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Sustainability West Midlands (SWM) is the Regional Sustainability Partnership for the West Midlands with members from business, community, voluntary and public sector organisations who are leaders in the delivery of Sustainability in the region.

Through its members and through its partnerships with the key Regional Bodies including the West Midlands Regional Assembly, Advantage West Midlands, the Government Office for the West Midlands and the Environment Agency, SWM acts as a champion body for sustainable development in the Region and seeks to communicate, promote and champion the principles of sustainable development and good corporate governance.

This report was written and designed by Nick Dodd of URBED (Urbanism, Environment, Design) and Ben Ross of Forum for the Future for the West Midland's Sustainable Housing Action Programme (SHAP), with support from John Sampson and Stephanie Fischer (URBED) and Martin Hunt (Forum for the Future).

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Cover and Character Area images courtesy of Google Earth

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1.Introduction

Case studies of low and zero carbon housing

This report presents the findings of action research to explore the lessons from over 20 case studies of low and zero carbon housing, and engagement with stakeholders in the public and private sectors involved in housebuilding, management and maintenance.

The aim of this report is to explore the issues arising from new standards such as the Code for Sustainable Homes and Energy Performance Certificates, as well as the need to improve the existing housing stock, and to identify solutions that have been adopted to date.

The case studies were selected based on initial desk research which was informed by the following sources of information:

- Previous work for SHAP 1 (2005-06) and SHAP2 (2006-07) work programmes,
- Input from the SHAP steering group,
- The consultant teams' knowledge of current best practice and their industry experience,
- Best practice listings such as CABE's Building for Life and the Housing Corporation's Sustainable Homes.

Data and background information relating to each of the case studies were collated using the following sources:

- Desktop review of background materials, including:
    - Case study reports;
    - Technical monitoring reports;
    - Post-occupancy reports.
- Telephone and face to face interviews, where possible.

Performance data has been presented based on the information readily available from the information available in the public domain, or as provided through direct contact with the developer or their technical team.

The case studies have been clustered so that they can be related to spatial 'character areas' which align directly with West Midlands housing market trends and emerging policy and planning frameworks. As well as illustrating a response to the different character areas the case studies illustrate a full range of new-build homes, and refurbishment solutions for the existing housing stock, illustrating different:

- Typologies, forms and ages - flats, maisonettes, terraces, semi-detached, detached;
- Developers – including social landlords and housebuilders ranging from national firms to small specialist local and regional builders;
- Low carbon technologies – including solar thermal, solar photovoltaic, biomass heating, gas-fired CHP and wind turbines;

Direct performance comparison between the case studies was difficult because of a lack of standardised reporting. To try and overcome this we have sought to benchmark the performance of each case study using the new Energy Performance Certificate format, with a new category added to reflect the need to include Code for Sustainable Homes level 6 'net-zero' carbon performance (see carbon definitions discussion below).

A simple dataset has been used to develop the comparative energy ratings. This is based on the different ages of properties, variation in housetypes, and the performance improvements that can be achieved by different measures on the basis of our research and evidence from case studies.

2.Benchmarking performance

Low and zero carbon home benchmarks

The case studies have been benchmarked against a 'ladder' of improvement which recognises the need to significantly improve the performance of existing homes, and for new-build homes to respond to the Code for Sustainable Homes.

'Basic' refurbished homes

Housing built prior to the formal regulation of fuel and power under the Building Act of 1984 that has been brought up to Building Regulations standards for 1995. This represents a SAP rating of over 70, bringing properties into Energy Performance Certificate band C. For most West Midland properties this would deliver at least a 60% reduction in CO_2 emissions in-line with the Government's current target for 2050.

Target market: This definition is aimed at existing homes which in the West Midlands have an average SAP rating of 48 depending on age, construction and external wall area (variable for flats, terraces, detached or semi-detached properties).

'Current' new-build homes

Housing built to the current 2006 Part L of the Building Regulations which requires a 20% reduction in the Target Emission Rate (TER) on the 2002 Part L. In addition it also requires improved air tightness, with sample pressure testing of properties, additional low energy fixed lighting. This would place these properties in EPC band B. Surveys have shown that a proportion of new homes fall short due to their poor build quality.

Target market: This definition is aimed at ensuring that new homes built to 2006 Building Regulations are well constructed, with attention to robust detailing and low energy design principles, and seek to avoid carbon intensive electric heating systems.

'Advanced' new-build homes

Homes that reduce emissions beyond the current Building Regulations within reasonable cost constraints, equivalent to Code for Sustainable Homes Level 3 and 4 which require a 25% and 44% reductions on the Building Regulations 2006 TER.

