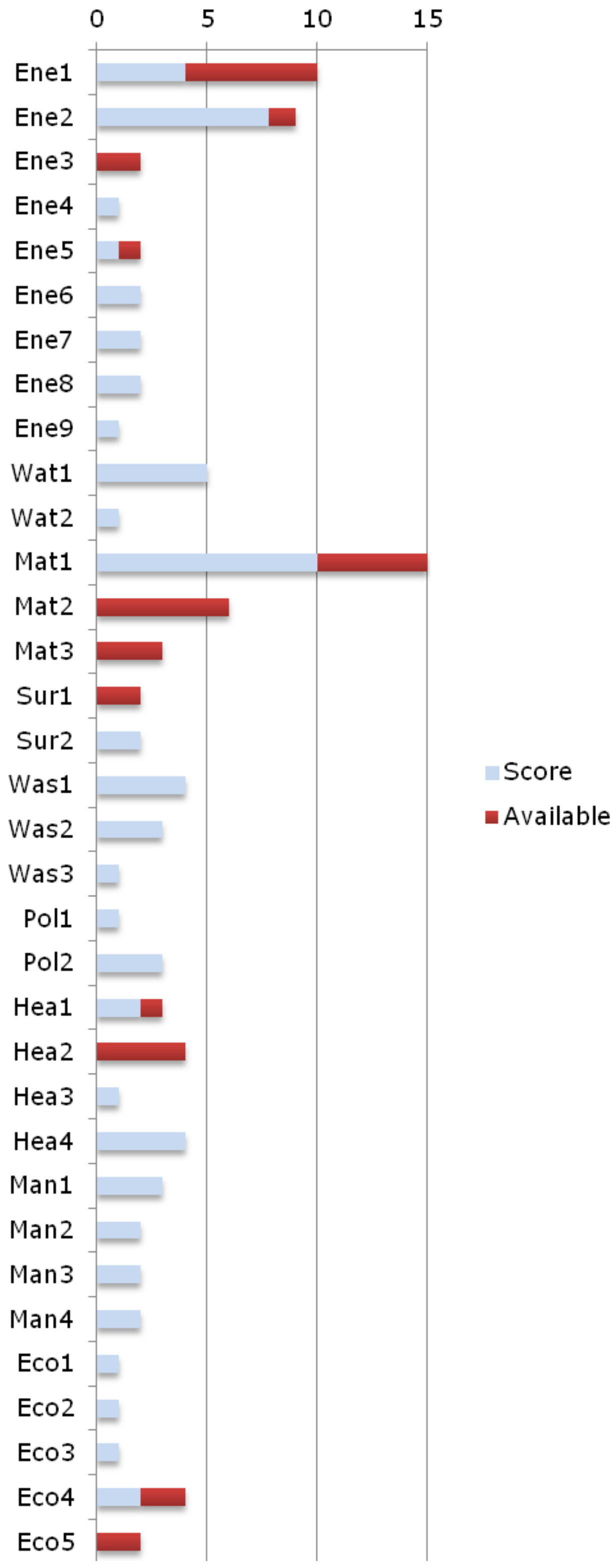
4.10. **Health and wellbeing**: Each unit has its own private outside area and the flats are built to Lifetime Homes standards.

4.11. **Management**: A home user guide has been provided to each resident and their carer. This provides information on local amenities and transport networks, energy saving tips, information on recycling and sustainable maintenance.

4.12. **Ecology**: The plot was an amalgamation of residential gardens, a good portion of which had been neglected and was supporting a population of reptiles. These were relocated to a suitably prepared area on a neighbouring nature reserve. An ecologist's report suggested a number of features that could be included to enhance the ecology of the area, such as bat and bird boxes, which have been installed on the site. Scheme planting has also been provided in accordance with the ecologist's recommendations.

Code scoring by category

Category	Score	Credits available
Energy/CO2 emissions		
Ene1	4	10
Ene2	7.8	9
Ene3	0	2
Ene4	1	1
Ene5	1	2
Ene6	2	2
Ene7	2	2
Ene8	2	2
Ene9	1	1
Water		
Wat1	5	5
Wat2	1	1
Materials		
Mat1	10	15
Mat2	0	6
Mat3	0	3
Surface water run-off		
Sur1	0	2
Sur2	2	2
Waste		
Was1	4	4
Was2	3	3
Was3	1	1
Pollution		
Pol1	1	1
Pol2	3	3
Health & wellbeing		
Hea1	2	3
Hea2	0	4
Hea3	1	1
Hea4	4	4
Management		
Man1	3	3
Man2	2	2
Man3	2	2
Man4	2	2
Ecology		
Eco1	1	1
Eco2	1	1
Eco3	1	1
Eco4	2	4
Eco5	0	2



Costs and performance

Cost analysis

4.13. The total build cost for Bramble House was £594,825, working out at £1,680 per m^2, excluding land costs and professional fees.

4.14. The thin joint blockwork construction system is more expensive than timber frame. On another council development site involving nine units, the council reported that it cost around £30,000 more than timber frame (around £3,300 per unit).

Performance data

Item	U-value (W/m^2K)
External walls	0.20
Roofs	0.11
Floors	0.12
External doors	1.50
Windows	1.50

4.15. The airtightness achieved was 4.39 $m^3/(h.m^2)$.

User experiences

4.16. The council has run sessions for residents and carers at Bramble House on how to use the heating systems and how to take advantage of the photovoltaics.

4.17. Residents first moved into the properties in November 2011. There have been teething problems with the heating systems, largely due to the fact that the contractor installed complex room thermostats that switch to 'engineering mode' if a particular button is pressed down too long. Unsurprisingly, this has caused a number of problems. The council is continuing to monitor this and to provide training to residents in the correct use of the controls.

4.18. No overheating has been reported in these properties. The client feels that the construction type protects against overheating more effectively than timber-frame construction.

4.19. The carer of the resident interviewed felt that the energy bills were what she would expect for a property of that size.

Post-occupancy and maintenance issues

4.20. No major maintenance or other issues have been reported with the dwellings.

Learning

What worked well?

4.21. Up to the planning stage, everything was carried out in-house by the council, including the design and the code assessment. Those involved are all located in the same office, making it easy to work together. Having gained substantial experience of building to code level 3 on the previous development sites, the team found that the process of designing and building these properties worked smoothly.

4.22. The council also imposed a contract condition on the successful contractor to source local sub-contractors for an amount of the work. This contributed to the sustainability to the scheme, although it is not specifically rewarded under the code.

Issues faced and how they were addressed

4.23. The council chose to use a design and build contract for this development since this would allow it to be built in the timeframe required by the Homes and Communities Agency. However, this resulted in some glitches, such as the overcomplicated heating controls being installed, which have proved very difficult for residents to use properly. In future, the council would provide more detailed specification within the contract.

Chapter 5

Case study 17: Forresters Fold, Dudley, West Midlands

Overview

Location	Forresters Fold, Wood Road, Lower Gornal, nr. Dudley, West Midlands
Developer(s)	Frank Haslam Milan, part of Keepmoat (design & build contract)
Client	Dudley Metropolitan Borough Council
Code assessor	The Marks Davis Partnership
Architect	Pinnegar Hayward Design LLP
Date of completion	February 2012
House type(s)	3 x 2-bedroom houses 6 x 3-bedroom houses 4 x 4-bedroom houses 6 x 2-bedroom apartments (for over-55's, including a carers unit)
Funding	Homes and Communities Agency
Post-construction code level	4 (Nov 2010 scheme version)

Introduction

5.1. Built for Dudley Metropolitan Borough Council, this scheme provides a range of family houses of varying proportions, as well as apartments for older people. It is built on a triangular site bounded by houses to the west of Dudley. The site was previously used for garages, but was largely derelict and overgrown prior to the development taking place. Extensive re-landscaping and drainage works were necessary to achieve the sustainability and accessibility requirements on this challenging, steeply sloping site. To facilitate the integration of the scheme with the surrounding area, all of the new buildings are two storeys, including the apartment block.

Construction details

Methods of construction

5.2. The houses and apartments were built using traditional cavity wall construction, with lightweight insulating blocks, 150mm cavities and facing brickwork. The ground floor was constructed using concrete beams infilled with expanded polystyrene blocks.

5.3. This was found to be the most cost-effective way of meeting code level 4 on this scheme, following extensive scenario testing by the developer and code assessor at the design stage.

Key materials utilised

Walls	External walls - 100mm lightweight aerated blocks Party walls - 100mm lightweight solid concrete blocks
Floors	Ground floor - inverted concrete beams, infilled with expanded polystyrene blocks Upper floors – chipboard on timber I-section joists
Windows	uPVC double glazed
Doors	Houses – fibreglass composite Apartments – uPVC double glazed
Roofs	Concrete tiles

Technologies utilised

5.4. A photovoltaic system is included on every dwelling as the principal means, along with an efficient fabric, of achieving the energy requirements of the code. As well as being economical for the developer, the feed-in-tariffs were seen as an added benefit of utilising photovoltaics.

5.5. The developer advised that the costs to them for photovoltaics have reduced from approximately £3,000 per kiloWatt to £1,200 per kiloWatt in the last two years alone, helped by the fact that they have their own in-house photovoltaics division. The developer suggested that they find it more cost-efficient to invest more in the fabric and photovoltaics than incorporate mechanical ventilation with heat recovery.

5.6. A rainwater harvesting system is included for each of the houses, which was an essential component of achieving the surface water drainage requirements of the code on this scheme.

Other key features incorporated

5.7. **Ecology**: The client carried out an outline ecology assessment prior to letting the contract, which informed the strategy for addressing the ecology elements of the code. There is extensive planting on the site, particularly above the large retaining wall at the top of the site. Three different types of bird boxes and a number of bat boxes are also incorporated.

5.8. **Waste**: Waste separation bins are provided in all units and the houses are all supplied with composting bins.

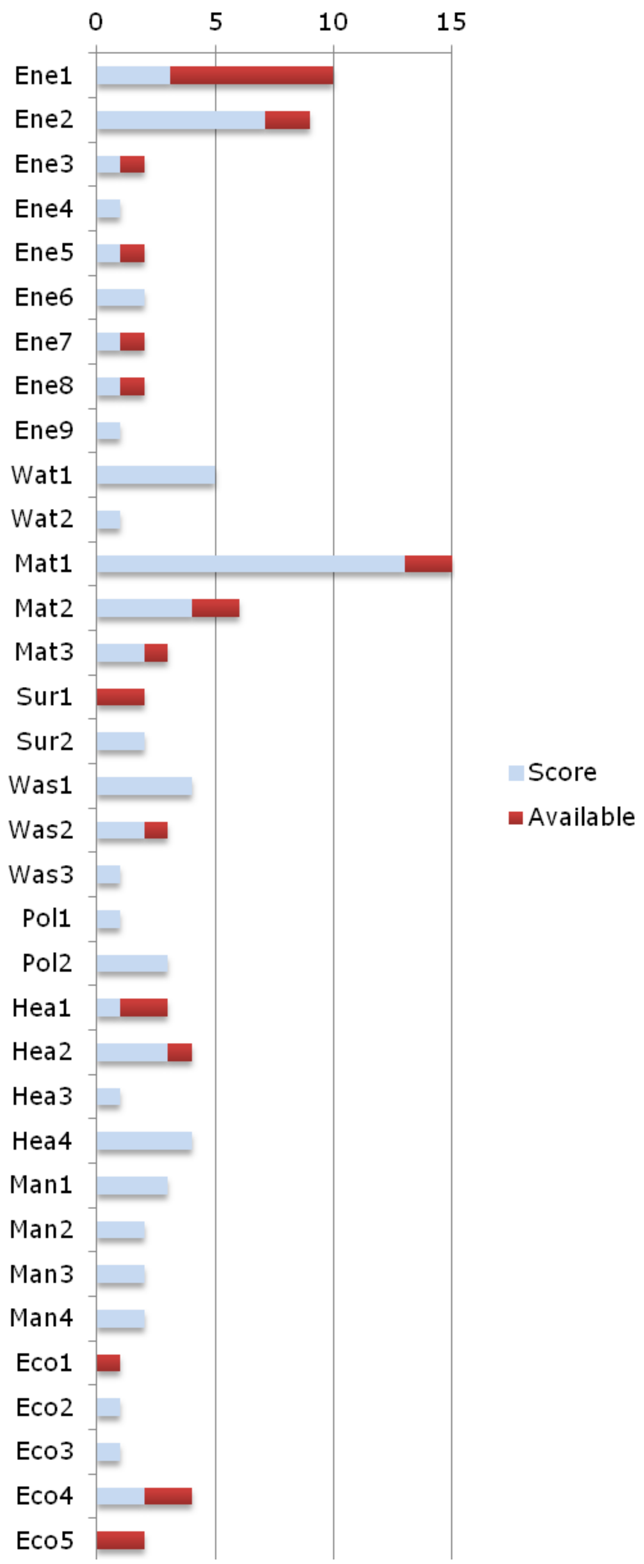
5.9. **Water**: Water conservation measures include low flow taps, low volume baths, dual flush toilets and low volume showers. Water butts are provided for each of the houses.

5.10. **Energy:** A-rated boilers are utilised throughout, along with time and temperature zone controls for the heating systems. Energy efficient lighting and A-rated appliances are provided in all dwellings. All of the dwellings are provided with lockable sheds and rotary dryers.

Code scoring by category

Code scores for plot No. 10 (House)

Category	Score	Credits available
Energy/CO2 emissions		
Ene1	3.1	10
Ene2	7.1	9
Ene3	1	2
Ene4	1	1
Ene5	1	2
Ene6	2	2
Ene7	1	2
Ene8	1	2
Ene9	1	1
Water		
Wat1	5	5
Wat2	1	1
Materials		
Mat1	13	15
Mat2	4	6
Mat3	2	3
Surface water run-off		
Sur1	0	2
Sur2	2	2
Waste		
Was1	4	4
Was2	2	3
Was3	1	1
Pollution		
Pol1	1	1
Pol2	3	3
Health & wellbeing		
Hea1	1	3
Hea2	3	4
Hea3	1	1
Hea4	4	4
Management		
Man1	3	3
Man2	2	2
Man3	2	2
Man4	2	2
Ecology		
Eco1	0	1
Eco2	1	1
Eco3	1	1
Eco4	2	4
Eco5	0	2



Costs and performance

Cost analysis

5.11. Build costs were £1,130 per m^2 including preliminaries but excluding land costs and consultants fees. A breakdown is provided below.

Item	Cost	Cost per m^2
Prelims	£279,781.00	
Materials	£267,168.00	
Sub con	£1,574,812.00	
Plant	£9,006.00	
Stats	£71,807.00	
Consultants fees	£75,921.00	
Total	**£2,278,495.00**	**£1,168.46**
Total exc. fees	**£2,202,574.00**	**£1,129.53**

5.12. The developer estimates that the code requirements added £4-5,000 for each of the apartments and £7-8,000 for each of the houses. The difference between the two stems from the fact that the houses incorporated rainwater harvesting, whereas the apartments did not.

5.13. The developer suggested that a minor part of the uplift in costs stems from the fabric requirements and sundry items such as composting bins and bike stores but the major additional cost stems from the photovoltaics and the rainwater harvesting. The photovoltaic systems cost between £1,800-4,000 per dwelling on this scheme.

Performance data

Item	U-value (W/m^2K)
External walls	0.17
Roofs	0.10
Floors	0.14
External doors	1.60
Windows	1.40

5.14. The airtightness achieved for plot 1 was $3.84m^3/(h.m^2)$.

User experiences

5.15. One resident was interviewed as part of this research and gave an overwhelmingly positive response, both in terms of the general experience of living in the property and in terms of energy and water usage:

“Even though the house is big and open, it’s easy to heat. I have only been here since March but the temperature seems to remain steady at 23-24 degrees with the heating off. I haven’t noticed any difference with the water fittings but I’m sure my water bills will be cheaper, as well as the gas and electricity.”
[Resident, Forrester’s Fold]

5.16. The resident also reported that they had made changes to their living habits to take advantage of the photovoltaics.

“In my old house I had cheap electricity at night but now I get free electricity during the day. You can’t get better than that. I try and do as much as possible during the day now.”
[Resident, Forrester’s Fold]

Post-occupancy and maintenance issues

5.17. Dudley Metropolitan Borough Council arranged for the contractors to hold training sessions for the council’s lettings and housing management staff so that they could disseminate the information to the tenants as part of the handover. All tenants were supplied with a detailed home user guide and the dwellings were said to have been designed with ease of use in mind, e.g. using combination boilers and simple controls.

5.18. However, the council acknowledge that efforts to educate residents have only been partly successful.

‘We are currently undertaking a survey of all new tenants… and they are suggesting that some tenants are struggling to understand the rainwater harvesting and photovoltacis.’
Steve Wilson, Partnerships Manager (Minor Contracts), Dudley MBC

5.19. Since completion, one of the rainwater harvesting system pumps failed, leaving one of the houses without flushing toilets for a short period and leading to an expensive and difficult repair (the pumps are located below the ground).

Learning

What worked well?

5.20. The developer suggested that meeting the energy requirements of the code was straightforward in this case, because of their intensive work on design and materials at the design stage.

"The best approach to meeting the code requirements is to focus on building fabric first. It makes you far less M&E [mechanical and electrical] *reliant. I have a set of U-values that I always aim for. I have to be a bit flexible about it but it gives me a useful benchmark to work to."*
[Guy Marks, code assessor, The Marks Davis Partnership]

5.21. Another stakeholder pointed to the importance of a fabric first approach in terms of keeping homes as usable and straightforward to live in as possible, and in terms of keeping down longer term maintenance costs. Such issues were seen to be particularly important in social housing schemes.

5.22. The fact that there was plenty of suitable roof space for the incoporation of photovoltaics also helped in this scheme and the inclusion of photovoltaics has led to significant income for the council from the feed-in-tariffs.

5.23. The developer suggested that an extra attraction of using photovoltaics is the flexibility it offers in terms of meeting code requirements – capacity can be reduced or expanded depending on the number of points required. This played out in the Forresters Fold scheme in relation to one of the dwellings which had more external walls than the others and struggled to meet the energy requirements as a result. By increasing the capacity of the photovoltaics scheme on this dwelling, the code requirements were able to be met.

"Because photovoltaics are a bolt-on, on a scheme like this you can just get the fabric as efficient as possible and then add photovoltaics as necessary."
[Guy Marks, code assessor, The Marks Davis Partnership]

Issues faced and how they were addressed

5.24. The history of mining in the area meant that the foundations had to be piled, which led to additional costs. The topography also made this a difficult construction site, with steep slopes requiring significant levels of earth movements. It also led to challenges in achieving the level thresholds necessary for meeting Lifetime Homes requirements.

5.25. However, the principal challenges related to the surface water drainage requirements. The developer suggested that they always seek to design out rainwater harvesting because of the costs and the resulting liabilities but in this development it was found to be necessary to incorporate rainwater harvesting systems on each of the houses in order to meet the mandatory surface water drainage requirements of the code.

Chapter 6

Case study 18: Dairy Close, Enfield

Overview

Location	Dairy Close, Gilbert Street, Enfield, Middlesex
Developer(s)	Bugler Developments Ltd (Design & Build contract)
Client	Origin Housing
Architect	HTA
Code assessor	Abdale Associates
Date of completion	January 2012
House type(s)	62 residential units, including 28 for private sale. The scheme includes: 6 x 2-bedroom terraced houses 14 x 3-bedroom terraced houses 4 x 4-bedroom terraced houses 8 x 3-bedroom maisonettes 10 x 1-bedroom flats 18 x 2-bedroom flats 2 x 3-bedroom flats 62 car parking spaces
Funding	Homes and Communities Agency, Origin Housing
Post-construction code level	4

Introduction

6.1. Built on the site of a derelict former Co-op dairy, Dairy Close is a development for Origin housing association. Of the 62 properties, 28 were sold privately, including some on a shared ownership basis. The remaining homes are managed by Origin. It is one of the earliest large code level 4 developments in Enfield.

6.2. The scheme is a mixture of two and three-storey blocks. Although surrounded on three sides by existing housing, the new homes were set further back from the existing houses than the old dairy, with the taller three-storey blocks located in the centre of the site, furthest from the neighbouring houses. Bedrooms are provided in some of the roof spaces to make the most efficient use of space whilst maintaining an appropriate scale.

6.3. As well as private rear gardens for the houses and communal rear gardens for the flats, the properties are designed around a central communal green space.

Construction details

Methods of construction

6.4. Traditional construction methods were sufficient for meeting code requirements on this scheme. The dwellings are built with a brick outer leaf, insulated cavity and medium density block work inner leaf. All ground floors are beam and block, insulated and screeded. The flats have concrete upper floors and stairs whilst the houses have timber upper floors.

Key materials utilised

Walls	100mm lightweight aerated concrete blocks, 100mm PIR insulation, 50mm clear cavity and 102.5mm facing brickwork
Floors	Standard beam and block with 150mm PIR insulation
Windows	UPVC double glazed
Doors	Softwood double glazed
Roofs	Concrete tiles

Technologies utilised

6.5. The development incorporates extensive roof-mounted photovoltaic arrays and most units have mechanical ventilation with heat recovery. When considering the renewables options, the developer found that the costs of photovoltaics had reduced significantly in recent years, which made it as cost effective as solar thermal.

6.6. The photovoltaic systems contribute to meeting the code requirements but also to a planning condition which required a 20 per cent reduction in carbon dioxide emissions from the scheme through the use of renewables.

Other key features incorporated

6.7. **Energy:** The units include gas boilers. Additional heating controls are provided in the units, including day and night thermostats. All units have natural drying facilities. The flats are provided with an integrated cycle store, whilst the houses have external lockable cycle stores. All units include a home office area or room.

6.8. **Water:** Water efficient fittings are included throughout. Prior to the development taking place, the site consisted of almost entirely impermeable surfaces, meaning that the surface water runoff requirements of the code have been relatively straightforward to meet. The requirements have been met through the use of soakaway infiltration and asustainable urban drainage system. Water butts are provided to each of the houses and each of the communal gardens serving the flats.

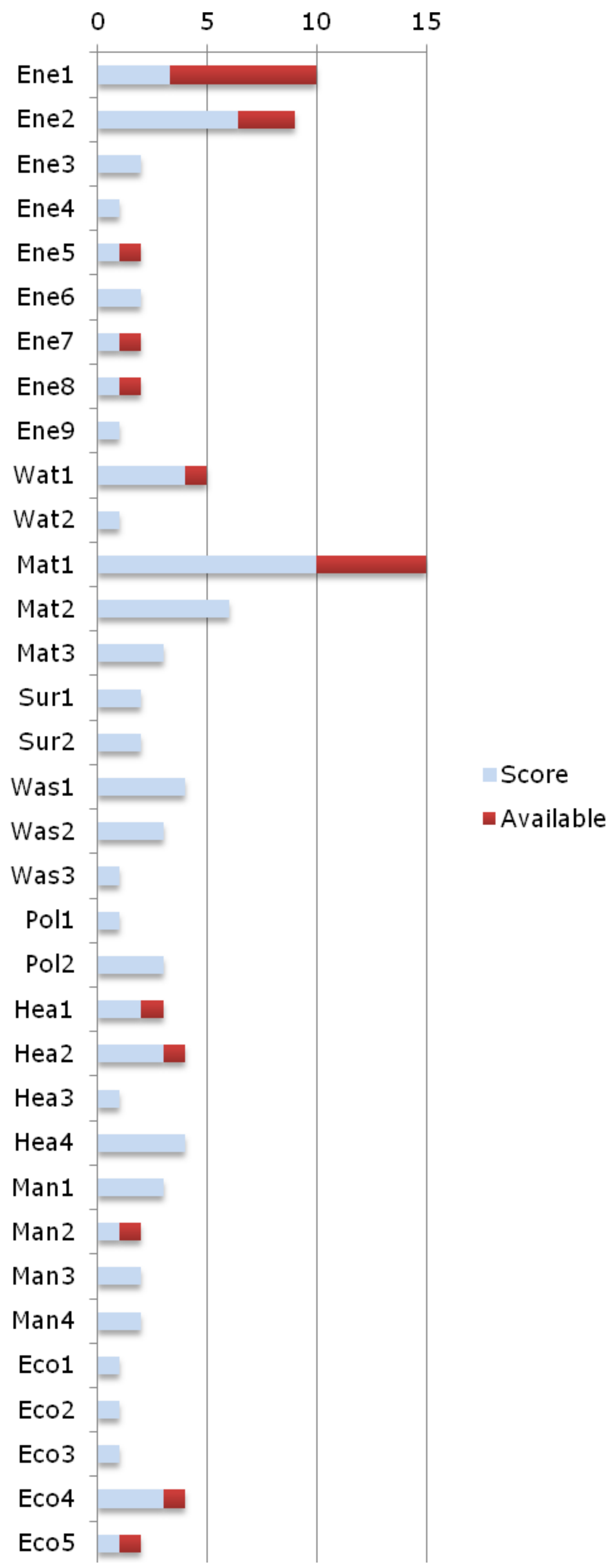
6.9. **Waste:** Each unit is provided with internal and external space for waste and recycling.

6.10. **Ecology:** Landscaping and planting was carried out in accordance with the recommendations of an ecologist’s report.

Code scoring by category

Scores for Flat 1, 22 Dairy Close

Category	Score	Credits available
Energy/CO2 emissions		
Ene1	3.3	10
Ene2	6.4	9
Ene3	2	2
Ene4	1	1
Ene5	1	2
Ene6	2	2
Ene7	1	2
Ene8	1	2
Ene9	1	1
Water		
Wat1	4	5
Wat2	1	1
Materials		
Mat1	10	15
Mat2	6	6
Mat3	3	3
Surface water run-off		
Sur1	2	2
Sur2	2	2
Waste		
Was1	4	4
Was2	3	3
Was3	1	1
Pollution		
Pol1	1	1
Pol2	3	3
Health & wellbeing		
Hea1	2	3
Hea2	3	4
Hea3	1	1
Hea4	4	4
Management		
Man1	3	3
Man2	1	2
Man3	2	2
Man4	2	2
Ecology		
Eco1	1	1
Eco2	1	1
Eco3	1	1
Eco4	3	4
Eco5	1	2



Costs and performance

Cost analysis

6.11. Build costs were £1,348 per m^2, excluding land costs, professional fees and on-costs.

6.12. Origin's sales manager reported that the people buying the properties for sale had little interest in the sustainable aspects of the homes and that they did not lead to an increase in the sales prices.

Performance data

Item	Typical U-value (W/m^2K)
External walls	0.18
Roofs	0.10
Floors	0.15
External doors	1.40
Windows	1.40

6.13. The airtightness achieved for plot 1 (a house) was $3.79m^3/(h.m^2)$.

User experiences

6.14. One resident was interviewed as part of the case study research and gave very positive feedback on their home.

"The property is warm all the time, I don't have to put the heating on that much and the bills are less than I thought - I am not paying very much. It's also easy to live in and maintain… and I use the fan boost which is useful."
[Resident, Dairy Close]

Post-occupancy and maintenance issues

6.15. Detailed user manuals were provided to all residents, including the social rented and private homes. This included a DVD which explained how to use the mechanical ventilation heat recovery system and other controls.

6.16. There have been some issues with excessive noise from the heat recovery units when the systems are on the boost setting. This may have resulted in residents switching them off but no problems have yet been reported in terms of ventilation or condensation.

Learning

What worked well?

6.17. A number of success factors are apparent in the successful and seemingly smooth delivery of the Dairy Close scheme to code level 4:

- code requirements being factored into the design by the architects from the earliest stages
- a developer with experience of building to the code, and a clear strategy for achieving level 4. In conjunction with their code assessor, Bugler prepared a detailed specification for achieving the requirements following the award of the contract
- a very proactive code assessor with a close working relationship with the developer and an active role in the design team. Regular design team meetings were convened by the developer throughout the construction process, involving the architects, code assessor and engineers
- early completion of the design stage assessment to provide confidence and reassurance that the development would meet the necessary requirements
- close working between the code assessor and SAP assessor, which helped to ensure that the energy aspects of the code were met without any major problems

"When we take on a design & build contract, we have to minimise the risks of not meeting code requirements so we carry out the design stage assessment as early as possible, usually within the first two-three months. This gives us confidence that we're on the right lines."
[Tom Locke, Bugler Developments]

Issues faced and how they were addressed

6.18. One of the challenges faced by the architects was in providing cycle storage. The flats have internal shared cycle stores but space needed to be found in the small front gardens of the houses for lockable cycle stores, as well as utility meters and waste and recycling bins. By recessing the front doors, projecting canopies were able to be avoided, which helped maintain space at the front of the houses and helped to give the elevations a simple, contemporary appearance.

6.19. Achieving the other requirements of the code was relatively straightforward with no major issues encountered. More photovoltaics were needed than was included in the original designs because the performance of the panels used was slightly lower than anticipated.

Chapter 7

Case study 19: Ravenscroft, Wimbish, Saffron Walden

Overview

Location	Ravenscroft, Tye Green, Wimbish, near Saffron Walden, East Anglia
Developer(s)	Bramall Construction, part of Keepmoat Group (Design & Build contract)
Client	Hastoe housing association
Architect	Parsons + Whittley Ltd
Code assessor	RES Inbuilt
Employer’s agent	Davis Langdon
Date of completion	June 2011
House type(s)	Social housing development, approved as a ‘rural exception scheme’ to meet housing need. There are 14 dwellings, which provide a mixture of rented and shared-ownership accommodation: 6 x 1 Bed flats (51sqm), 5 x 2 Bed/4 Person houses (76sqm) 3 x 3 Bed/5 Person houses (88sqm).
Funding	Homes and Communities Agency, Hastoe housing association
Post-construction code level	4 (May 2009 version)

Introduction

8.1. This development of 14 homes was certified to the Passivhaus standard, as well as code for sustainable homes level 4. This was a pioneering development for Hastoe housing association, being their first Passivhaus scheme. The Passivhaus requirements were met using a ‘fabric first’ approach, combined with mechanical ventilation with heat recovery. This approach met the energy requirements of code level 3, but solar thermal panels were added to ensure that the development reached code level 4, and the Passivhaus standards for primary energy demand.

8.2. The buildings were orientated to achieve high solar gain, with solar shading to avoid summer overheating. High levels of external insulation were fitted outside thin-joint blockwork walls, and below the ground floor concrete slab, to achieve very low u-values. The external surfaces were finished with coloured render, in a style consistent with local vernacular architecture. Penetrations of the external envelope were minimised, to achieve extremely good levels of air tightness.

Construction details

Methods of construction

8.3. The dwellings were constructed using reinforced concrete slab foundations, with thin-joint blockwork and a timber roof. This method of construction was chosen to ensure that local building firms and labour could be used. External insulation was fitted to the outside of thin-joint blockwork. Throughout the design and construction process, maintaining air-tightness and minimising u-values were a prime consideration.

Key materials utilised

Walls	External walls: 190 mm lightweight aerated concrete blocks, 285mm external EPS insulation panels, external 8mm modified silicone resin render Party walls: 300mm cavity walls of lightweight aerated concrete blocks, consisting of two layers of 100mm blocks with 100mm filled cavity in between
Ground floors	Ground floor slabs - 300mm reinforced concrete raft, on 50mm concrete blinding, on eco-membrane, on 400mm Styrofoam structural insulation, on 25mm ‘fines’ blinding, on compacted type 1 sub-base Ground floors - 65mm thick sand & cement screed, with fabric reinforcement, on 30mm thick expanded polystyrene insulation.
First floors	Mostly 150mm pre-cast concrete plank floors
Windows	Triple glazed composite (timber and aluminium)
Doors	Boarded external composite (timber and aluminium) with triple glazing
Roofs	Plain grey concrete tiles; timber trusses; 500mm glass fibre insulation to loft spaces

Technologies utilised

8.4. The layout and orientation of buildings on the site was designed to maximise solar gain. There are two arcs of buildings, which enable each dwelling to be orientated east-west. The glazed areas on the north side were minimised, while larger glazed areas were incorporated on the south elevation, combined with brise soleil to ground floor (see right) and blinds to first floor with eaves overhang to reduce overheating in summer. The flats were located on the northern line of buildings, with gardens to the north and with their main living spaces facing south over the communal space and parking at the centre of the development. The houses were located in the southern arc of buildings, with kitchen/living areas opening out onto private gardens to the south.

8.5. Extremely low u-values were achieved through the use of high levels of insulation, including external foam insulation and triple glazing. The target u-values for the walls was 0.09W/m^2K. This is based on the manufacturer's statement of performance - test results of actual performance were not available at the time of this case study. A key feature of the external insulation was that it was designed to be bonded to the blockwork, with no cavity between the blockwork and insulation.

8.6. The construction materials and methods were carefully specified to minimise thermal bridging and create a highly insulated airtight envelope for each dwelling. Extremely good levels of air tightness were achieved by minimising penetrations in the external envelope. For example, the solar shades were designed to be free standing rather than fixed to the external walls.

8.7. All the properties are fitted with mechanical ventilation heat recovery units (Focus 200) which in practice recover almost 87 per cent of the outgoing heat[4]. Air circulation within each property is facilitated through internal vents and 3cm ventilation gaps at the bottom of internal doors. Windows can be opened, but the mechanical ventilation system provides continual fresh air so that window opening is only necessary as a cooling strategy.

8.8. Water is heated using a combination of gas boilers and solar thermal panels. There is virtually no space heating, other than a heated towel rail in the bathroom of some properties. The mechanical ventilation heat recovery unit has a heating coil within the air duct, connected to the hot water system, which can be switched on to provide additional warming of the incoming air when needed.

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[4] *Wimbish Passivhaus - interim evaluation report, March 2012*. Prepared by Martin Ingham, UEA Associate, for the Technology Strategy Board's building performance evaluation and EU Build with CaRe programmes.

Other key features incorporated

8.9. **Ecology**: The site was assessed as having low ecological value, since a major part of it was previously agricultural land. Whilst the surrounding trees and hedgerows do have some ecological value, including potentially great crested newts, these areas were protected during construction. The ecological value of the site was enhanced through ecological planting and other measures recommended by a qualified ecologist.

8.10. **Waste**: Recycling bins and composting bins were provided for each property. The contractor was required to develop and implement a site waste management plan, to minimise construction waste and its impacts.

8.11. **Water and drainage:** Flow restrictors were fitted to baths and showers, and rainwater butts were provided for each property. The soil was unsuitable for soakaways, so surface water drainage works included gabions and holding tanks under the road, linked to a holding ditch behind the houses.

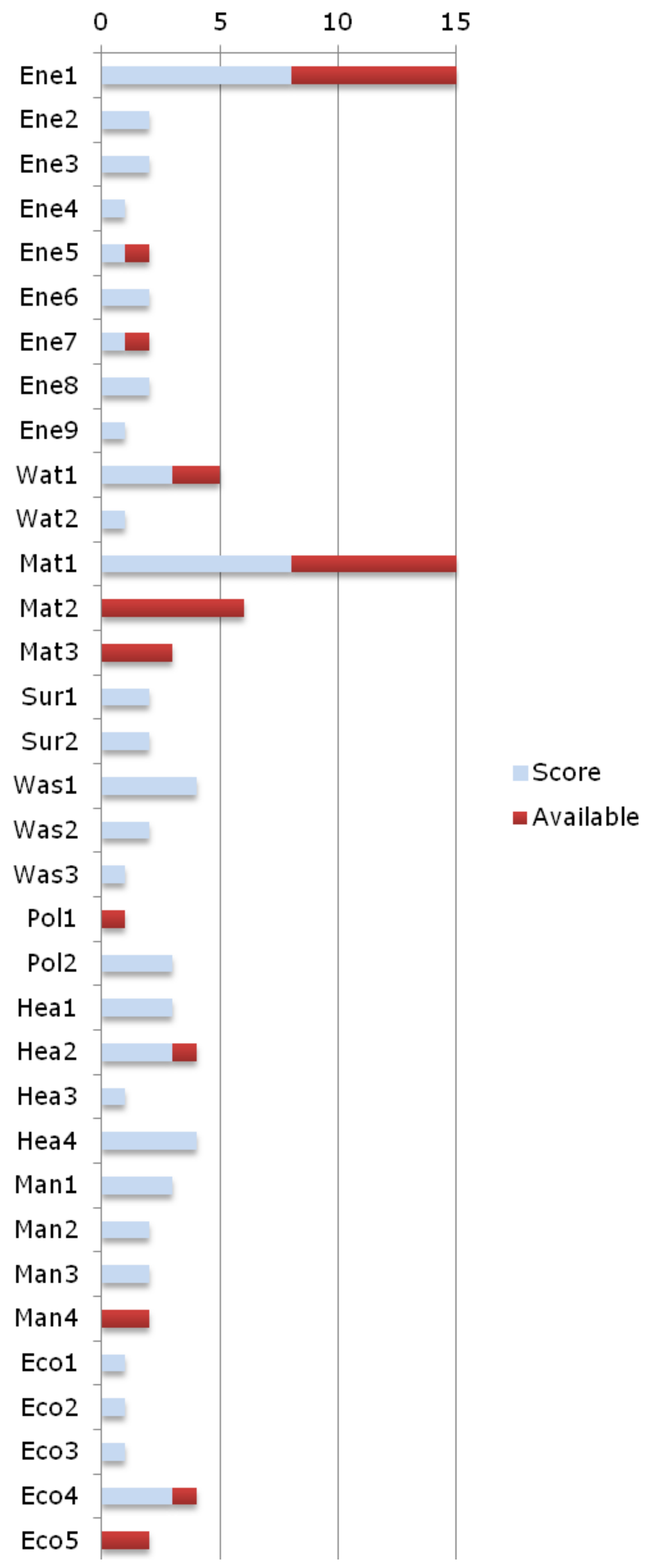
8.12. **Energy:** Credits were also obtained for provision of a rotary clothes drier, cycle storage shed and home office space for each property. Residents were, however, allowed to select their own white goods, although the home user guide advised the use of eco-labelled products.

8.13. **Health and wellbeing:** Daylighting was considered early in the design process, as were Lifetime Homes requirements. Sound insulation credits were achieved in the houses but not in the flats.

Code scoring by category

Code scores for houses

Category	Score	Credits available
Energy/CO2 emissions		
Ene1	8	15
Ene2	2	2
Ene3	2	2
Ene4	1	1
Ene5	1	2
Ene6	2	2
Ene7	1	2
Ene8	2	2
Ene9	1	1
Water		
Wat1	3	5
Wat2	1	1
Materials		
Mat1	8	15
Mat2	0	6
Mat3	0	3
Surface water run-off		
Sur1	2	2
Sur2	2	2
Waste		
Was1	4	4
Was2	2	2
Was3	1	1
Pollution		
Pol1	0	1
Pol2	3	3
Health & wellbeing		
Hea1	3	3
Hea2	3	4
Hea3	1	1
Hea4	4	4
Management		
Man1	3	3
Man2	2	2
Man3	2	2
Man4	0	2
Ecology		
Eco1	1	1
Eco2	1	1
Eco3	1	1
Eco4	3	4
Eco5	0	2



Costs and performance

Cost analysis

8.14. The construction cost, excluding land costs, abnormal costs, external works and design fees was £1,206 per m^2. This is broken down below.

Construction elements	**Cost (£)**	**%**
Substructure	£178,789	7%
Superstructure	£191,983	12%
External cladding & doors	£266,813	17%
Internal walls, partitions & doors	£57,724	4%
Finishes, decorations & fittings	£141,288	9%
M&E Installations	£152,520	10%
External works	£289,520	18%
Preliminaries and design fees (including site management)	£359,448	23% (c. 15% prelims, 8% design fees)
Total cost, excluding land and abnormals	**£1,577,067**	**100%**
Cost per m^2, excluding land and abnormals	**£1,555/m^2**	
Total cost, excluding land, abnormals, external works and design fees	**£1,223,540**	
Cost per m^2, excluding land, abnormals, external works and design fees	**£1,206**	

Source: Davis Langdon, Employer’s Agent.

8.15. The construction cost, excluding land and abnormals, was approximately £1,555 per m^2. Davis Langdon have undertaken a comparison between these costs and a recent, equivalent code level 4 scheme. They estimate that the costs of building a similar scheme to code level 4 were typically £1,375 per m2, while the cost of building to code level 3 are typically about £1,175 per m2. So Passivhaus costs for Wimbish are estimated to be 12 per cent higher than building to code level 4 alone. But they anticipate that future Passivhaus schemes would be able to take advantage of learning from Wimbish and reduce this differential.

Performance data

Item	U-value (W/m²K)
External walls	0.09
Roofs	0.08
Floors	0.07
External doors	0.80
Windows	0.77

8.16. The buildings were designed to meet or exceed the Passivhaus standard of 0.6 air changes per hour. The actual average air tightness achieved on the site was 0.45 air changes per hour. This equates to approximately 0.65 $m^3/(h.m^2)$ for the flats and 0.55 $m^3/(h.m^2)$ for the houses.

8.17. The Passivhaus standard requires that space heating requirements do not exceed 15 kWh/m^2 per year. This is significantly more onerous than the fabric energy efficiency requirements for code level 6.

User experiences

8.18. A detailed monitoring study is being undertaken by the University of East Anglia, covering both technical performance and user behaviour. Remote monitoring equipment is being used to monitor energy consumption, and measurements have been taken of internal temperatures, comfort levels and other aspects of building performance. There has also been a research programme with residents. This research has been funded by the Technology Strategy Board's building performance evaluation programme, and also forms part of the European Union build with care programme[5].

8.19. Residents are generally very happy with their properties. They enjoy high levels of comfort and warmth, with very low gas bills (typically £7 per month) and low water bills. Electricity bills tend to vary according to the lifestyles and choices of different residents, and are not as dramatically low as gas and water bills. One resident of a house reported that she had not needed to use any additional heating (excluding the mechanical ventilation heat recovery) during the previous winter, not even the heated towel rail.

8.20. Temperature monitoring shows that the dwellings are generally very warm - most are typically 23-24°C and sometimes up to 25°C. It is not yet clear whether overheating will be a problem during heatwave periods. The brise-soleils are designed to keep out high-angle summer sun, but will be less effective at providing shade during warm spring and autumn periods.

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[5] An interim report from this study forms part of, and was funded by, the EU Build with CaRe programme; it is available at: www.buildwithcare.eu/news/238-energy-data-in-a-non-technical-manner

Post-occupancy and maintenance issues

8.21. The residents have received considerable briefing about living in a Passivhaus home, including a home user booklet and briefings before and during their move-in. The mechanical ventilation system and solar hot water controls are relatively simple, but there are some complexities: for example, some residents are not clear that they should keep the ventilation system switched on, at a low setting, even when they are out. The system can be put on 'boost' to increase ventilation rates, for example after cooking or during a party, but it is not clear how much residents use this facility. Although the ventilation system has low electricity consumption, some may see it as 'wasting energy' to leave it on. Residents have been encouraged to open windows if they want to, but not to leave them open for long periods, to allow the ventilation systems to work efficiently.

8.22. Initial problems were encountered with humidity and mould, which appear to have been due mainly to drying plaster and - in one case - to the fact that the mechanical ventilation system had not been switched on when the property was first occupied. There were teething problems with condensation in one of the heat recovery units but these appear to have been resolved.

8.23. One resident in the flats reported that she switched off the mechanical ventilation system at night, because it is located near her bedroom and is too noisy for her. The monitoring team found that such noise becomes more noticeable when the filters need replacing, so Hastoe housing association brought forward the timing of filter replacement. While Hastoe replaces filters on renters' mechanical ventilation heat recovery systems, residents in shared ownership properties are responsible for replacing their own filters.

Learning

What worked well?

8.24. This scheme benefited from having a coherent and highly-motivated design and construction team who shared a vision of developing a Passivhaus/code level 4 development. Hastoe housing association and their architects Parsons and Whittley developed this vision together, seeing Passivhaus as a possible way forward for other developments in future. As code assessors themselves, the architects integrated code requirements into the design from the outset. RES Inbuilt did the formal code assessments for the scheme, and also modelled the design using the Passivhaus planning package to ensure that it would meet the Passivhaus standard. While none of the team had direct experience of constructing to Passivhaus standards, they were committed to the concept and were already highly familiar with delivering code level 4 requirements.

8.25. There is generally a high level of knowledge of code and sustainable construction locally, owing to Uttlesford District Council's code 3 and consequential improvement planning policies. The council has done a great deal of work to educate local builders in sustainable construction methods.

8.26. The Passivhaus standard is more demanding than the code for sustainable homes, not only in its fabric efficiency standards, but also in the level of evidence that has to be produced. Passivhaus certification includes on-site post-construction assessment of the development (e.g. air tightness testing and commissioning of the mechanical ventilation heat recovery system), while code certification is based primarily on documentary evidence. Construction standards had to be extremely high to achieve Passivhaus certification. Although the construction team were familiar with the thin-joint blockwork construction method, they had to learn the importance of cutting insulation blocks precisely, eliminating gaps between construction elements, avoiding thermal bridging and minimising penetrations in the thermal envelope. Achievement of these high standards was greatly assisted by employment, by the developer Bramall, of an ‘air tightness champion’. This individual had been trained in Passivhaus standards in Germany and spent considerable time onsite, ensuring that all members of the team understood the requirements. He even tested air-tightness on an ongoing basis during the construction process. While this had significant benefits for the quality of the Wimbish development, it also had costs for the developer. Bramall are not using an equivalent post in their second Passivhaus development which is now underway, with the Hastoe housing association and Parsons and Whittley team, presumably on the assumption that sufficient members of their team now have understanding of air tightness requirements and how to achieve them during the construction process.

8.27. Another success factor in this scheme was careful briefing of potential tenants and owners on the implications of living in a highly-insulated house with mechanical ventilation heat recovery.

Issues faced and how they were addressed

8.28. Users need ongoing support/education, in addition to briefing before and during the move-in process. At Wimbish, there was too much information for people to take in on ‘move-in’ day, when they were more interested in the practicalities of the move. Hastoe housing association envisage that on future schemes they will let the residents move in and, with contractor’s assistance, provide explanation / hands-on trying out of the mechanical ventilation heat recovery systems approximately 1 week after moving in. For future Passivhaus schemes, Hastoe‘s own experience is growing, so they will be better able to provide ongoing support to tenants and owners.

8.29. It was difficult to model the wet coil heating system used in the dwellings’ mechanical ventilation heat recovery systems in SAP. The assessors treated this as a mini-radiator as there was no option specific to this kind of heating system in SAP 2005.

8.30. Pollution credits were difficult to achieve - some insulation materials came from Germany, where global warming potential is not measured in the same way. Similarly, materials credits were very difficult to achieve, particularly for German materials. The design team decided that it was not cost-effective to build the evidence base required to achieve the materials credits, so the code strategy was to obtain credits in other areas. Most of the materials were A-rated but getting the evidence and certificates was not considered to be worth the effort.

8.31. There were some issues in reconciling Secured by Design requirements with those of the Passivhaus standard, particularly for doors and window fittings. No one in the UK was then making windows to meet Passivhaus standards, so windows with a slightly different locking mechanism had to be imported from Germany. These were not certified as compatible with Secured by Design, but the architectural liaison officer was happy that they provided equivalent security.

8.32. There can be challenges in meeting the low space heating standard in the Passivhaus regime (easier if smaller north facing windows are utilised) and the daylighting standards of the code.

8.33. Communication generally worked well but the ‘design and build’ contract caused some complications. Since this was a cutting edge scheme, the architects were asked to specify the scheme in greater detail than would normally be the case, and were retained by Hastoe housing association throughout the construction process to oversee the design. In practice, Bramall adjusted the design that Parsons and Whittley had developed, particularly the mechanical ventilation heat recovery and duct work. For future schemes, Hastoe would involve a mechanical and electrical designer in the design process from the outset.

Chapter 8

Case study 20: Bath Western Riverside

Overview

Location	Bath Riverside
Developer(s)	Crest Nicholson
Client	Crest Nicholson. Curo Housing are acquiring the affordable housing element
Architect	Fielden Clegg Bradley - master planner, Holder Mathias - phase 1 detailed desgners
Code assessor	Verco Global
Date of completion	First phase completed spring 2012
House type(s)	More than 2,000 homes in total – mixture of houses (3 and 4 bed), apartments (ranging from studio to 3 bed) and mixture of private sector and social housing. Plus a new primary school. Phase 1 comprises 59 homes in total, as follows: Private sector: 7 x 3 bed houses; 4 x 4 bed houses. Social housing (some shared ownership): 2 x 3 bed houses; 4 x 2 bed houses; 18 x 2 bed apartments; 24 x 1 bed apartments Phase 2 - 240 flats (ranging from studio flats to three bedroom apartments) with the first properties completed summer 2012 Work has yet to start on phase 3 and later phases.
Funding	Mixed Homes and Communities Agency and private, plus investment from Bath and North East Somerset Council
Post-construction code level	4

Introduction

8.1. Bath Riverside is the largest new housing development to be built in Bath in many years. The 44 acre site is located by the River Avon on the western side of central Bath. The scheme is bringing back into use the southwest's largest brownfield site, which had been derelict for over 25 years. Part of the development involves opening up the river to public access and creating a riverside park. The aim is to create an active and safe sustainable community, with affordable housing integrated throughout the development.

8.2. The development has received funding from the Homes and Communities Agency (for the affordable housing components). To help ensure high quality development of this major site, Bath and North East Somerset Council has also invested several million pounds in the site. The council has entered into a corporate agreement with Crest Nicholson, with the council entitled to a receive repayment of any loans or grants made out of a proportion of surplus proceeds on the development (if any) after initial priority returns to the developer. This case study focuses on phase one of the development.

Construction details

Methods of construction

8.3. In phase one, houses were constructed using structural insulated panel systems, finished internally with plasterboard. This system was chosen for its very good thermal properties and air tightness.

8.4. In phase two, the developers were looking for a solution to meeting code 4 that would be more space efficient (particularly important since phase two primarily comprises flats) as well as not increasing the height of the buildings. Concrete frame with metal stud infill was therefore chosen for this phase, which is capable of achieving the same u-value as timber frame but without so much loss of space.

Key materials utilised

Walls	Timber frame structure. Either Bath stone or render (on battened carrier board system). Both with structural insulated panels and two layers 15mm plasterboard. Properties are finished in Bath stone, which is sourced from a quarry less than two miles from the site.
Ground floors	200mm reinforced concrete raft slab with 60mm PIR insulation and 22mm chipboard flooring on timber battens.
Upper floors	18mm chipboard & 19mm plasterboard on acoustic battens, on ply deck over posi-joists with two layers 15mm plasterboard ceiling on acoustic resilient bars.
Windows	The majority are softwood, with powder coated aluminium cladding. All double glazed.
External doors	Solid uPVC or uPVC with double glazing.
Roofs	Timber framed, with biodiverse brown roofs incorporated on some blocks.

Technologies utilised

8.5. The key technology utilised in the Bath Riverside development will be the biomass-fuelled combined heat and power energy centre, which will provide all 813 units on the eastern part of the site with heat and hot water. The electricity generated will be sold back to the grid. It is currently planned that the remaining 1,200 units on the western and northern parts of the site will be provided through a second energy centre. Construction of the permanent centre starts in January 2013. In the meantime, there is a temporary energy centre located under the Phase 1 apartment block, with 2 x 1MW gas boilers being used to supply heat and hot water to the first 299 properties. The code rules require the main centre to be online before 60 per cent of the site is completed. The system has been designed so that residents will not notice any change once supply is switched to the main energy centre.

8.6. The biomass-fuelled energy centre was originally included to meet the planning authority's requirement for 10 per cent of the site's energy demand to be met from renewable energy. This was chosen instead of other renewable technologies on the basis of its relative cost-effectiveness and because of the following local circumstances:

- it was felt that solar panels would be sensitive given the site's location, overlooked by Bath's Royal Crescent, a world heritage site
- heat pumps were not an option because of the local geological/hydrological conditions

8.7. EON has been contracted to run the centre and is responsible for billing residents or, in the case of social housing, the housing provider, which in turn is responsible for billing its tenants. EON's 25 year contract requires it to use biomass to fuel the centre (but with gas boilers to provide backup if necessary) with the stipulation that this must be sourced from within the UK if possible. The contract also ensures that occupants will pay no more than the local average for their heat and hot water, whilst also benefiting from excellent service and not needing to worry about boiler breakdowns or paying for a service contract. Prices will be reviewed every six months to ensure they are fair. Meters can be read remotely and remote servicing is also possible. EON will monitor homes to see if anyone is using more energy than expected and, should this be the case, will alert residents and provide appropriate advice about reducing consumption.

Other key features incorporated

8.8. **Materials:** The majority of materials were selected using the BRE's green guide to specification and are A-rated. Low volatile organic compounds paints were used throughout and natural floor finishes were offered as an option to buyers.

8.9. **Ecology**: As a brownfield site, most of the site was of low ecological value and will therefore score well on the ecology section. However, phase one was built on the greenest part of the site, and so does not score very highly. Ecological work has involved protecting or moving the existing badger and slow worm populations and creating new habitats, including wetland areas and 'brown' roofs which use soil from the old site to replicate the existing habitat. Two new riverfront parks will be created as part of the development with new habitats for wildlife.

8.10. **Waste**: Waste separation bins are provided in all units and the houses are all supplied with composting bins.

8.11. **Flood risk**: Located next to the river Avon, the site is at risk of fluvial flooding. Flood risks are minimised through a contoured, landscaped area along the river banks which provides flood compensation. A minimum threshold for all building and car park entrances was set at 19.5m ordnance datum[6]. Sustainable urban drainage solutions have been incorporated into the development including attenuation ponds, reed beds and porous/permeable paving.

8.12. **Management**: Because of the management systems put in place by Crest Nicholson, the site achieved all of the available management credits.

[6] I.e. above sea level

8.13. **Acoustics**: Careful detailing of partition walls and close attention to detail on the floor build up and materials used, with an acoustician onboard to advise, resulted in the development exceeding the building regulations by five decibels, gaining a good score on this category.

8.14. **Water**: Water conservation measures include best practice washing machines, low flow taps, dual flush toilets and low volume showers. The developers used their experience from previous schemes to specify the best water efficient fixtures which meet the requirements of the code whilst also providing good functionality for the occupant. Water butts are provided in all gardens.

8.15. **Energy:** The properties incorporate mechanical ventilation with heat recovery, achieving approximately 93 per cent heat recovery. Low energy lighting and appliances, including A+ rated appliances, are included in all units, with bike sheds provided for all houses.

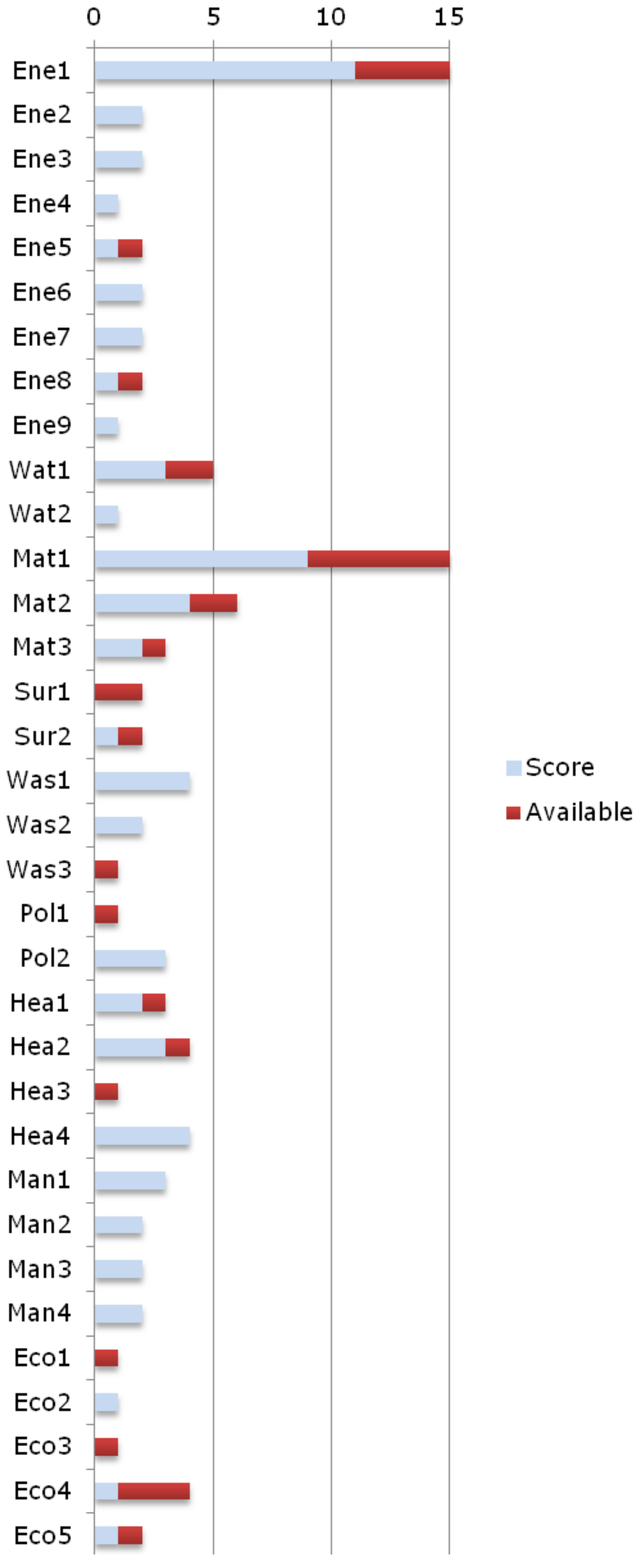
8.16. There are also a number of sustainable features incorporated in the development that do not score any credits under the code for sustainable homes. For example:

- the electricity supply for all new properties is based on a ‘green’ tariff, (though residents are free to change this tariff if they wish to)
- a green travel pack is provided to all occupants, with various incentives to encourage residents to travel by public transport, bike or by foot. This includes a £100 bike voucher and discounts on local trains and buses. Car parking spaces have been provided onsite for the Bath car club, whilst walking and cycling has been prioritised within the development with shared surfaces
- a sustainable living centre (co-located with the energy centre) will be open to provide information to local residents about how to reduce their ecological footprint. There will be a viewing platform allowing visitors to see the boilers, with minibus parking to enable school and community groups to visit

Code scoring by category

Scores for 1 Beau House (flat)

Category	Score	Credits available
Energy/CO2 emissions		
Ene1	11	15
Ene2	2	2
Ene3	2	2
Ene4	1	1
Ene5	1	2
Ene6	2	2
Ene7	2	2
Ene8	1	2
Ene9	1	1
Water		
Wat1	3	5
Wat2	1	1
Materials		
Mat1	9	15
Mat2	4	6
Mat3	2	3
Surface water run-off		
Sur1	0	2
Sur2	1	2
Waste		
Was1	4	4
Was2	2	2
Was3	0	1
Pollution		
Pol1	0	1
Pol2	3	3
Health & wellbeing		
Hea1	2	3
Hea2	3	4
Hea3	0	1
Hea4	4	4
Management		
Man1	3	3
Man2	2	2
Man3	2	2
Man4	2	2
Ecology		
Eco1	0	1
Eco2	1	1
Eco3	0	1
Eco4	1	4
Eco5	1	2



Costs and performance

Cost analysis

8.17. The total cost for phase one (59 units, net surface area of 4,273 m^2) is £1,512.20 per m^2, excluding land costs and professional fees.

8.18. These costs include pro-rata costs for the temporary energy centre (the cost of which is split across the phases). Infrastructure costs include both publicly and privately procured works.

8.19. The private sector dwellings in this development are being successfully sold on the open market and thus demonstrate that it is possible to build to code 4 commercially.

"This is a unique development and our aspiration was always to make it a sustainability exemplar. For Crest Nicholson, sustainability and quality go hand in hand."
[Debbie Aplin, Managing Director of Crest Nicholson Regeneration]

Performance data

Item	Typical U-value (W/m^2K)
External walls	0.25
Roofs	0.11 W/m^2K (plane elements), 0.19 W/m^2K (flat elements), 0.21 W/m^2K (sloping elements)
Floors	Dependent on P/A ratio (i.e. ratio of perimeter to floor area)
External doors	1.30 (houses), 0.90 (apartments)
Windows	1.20

8.20. The airtightness achieved was 4-6 $m^3/(h.m^2)$, depending on dwelling type.

User experiences

8.21. The units have only been occupied for a few months and no post-occupancy survey has been undertaken as yet. A home user's guide has been produced for all occupiers, providing comprehensive information on the district heating network, explaining how the service works, how customers are billed and the customer service that is on offer. Once the first 100 units are occupied, EON will visit the site to run a roadshow for residents to provide further information.

8.22. One resident (who has bought his property on a shared ownership basis with Curo) was interviewed for this case study. He reports that the heat and hot water is very reliable, but feels that the costs may be slightly higher than he would normally expect. The service is good and EON have explained everything very clearly. The resident was attracted to the property because he wanted a new build property without the problems of damp or cold that are associated with historic properties in the city. However, he has experienced problems with the property overheating on hot sunny days. For example, when left unoccupied on a sunny summer's day, with the windows closed, the temperature in the property can get up to 27°C.

Post-occupancy and maintenance issues

8.23. No major maintenance or other issues have been reported with the dwellings.

Learning

What worked well?

8.24. District heating requires a pipe network which would be difficult and very expensive to retrofit. Having this designed as an integral part of the development from the outset made it relatively easy to achieve the energy requirements of code level 4.

8.25. The code assessor reports that the development of this scheme adhered to the original sustainability strategy that was developed as part of the masterplan and is thus developing into the sustainability exemplar that was originally envisaged.

8.26. All partners reported that good partnership working on this development has helped to ensure that the sustainability aims are met.

8.27. Going forward, the intention is to monitor the energy strategy closely, review this with the local council, and then develop a new strategy for the later phases of the development (which the first energy centre will not have the capacity to supply). If the energy centre is working well, then it is likely that a second energy centre will be constructed to supply these later phases.

8.28. Verco provided training on the code for all Crest Nicholson's sales staff, enabling them to fully understand the benefits of the various sustainability features on this development and, in particular, the way the heat and hot water supply will be managed.

Issues faced and how they were addressed

8.29. Compliance with Lifetime Homes offers a third of the potential marks under the code's health and wellbeing category. This proved to be one of the most challenging areas for this development. Lifetime homes requires level access to all entrances of a property, but, due to flood risk, the houses in this development require steps at the front. The code assessor consulted with BRE on this challenge and BRE allowed Lifetime Homes accreditation based on the houses having level access only at the rear of the property.

8.30. A significant amount of time was invested in developing the metering system for the energy centre. To minimise confusion for residents, it has been designed to be very similar to that used for individual boilers, with a control panel located inside the property.

8.31. It had been hoped that the local council would have introduced a food waste collection scheme by the time the first units were occupied. This hasn't yet happened and so the flats cannot get the compost credit.

8.32. Phase 3 will involve family homes being built on a relatively compact site. Incorporating the necessary number of bike spaces is proving difficult and has resulted in a loss of accommodation space.

8.33. It has been seven years from this development's inception to the occupation of the first units, with later phases not expected to be occupied until the end of this decade. As a result, there are inevitably changes in personnel which can present problems. The fact that Verco Global has been involved from the masterplanning stage to completion has been very helpful in terms of ensuring continuity.

8.34. Bath has many interest groups and a lot of alterations had to be made to the original plans to incorporate the views of the public and stakeholder groups.

8.35. Negotiating with organisations to run the energy centre also proved challenging. EON was not in the market when Crest Nicholson first tried to procure a provider. A company was initially appointed that subsequently went out of business. In addition, the original plan was for the energy centre to provide customers with electricity as well as heat. However, in 2008, the EU ruled that it is illegal to operate a private wire electricity network, thus making it impossible to sell the electricity from the energy centre to residents. The plans therefore had to change to just providing heat and hot water to residents.

Chapter 9

Case study 21: Rainham House, Middlesbrough

Overview

Location	Rainham House, Middlesbrough
Developer	Frank Haslam Milan
Client	Endeavour Housing Association
Architects & code assessors	HMH Architects
Date of completion	November 2011
House type(s)	Supported housing building 1: 11 x 2-bedroom self-contained flats 1 x emergency admission flat communal spaces and facilities offices Supported housing building 2: 4 x 1-bedroom self-contained flats 7 x 2-bedroom self-contained flats 3 x 3-bedroom self-contained flats 1 x emergency admission flat communal spaces and facilities offices
Funding	Homes and Communities Agency
Post-construction code level	4

Introduction

9.1. This two-building scheme provides accommodation and support to two distinct client groups: women with complex needs; and women fleeing domestic violence. The scheme was built on a previously developed vacant green space, formerly occupied by a residential home for older people. The site, in Thorntree on the eastern side of Middlesbrough, is surrounded by low density housing. Both buildings are two storeys in height and incorporate self-contained flats, as well as communal spaces and offices. The two buildings at Rainham Close are now home to two support services that had previously been delivered out of ageing and unsuitable buildings in central Middlesbrough.

Construction details

Methods of construction

9.2. Pre-fabricated timber-frame construction methods were used. This was seen as the best way to achieve an efficient and airtight fabric, which was the starting point in the design team's approach to meeting the energy requirements of the code. It was also adopted in order to facilitate rapid on-site erection, reduce waste and achieve low levels of embodied energy.

Key materials utilised

External walls	140mm timber frame structure insulated with 120mm polyisocyanurate (PIU) insulation, 50mm clear cavity plus external cladding, brick or render
Ground floors	Screed on insulation laid on grouted beam and medium dense solid block flooring
First floors	Chipboard decking on timber I-joists
Windows	uPVC with steel reinforcement
External doors	Aluminium double glazed units to entrances, composite steel faced units to plant rooms and uPVC double glazed elsewhere
Roofs	Part sedum blanket, part concrete tiles

Technologies utilised

9.3. Solar thermal panels are incorporated in the scheme, connected to a centralised heating and hot water system. Underfloor heating is used and the system is supplemented by two large gas boilers.

9.4. All flats have mechanical ventilation systems with heat recovery. Up to 92 per cent heat recovery is said to be achieved, reducing building heating loads and lowering energy costs for residents.

Other key features incorporated

9.5. **Ecology:** The development took place on previously developed vacant green space. Whilst one of the buildings has a traditional pitched roof, the other incorporates Middlesbrough's first green sedum roof to promote biodiversity and attenuate rainwater runoff. It also provides additional insulation. A line of mature trees along the eastern boundary of the site was retained in the development. Further landscaping and planting was carried out in accordance with the recommendations of an ecological consultant who was commissioned to carry out an ecological survey of the site. For example, tree prunings from the site were used to create an area for invertebrates.

9.6. **Water:** Rainwater harvesting is incorporated in both buildings to reduce mains water usage and surface water runoff. The green roof also assists in attenuating surface water runoff. Water efficient fittings are included throughout.

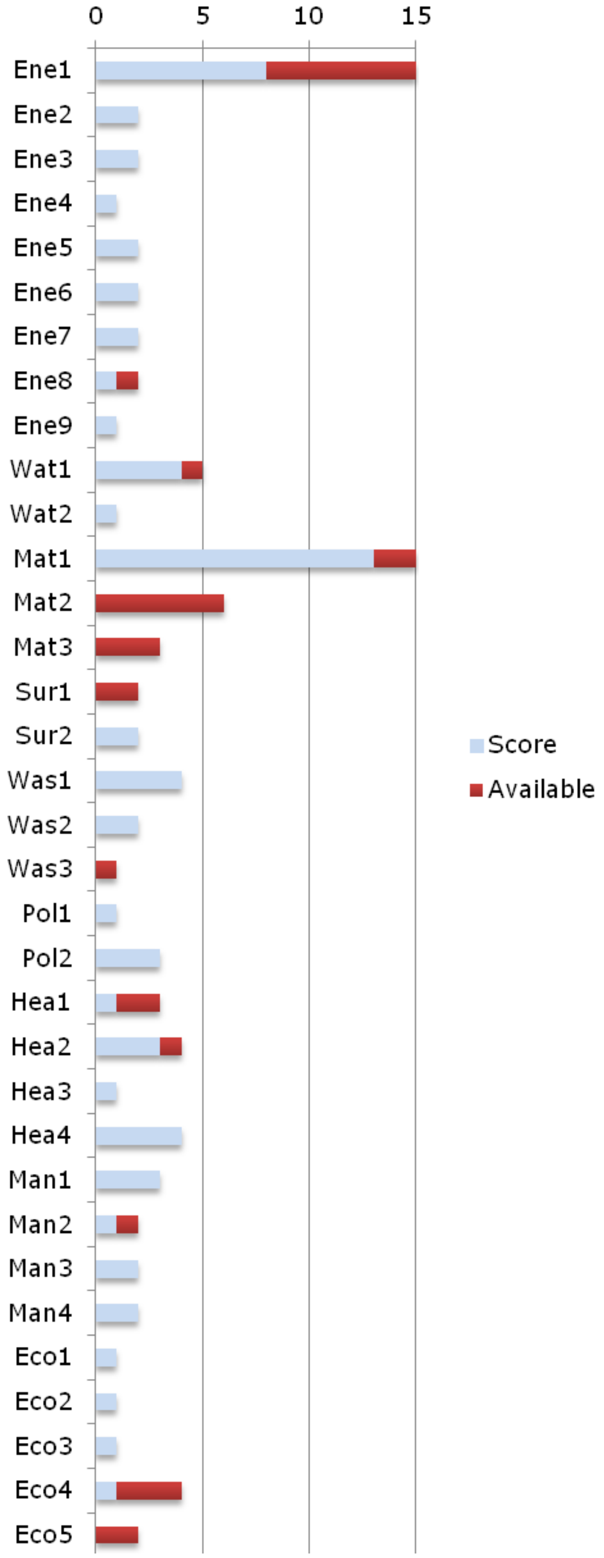
9.7. **Materials:** All superstructure and building fabric, apart from the ground floor beam and block construction, achieves A or A+ rating in the BRE green guide to specification.

9.8. **Waste:** Storage is provided internally and externally for recycling.

9.9. **Energy:** Covered cycle storage is provided, although this appears to be little-used in practice.

Code scoring by category

Category	Score	Credits available
Energy/CO2 emissions		
Ene1	8	15
Ene2	2	2
Ene3	2	2
Ene4	1	1
Ene5	2	2
Ene6	2	2
Ene7	2	2
Ene8	1	2
Ene9	1	1
Water		
Wat1	4	5
Wat2	1	1
Materials		
Mat1	13	15
Mat2	0	6
Mat3	0	3
Surface water run-off		
Sur1	0	2
Sur2	2	2
Waste		
Was1	4	4
Was2	2	2
Was3	0	1
Pollution		
Pol1	1	1
Pol2	3	3
Health & wellbeing		
Hea1	1	3
Hea2	3	4
Hea3	1	1
Hea4	4	4
Management		
Man1	3	3
Man2	1	2
Man3	2	2
Man4	2	2
Ecology		
Eco1	1	1
Eco2	1	1
Eco3	1	1
Eco4	1	4
Eco5	0	2



Costs and performance

Cost analysis

9.10. Build costs for this scheme were £981 per m^2, excluding land costs, external works outside the curtilage of the buildings and design fees. A breakdown of costs is provided below.

Construction elements	**Cost (£)**	**%**
Substructure	£95,886	4%
Superstructure	£740,676	28%
Internal finishes	£272,469	10%
Fittings	£77,914	3%
Services	£607,637	23%
In-curtilage external works	£181,714	7%
External works outside curtilage	£66,017	2%
Provisional sums	£143,000	5%
Prelims	£389,066	15%
Design fees, planning fees etc	£93,986	4%
Total cost, excluding land	**£2,668,365**	**100%**
Total cost, excluding land, external works outside the curtilage of the buildings and design fees	**£2,508,362**	
Cost per m^2, excluding land, external works outside the curtilage of the buildings and design fees	**£981**	

9.11. Cost comparisons between this and other schemes are difficult because of the very specific nature of the development, e.g. it includes centralised heating and hot water plant, communal spaces and facilities, office space and enhanced security and fire systems.

9.12. The biggest additional cost brought by code requirements was for the rainwater harvesting systems.

9.13. The architects have not carried out a detailed cost review of the scheme but suggest that the uplift compared to code level 3 was probably around £2,000 per unit (the approximate costs of the mechanical ventilation system, which would probably not have been necessary at level 3).

Performance data

Item	U-value (W/m^2K)
External walls	0.18
Roofs	0.09
Ground floors	0.20
Windows	1.33

9.14. The airtightness achieved ranged from 2.96 to 3.74 $m^3/(h.m^2)$.

User experiences

9.15. Although it was not possible to interview any residents as part of the development of this case study, Endeavour report that very positive feedback has been received from users (residents and staff) of the buildings, particularly with regard to the size, warmth and comfort of the flats and communal spaces. The low energy bills have also been welcomed.

"I love my flat because it is so warm and secure. My heating bills are loads cheaper than before (at the old facility) and I like the staff and the social scene. The big communal kitchen area is great because we do cooking classes and things in there. There is loads of space for the kiddies to run around in"
[Resident, Rainham House]

9.16. Residents are said to have taken a little time to adjust to the underfloor heating system, because it heats more slowly but retains heat for longer than more traditional heating systems. However, on-site staff have been provided with detailed briefings regarding the operation and management of all of the features of the buildings. Although residents are provided with a user guide, the information and education provided by the staff is said to be more important because of the turnover of residents in the two buildings.

Post-occupancy and maintenance issues

9.17. Since completion of the scheme, the principal problem has related to the rainwater harvesting systems, in which the pumps on both systems failed at the same time. No mains override was installed so the system ceased working altogether for a time, including toilet flushing in part of one of the buildings. Although the maintenance teams have been briefed regarding the operation of the systems, specialist contractors are needed for repairs and the client reported difficulty in finding such contractors.

Learning

What worked well?

9.18. The very specific needs of the services accommodated in these buildings led the housing association to establish a design group for the scheme which incorporated users of a similar service and frontline staff alongside the architects. This involved consideration of the finest details, such as the location of loft hatches and the designs of the doorways and entrances. The resources and time which were invested in the design stages (approximately 20 different designs were developed prior to the designs being finalised) and the collaborative nature of the process has helped to ensure that the buildings meet the various requirements of the code, planning policy and the constraints of the site, as well as meeting the needs of the users.

9.19. The integral role which the code assessor played within the design team from the earliest stages appears to have contributed to the code requirements being met in a straightforward fashion in this case.

"We utilise the code as a design tool, allowing it to inform the designs from the earliest feasibility and pre-planning stages."
[HMH Architects]

Issues faced and how they were addressed

9.20. The biggest challenge faced by the design team in meeting the requirements of the code related to surface water runoff. Since the development site comprised almost entirely permeable surfaces prior to development, a significant level of surface water runoff reduction and attenuation was required to meet code requirements (Sur1). The client was reluctant to include it because of the maintenance issues but it was found to be necessary to meet the requirements.

Chapter 10

Analysis

Successful approaches to code implementation

10.1. The case studies demonstrate that code level 4 can be achieved relatively easily by experienced developers and designers. Interviewees reported that achieving code level 4 can be challenging on compact urban sites, where roof space (for accommodating solar panels) and other space (e.g. for bike storage) is limited. Energy standards are often met in such schemes by utilising central heating plant, but some issues were reported in terms of allowing consumer choice and achieving accurate billing of individual properties.

10.2. A common feature of successful schemes was that code requirements had been integrated into the design from the outset, rather than bolted on at a later stage. This enabled the code to be used as a ‘design tool’ during the initial design stages. Several interviewees commented that this helped to keep down the costs of meeting code requirements since, for example, energy requirements could largely be met through fabric energy efficiency. One developer commented that code assessment should ideally be undertaken before a planning proposal is made, to ensure that the number and external envelope of the proposed dwellings were consistent with cost-effective achievement of the relevant code standard.

10.3. One of the keys to achieving this early integration of code requirements appears to be to involve a code assessor from the outset. In many of the case studies, the architect or developer was also qualified as a code assessor. One developer commented that, even if an external code assessor was used, it was beneficial for the code assessor to be contracted directly to the developer rather than to the client, so that the finer details of design could be optimised. Similarly, another developer reported that their code assessor sat in the same room as the design team, to enable very close working on design details.

10.4. Many of the case study developments were built under ‘design and build’ contracts for social housing providers. This type of contract is often preferred by clients because the developer carries the risk of unforeseen design problems or cost overruns. However, this type of contract does give the developer freedom to vary some aspects of the design, within an overall specification. With more innovative case studies, there was sometimes a tension between the client’s need to transfer risk to the developer, and their desire to take the specification to a more detailed stage, to ensure that the initial design ideas were carried through.

10.5. Good practice also involves combining planning, building regulations and code requirements. For example, one interview commented that if an ecologist needed to be used to respond to planning objections to a development, then it would generally make sense to use the ecologist's recommendations as the basis for seeking the ecology credits within the code.

10.6. A degree of flexibility and common-sense was also a feature of good practice. For example, an architectural liaison officer was reported to have used their judgement in assessing whether window fixings on a Passivhaus development were consistent with the Secured by Design standard. And a planning authority that requires code level 3 for all developments was reported to have accepted a 'straw-bale' development as meeting sustainability standards equivalent to the code, even if the development could not actually achieve certification because of lack of evidence for the innovative materials used.

Implementation of code Level 4

10.7. Interviewees reported that, while code level 3 could generally be achieved through fabric energy efficiency alone, achievement of code level 4 required use of low or zero carbon energy technologies in addition to high fabric performance. The case studies show that the choice of technology depends on local factors, such as the orientation of the site, whether it was in a conservation area and so on. But common energy strategies were:

- fabric energy efficiency with mechanical ventilation heat recovery and photovoltaics/solar thermal
- fabric energy efficiency plus heat pump and photovoltaics

10.8. It is likely that the prevalence of photovoltaics in the case study examples has been partly driven by the availability of the feed-in-tariff during their development. With the introduction of the renewable heat incentive, future energy strategies may see more emphasis on heat pumps, biomass and solar thermal technologies.

10.9. Many of the case studies used thin-joint blockwork, combined with internal and/or external insulation. Timber frames were also a common feature of many designs, due to their good thermal insulation properties. But some concerns were raised about the risk of overheating in timber frame buildings.

Achievement of specific elements of the code

Energy (ENE)

10.10. Achievement of energy credits is central to any code strategy. One stakeholder reported that *"80 per cent of the cost of meeting the code for sustainable homes is energy"*.

10.11. Many interviewees felt that the code should put more emphasis on fabric energy efficiency, beyond the changes made to the 2010 version of the code. Some felt that the higher code levels should aspire to Passivhaus standards, which require fabric energy efficiency of 15 kWh/m^2 per year compared to the code level 5 and 6 standards of 37 and 42 kWh/m^2 per year.

10.12. In some cases an emphasis on fabric appears to have been hindered by planning requirements. For example, many planning authorities have policies which require a certain percentage of energy needs to be supplied by renewables in new developments. In the Oxford case study, there was some conflict between achieving the most efficient built form and a built form which was deemed to be compatible with local vernacular.

10.13. There was widespread concern that photovoltaic technologies were ‘eco-bling’ that acted as a badge of sustainability, but were not necessarily the most sustainable way of meeting a home’s energy needs. Given the 25-year lifespan of most low and zero carbon technologies, and their maintenance requirements, one quantitative surveyor reported that fabric-first approaches were likely to be more cost effective than low and zero carbon approaches in the long run.

10.14. Several interviewees commented that there were problems in using SAP assessments, which are required as part of the ENE standard. For example, SAP is not sufficiently flexible to model some innovative heating systems. And its results were reported, in some cases, to differ widely from actual building performance. The Passivhaus planning package was reported by some stakeholders to be easier to use and more accurate than SAP.

10.15. Other specific comments on the ENE standards were that:

- more emphasis should be placed on low carbon cooling systems, to deal with the hotter summers predicted by climate change
- more weight should be given to embodied energy (e.g. use of local materials which require less transport)
- cycle storage sheds are rarely used for their intended purpose, particularly in rural areas where occupiers are likely to run a car

10.16. Some interviewees felt that credit should be given for sustainable transport measures, although others commented that this would not be appropriate for rural schemes.

Water (WAT)

10.17. Water efficiency was felt to be more relevant in some areas than others, depending on levels of water stress in the region. Some stakeholders commented that there was too much emphasis on low-flow fittings, reporting that many of these were taken off and replaced over time. However, the occupiers interviewed during the case studies were generally happy with their low-flow fittings (see below). There was also comment that the water efficiency levels specified by the code (105 litres per person per day, and 120 litres per person per day) could be made more consistent with building regulations which specify a level of 125 litres per person per day.

Materials (MAT)

10.18. Few of the case study schemes achieved full materials credits. Many stakeholders commented that these credits were difficult to meet because of the volume of paper evidence required. One medium-sized developer had developed a comprehensive system for their supplies, which enabled them to meet the materials credits for all their developments with relative ease, but this was the exception rather than the rule. Material credits were reported to be particularly difficult to achieve for imported materials (e.g. windows compatible with the Passivhaus standard), and for innovative materials (e.g. straw).

Surface Water Run-off (SUR)

10.19. Only three of the eight case study schemes achieved Sur1 credits (reduction of surface water run-off). This credit, and the mandatory requirements, were reported to be the most difficult and costly to achieve, after the energy credits, particularly for sites which had previously had good permeability. For small schemes, such as single unit developments, employing a hydrologist was felt to be too costly in itself. One of the case studies reported that meeting Sur1 had required installation of an expensive rainwater harvesting scheme, which had been problematic, despite the fact that the local drainage system would have had no problems accepting run-off from the scheme. Similarly, another stakeholder commented that surface water measures are already required for any development in a flood risk zone, as part of planning requirements, and that requiring surface water run-off to be handled onsite was unnecessarily costly.

Waste (WAS)

10.20. Most of the case study schemes achieved full, or nearly full, waste credits. There were few comments on the waste requirements, except that many of the code's requirements are already largely covered largely by building regulations.

Pollution (POL)

10.21. Similarly, most of the case study schemes achieved full, or nearly full, pollution credits. Exceptions were a Passivhaus scheme which used insulation materials imported from Germany, for which a global warming potential rating was not available, and a scheme using air source heat pumps, which are not eligible for the nitrogen oxide credit (Pol2).

Health and wellbeing (HEA)

10.22. Many of the case studies scored well on Health and Wellbeing credits, recognising the benefits to occupants of good daylighting and sound insulation. There were a number of criticisms of the Lifetime Homes standard, which some interviewees felt was demanding in terms of space requirements and in some cases inconsistent or pointless (e.g. higher floors were required to have space for wheelchair movements, even thought there was no requirement for a lift to these floors; space needed to be set aside for potential measures that might never be used).

Management (MAN)

10.23. Many of the case studies achieved high scores for management, obtaining credits for the home user guide, considerate constructors scheme and construction site impacts. Achievement of the Secured by Design credit (Man4) was more problematic for some schemes. In one rural scheme, it was felt inappropriate to fit external lighting in a village setting where street lighting was not otherwise used. There were reports of inconsistency between the views of architectural liaison officers on whether security fittings on windows and doors met the required standard, particularly if these fittings were imported (as was required for the Passivhaus development). One developer reported that they contracted the same architectural liaison officer across all their developments, to ensure consistency of approach and reduce the uncertainty of achieving these and other credits.

Ecology (ECO)

10.24. Achievement of ecology credits differed widely between the case study schemes, depending on the ecological value of the original site and the feasibility of implementing the ecologist's recommendations. One stakeholder commented that employing an ecologist imposed too much of a cost burden on small developments.

Other comments on specific elements of the code

10.25. The weighting system that has evolved for the code was felt by some to be too complex: it was suggested that it would be preferable to amend the scores themselves rather than retain the original scores but weight them.

10.26. Some of the case studies incorporated other sustainability features which did not receive code credits. These included sustainable transport measures, brown roofs (reusing soil from the site) and use of local suppliers.

Issues for occupiers

10.27. The sustainability performance of a building depends not only on how it is constructed but also how it is used. And the future market for sustainable homes depends on their appeal to users. The case studies therefore considered how occupiers are using and experiencing homes built to code level 4. Evidence was gathered through a number of direct interviews with users, as well as issues reported by developers and clients, and occupant monitoring studies, where these existed.

10.28. The majority of occupants were reported as being very happy with their homes, which they found to be warm and comfortable. Several stakeholders were concerned that overheating in summer was a major risk in developments with high levels of fabric energy efficiency, particularly for timber framed buildings and those with communal biomass heating systems. However, the case studies did not demonstrate direct evidence of this from occupiers, possibly because few of the developments had yet been occupied during a hot summer.

10.29. The occupant monitoring study for the Wimbish development did suggest that occupiers were keeping their homes warmer than might be expected, around 23 or 24^{o}C. This is consistent with another stakeholder's report that actual energy savings in some code 5 homes are not as great as expected, because people keep their homes warmer than they would in a traditional property. If the carbon savings predicted for high code homes are to be achieved, occupiers need to be engaged and trained in how to heat their homes sensibly and not overheat them.

10.30. Some occupiers reported initial teething problems with condensation, where mechanical ventilation heat recovery systems had not been working properly or were not being utilised correctly. And rainwater harvesting systems were also reported as being unreliable and potentially problematic, particularly where there was no back-up system for flushing toilets. The principal problem appears to be unreliable pumps, which are difficult to service because they are underground. In contrast, occupants appeared to be happy with low-flow water fittings.

10.31. Many of the low and zero carbon energy technologies are new to occupiers and require them to develop new skills and new habits. Mechanical ventilation heat recovery and heat pump systems are particularly challenging, as they require the occupier to understand how the controls work, to accept that the unit needs to be left running most of the time, and to manage their own behaviour in terms of opening and shutting windows so as to ensure that the equipment runs cost effectively. Solar water heating can also be confusing for users, although photovoltaics were reported to be easier for users to adopt (e.g. timing their use of appliances to times when the photovoltaics were generating electricity). With all these systems, the potential for confusion is high, so simple, intuitive controls and good briefings are clearly important. A written home user guide, as required by Man1, is essential but often not enough: occupiers need to be able to access ongoing support as they learn to use their home during different seasons.

Overview of the code's achievements

10.32. Few seem to disagree that the code for sustainable homes has played a vital role in driving sustainability issues up the agenda within house building. Many case study interviewees felt that it had been important to have an agreed set of aspirational standards, to drive performance beyond the requirements of building regulations, and felt that the code's focus on a wide range of sustainability issues had been a great strength.

10.33. There were mixed views on the timetable for successive tightening of building regulations to higher levels of the code's energy standards: one developer commented that this had created a useful degree of certainty, while other representatives of the house building industry felt that the timetable for improving sustainability standards was no longer appropriate in the current economic situation.

10.34. While some organisations have a strong internal commitment to sustainability, which can be expressed by building homes to high levels of the code or other standards, some interviewees commented that this is not the norm for the larger housebuilders in the UK. The code may be a voluntary scheme, but the case studies show that achievement of higher levels of the code has often been driven by external factors such as funding or planning requirements.

10.35. Social housing and affordable housing schemes have tended to achieve code level 4 or higher more often than private housing schemes, driven by the proposed requirements of the Homes and Communities Agency. In practice, the Homes and Communities Agency has postponed its proposal to require code level 4 as a pre-condition of funding, except in London where it required compliance with the Mayor's London housing design guide which did involve achievement of code level 4. But nevertheless, code level 4 has been widely achieved in the social housing sector over the past few years.

10.36. The wide take-up of code level 4 within social housing has created familiarity with its requirements within the house building industry. Developers, architects, code assessors and builders working in the social housing sector now regard code level 4 as relatively easy to meet for most sites. Many interviewees commented that the energy requirements of code level 3 could now be met through fabric energy efficiency alone, provided that code requirements were taken on board sufficiently early in the design process, and that code level 4 was usually achievable through addition of some low or zero carbon energy technology (e.g. photovoltaics, solar thermal, mechanical ventilation heat recovery or heat pumps).

10.37. The wider implementation of high code level dwellings has also stimulated the supply of goods and services to meet code requirements and helped to reduce costs. While the dramatic reduction in the cost of photovoltaic systems in recent years is attributable to wider market forces outside the UK, this cost reduction has nevertheless made high levels of the code easier to achieve.

10.38. Some interviewees reported using the achievement of higher code levels as part of their marketing strategy, but all agreed that more sustainable houses do not yet attract a price or rental premium, despite their lower running costs. This is consistent with the findings of a study on property values by the Royal Institute of Chartered Surveyors[7]. This helps to explain why very few private code level 4 schemes have been built in recent years.

10.39. Other general comments about the code were that the combination of mandatory and flexible credits was felt to be relatively user friendly, at least for larger developers. And that the independence of code assessment processes helps to reduce the workload on local authority planners and building control officers.

10.40. But some interviewees commented that they welcomed the Government's current review of the code because of the drawbacks outlined below. In the words of one interviewee, it has 'done its job' and should be replaced by a different system. But the review is itself creating uncertainty in the housing industry.

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[7] http://www.rics.org/uk/knowledge/professional-guidance/information-papers/sustainability-and-residential-property-valuation/

Limitations of the code

10.41. The most common criticism of the code is that it increases development costs. Case study research suggests that code level 3 can now be achieved for a small margin above building regulation standards, since building regulations effectively require achievement of the energy standards within code level 3. The cost implications of specific requirements within the code are analysed further in the topic section above, but the overall cost of building the case study properties to code level 4 ranged from £981 per m^2 to £1,680 per m^2. Quantity surveyors interviewed as part of the research gave the typical cost of building to code level 4 as £1,375 per m^2. They reported the typical costs of building to code level 3 as being £1,175 to £1,350 per m^2, with a potential reduction of £100 per m^2 for properties that simply meet building regulations. One interviewee felt strongly that further tightening of sustainable building standards, with cost implications of this nature, was not appropriate when the Government needed to stimulate rather than dampen house building in the UK.[8]

10.42. A further drawback of the code that was emphasised in this research was its sheer complexity. Several interviewees commented that, while this was not a problem for larger firms with well-developed systems and familiarity with the code, smaller firms and self-builders had difficulty dealing with the full range of code requirements. This is an important issue, given the Government's commitment to encouraging self-build, which is reported to represent 10 per cent of new homes in the UK[9]. One interviewee commented that some planners do not yet fully understand the code, in particular the point that the code covers a wide range of sustainability standards rather than just energy.

10.43. The 'tick-box' nature of code compliance was also criticised in two respects. Firstly, many interviewees commented that the most cost-effective and simplest strategy for meeting code requirements were not always the lowest carbon or most sustainable. For example, the code gives relatively high levels of credit for air source heat pumps, possibly higher than is justified by their carbon efficiency in practice: interviewees felt that the code should do more to steer people towards the solutions that work best (e.g. fabric efficiency rather than heat pumps).

10.44. Secondly, the code was criticised for being largely based on 'paper compliance'. While evidence needs to be provided on paper, the code does not assess how well a building has been constructed. Some interviewees were concerned that there was often a gap between intended design standards and construction outcomes.

10.45. In a couple of case studies, there were criticisms of the time taken by BRE to issue code certificates. This is particularly an issue where local authority planning policies require design-stage certificates to be issued before construction can start, or post-construction certificates to be issued before a property can be occupied.

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[8] One interviewee commented that only 100,000 houses pa are being built at the moment and that 240,000 pa were needed to deal with the current housing crisis

[9] Source: The National Self Builders Association.

10.46. A common criticism of the code was that it is inflexible in relation to local variations and needs. While developers can choose which credits they aim for, cost considerations can push them towards credits that are not really appropriate to a particular development. For example, many developments incorporate cycle sheds, in order to achieve Ene8 at relatively low cost and effort. But cycle storage may be irrelevant for a rural scheme, or for a housing scheme designed for elderly people with mobility problems. Similarly, water efficiency may be an important issue in the south east of England, but much less relevant in Wales where rainfall is higher. Many interviewees would have welcomed more flexibility in how code requirements were interpreted to fit local circumstances.

10.47. Many interviewees commented that the current plethora of different versions of the code, and of building regulations, causes difficulties for the house building industry. For example, a developer may be involved in one scheme which is being built to the 2009 version of code 3, another which is meeting the 2010 version of code 4, another which is being built to new building regulation standards and so on. These complexities increase the time inputs required from both construction and design teams, with implications for overall design costs. A simpler system would be welcomed.

10.48. Further limitations of the code, in addition to the comments on specific code elements below, were reported to be that:

- there can be tensions between the requirements of the code, which now emphasise fabric energy efficiency to a greater degree than previously, and Merton-style planning policies which require a given level of renewable energy
- the code can push designers towards more modern architectural styles since, in the opinion of some interviewees, its standards are more difficult or costlier to achieve in some traditional vernacular styles
- while the code applies to new buildings, there is a need for a set of standards equivalent to the code for existing buildings

Passivhaus versus the code for sustainable homes

10.49. There is growing awareness of the Passivhaus standard as a potential alternative to the code. One of the case studies was chosen because it combined achievement of code level 4 with achievement of the Passivhaus standard. This allowed exploration of the differences between these two standards.

10.50. The main differences between the two standards is that, while the code covers a wide range of sustainability issues, Passivhaus focuses exclusively on energy and carbon. It is a narrower standard but it goes far further than the code in requiring a 'fabric first' approach. As stated above, fabric energy efficiency for code level 5 and code level 6 is 37-42 kWh/m^2/annum, while Passivhaus has to be 15 or less. Increasing low or zero carbon energy supply gains additional credits within the code, beyond code level 4 to code level 5 or 6, but does not gain additional credits under the Passivhaus standard.

10.51. The broader perspective of the code can lead to tensions between code and Passivhaus requirements. For instance, the code recognises the benefits of good daylighting, while the Passivhaus standard does not give credit for this. To meet Passivhaus energy requirements, north facing windows generally have to be minimised, which can bring challenges in meeting the daylighting requirements of the code.

10.52. As mentioned above, some code assessors mentioned that the Passivhaus planning package was more flexible and accurate in modelling energy performance than SAP assessment tools. One stakeholder suggested that the code could be amended to allow the option of awarding energy credits via the Passivhaus planning package rather than SAP.

10.53. There are other, more subtle differences between the two standards. The Passivhaus standard is much more demanding than the code for sustainable homes in terms of the level of evidence that has to be produced. Passivhaus certification is based on post-construction assessment of the development (e.g. air tightness testing, and commissioning of the mechanical ventilation heat recovery), while code certification is based primarily on documentary evidence.

10.54. One interviewee commented that the code is compliance driven, and quite inflexible in practice, while Passivhaus is more of a philosophical approach. While Passivhaus requires much more evidence to achieve certification, it is possible to get agreement from Passivhaus to vary small aspects of the design, where there are good reasons for this. In contrast the code is seen to be relatively inflexible.

10.55. Another difference between the standards is the code's design-stage assessment, which developers generally find useful. With Passivhaus, the design team can model the performance of their design using the Passivhaus planning package, but will not know whether the development meets the required standard until post-construction testing is complete. But, in contrast, the post-construction testing means that Passivhaus provides a more meaningful measure of eventual construction quality and energy efficiency in practice.

10.56. Some specific issues with achieving both code level 4 and Passivhaus related to the need, at present, to import some Passivhaus materials from Germany - and the lack of code evidence on these components.

Potential way forward for the code

10.57. During this research, interviewees were asked how they thought the code could be taken forward or improved. Many recommended that code requirements should be built into building regulations, to create a level playing field across the UK. Many of the interviewees would like to see tighter standards on fabric energy efficiency and more demanding definitions of zero carbon homes, but some felt that this would have a negative impact on the numbers of houses built. As well as wanting a consistent, simple system, interviewees would like to see more flexibility in response to local circumstances - there is clearly a tension here.

10.58. If the code is to continue, some would like to see the option of an energy-only version, possibly linked to the Passivhaus standard. But others value the broad range of sustainability issues covered by the code. An important recommendation, whatever the future standards, is the development of simple guidance on these standards for small firms and self-builders.

10.59. Stakeholders also suggested a number of ways of providing financial incentives for developers to build to higher sustainability standards, including:

- reduced council tax or stamp duty so that sustainable/zero carbon homes become a product that the consumer sees as desirable
- exemption from the community infrastructure levy for sustainable/zero carbon or Passivhaus dwellings
- increased new homes bonus, giving local authorities more for every house that was sustainable/zero carbon

Appendix 1

Contributors to the report

Case study 14: Roman Barn, Worth Matravers, Devon

- Chris Moglia, Synergy Housing
- Eugene Doherty, C.G. Fry & Son
- Robyn Berry, C.G. Fry & Son
- Jim West, Baqus Construction Consultancy
- Bob Kenyon, Worth Community Property Trust

Case study 15: Tattersalls, Oxford

- Peter & Anna Haxworth
- Corin Rae, Riach Architects
- Martyn Haxworth, Architect
- Tim Purrett, Yaffler Ltd
- Joanne Churchill, McBains Cooper

Case study 16: Bramble House, Ashford, Kent

- Giles Holloway, Building surveyor, Ashford Council
- Simon Lees, code assessor, Ashford Council
- Resident and carers at Bramble House
- Carol Ridings, Planning officer, Ashford Council
- Gregory Deakin, Architect, Hunters

Case study 17: Wood Road, Dudley, West Midlands

- David Cartwright, Senior Quantity Surveyor, FHM
- Guy Marks, Marks Davis Partnership
- Steve Wilson, Partnership Manager, Dudley Metropolitan Borough Council
- Leanne Walker, resident
- Andy Spink, Pinnegar Hayward Design
- Randip Singh-Bopara, Design Manager (Midlands area), Homes and Communities Agency

Case study 18: Dairy Close, Enfield

- Tom Locke, Technical Manager, Bugler Developments Ltd
- Jo Palmer, Senior Project Manager, Origin Housing

- Stuart Nottage, MDA Consulting
- Peter Reynolds, Drake & Reynolds
- Paul Maddock and Mark Trent, HTA
- Tony Norris, Abdale Associates

Case study 19: Ravenscroft, Wimbish, Saffron Walden

- Ulrike Marciello, Hastoe housing association
- Chris Parsons, Parsons and Whittley
- Jane Barnes, Davis Langdon LLP
- Nigel Banks, Keepmoat (formerly with Bramall Construction Ltd)
- William Wright, RES Inbuilt
- Nick Jones, BRE (formerly with RES Inbuilt)
- Andrew Taylor, Uttlesford District Council
- Martin Ingham, Strategic Carbon Management Consultant
- Chris Foulds, University of East Anglia

Case study 20: Bath Western Riverside

- Ian Steed (Development Executive) and Debbie Aplin (Managing Director of Crest Nicholson Regeneration), Crest Nicholson
- Dave Worthington, Managing Director, Verco Global
- Cleo Newcombe-Jones (Planning officer) and Jane Wildblood (Corporate Sustainability Manager), Bath and North East Somerset Council
- James Read, Development Manager, Curo
- Carolyn Merrifield (Partner) and Phil Stephenson (Senior Architect), Holder Mathias
- Fabien Coupat, resident

Case study 21: Rainham House, Middlesbrough

- Esme Flounders, Endeavour Housing Association
- David Wise, Architect, HMH Architects
- Jonathan White, FHM
- John Kinmond, code Assessor, HMH Architects

Additional stakeholder interviews

- David Mitchell, Technical Director, Home Builders Federation
- George Legg, Levitt Bernstein
- Mike Kiely, Chief Planning Officer, Croydon Council
- Paul King, Chief Executive, UK Green Building Council
- Rob Pannell, Director, Zero Carbon Hub
- Simon Corbey, Technical Manager, Good Homes Alliance
- Ted Stevens, Chair, National Self Builders Association
- Tim Parrett, Business Manager and Head of Building Control, Ashford District Council