Housing developments should also seek to reduce un-regulated emissions i.e. electrical use from appliances and plug loads which equate to 20-30% of household emissions. This would place these properties in the top end of EPC band B.

Target market: Social housing in receipt of Government subsidy and mixed tenure schemes developed on public sector land. Private commercial housebuilders developing advanced products to sell to niche consumers or to realise commercial advantage in skills and supply chain.

'Future' new-build homes

Homes that as a starting point achieve net zero carbon for all energy use regulated under 2006 Part L, with the potential to move towards net zero carbon for all regulated and non-regulated energy use. We have split this standard into two bands:

1. Zero carbon heating: Equivalent to Code for Sustainable Homes Level 5 which requires net zero carbon emissions for regulated energy use. This would place these properties in EPC band A.

   Target market: Exemplar new-build developments with sufficient scale and density to make the cost of installing District Heating achieveable. Households wishing to install biomass heating,

2. Net-zero carbon heat and power: Equivalent to Code for Sustainable Homes Level 6 which requires net zero carbon emissions for regulated and non-regulated energy use. This would place these properties in a notional new Band A+

   Target market: Exemplar public sector projects which aim to act as a showcase for innovation eg. English Partnership's Carbon Challenge.

3.Timeline

The recent history of low carbon housing

Low or zero carbon housing is by no means a new concept.

For the last three decades pioneers across Europe have sought to respond to pressures on fuel prices and the need to protect the environment.

This accumulated experience provides a rich body of innovation for the West Midlands to draw upon in seeking to raise the standard of its housing stock.

1970's 1980's

Refurbishment

New-build detached

1970's
Low Energy House, Centre for Alternative Technology, Wales
Super-insulated, low energy demonstration home.

1986
Energy World, Milton Keynes
Building exhibition of 50 homes which aimed to raise UK building standards

1989
IEA Task 13 project
Rottweil, Germany
Superinsulated design, solar thermal with interseasonal hot water storage

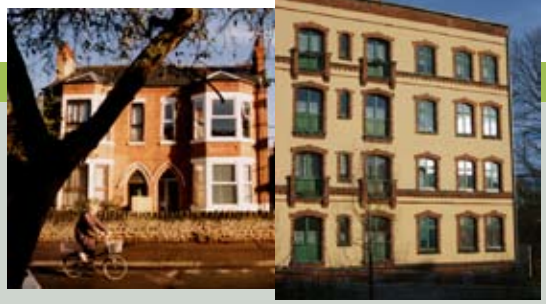
New-build terraces

1989
IEA Task 13 project
Row houses, Denmark
Passive, superinsulated design for terraces with different orientations.

New-build apartments

1989
IEA Task 13 project
Amersfoort, Netherlands
Super-insulated, group solar thermal supply system

1990's
Hebedygarde, Copenhagen
Pioneering test-bed for turn of the century apartment blocks.



2000
Eco-house, Nottingham
Private demonstration refurbishment of a Victorian Villa.

2000-2020
Building modernisation programme, Germany
A national programme to reduce domestic emissions 30% by 2020

1989
Eco-house, Leicester
Super-insulated, low energy demonstration home built as part of the City's Environment City project

1992
Fraunhofer hydrogen house, Germany
Family home which meets all its energy needs from solar produced hydrogen.

1994
Autonomous House, Nottingham
Super-insulated family home which balances all its needs by generating solar heat and power

2005 –
BRE Innovation Park
Low and zero carbon house types by mainstream builders and construction firms.

1990
Darmstadt Passivhaus, Germany
The original 'Passivhaus' built to exacting super-insulation standards

1992
Skotteparken, Denmark
Social housing project with communal solar thermal and CHP.

1999 - 2001
INTEGER project, UK
Five demonstration social housing schemes using low carbon building and energy technologies

2002
Beddington ZED, London
Pioneering super-insulated mixed tenure and mixed use housing project.

1996
Friedrichshafen, Germany
Large-scale scheme which meets all its heating from interseasonal solar thermal storage.

1994
'Green building', Dublin
Demonstration low energy block in Temple Bar with solar and wind power and ground source heating.

2000-
SIBART network
Large-scale (2000+) new urban extensions in Germany, Netherlands, Sweden, Finland and the UK with low carbon energy strategies

4.Findings and Recommendations

Lessons from UK case studies of low and zero carbon housing

The findings from the case studies are grouped under four key themes that reflect the messages that emerged from our research: Marketing, cost and value; Innovation and learning; technology and supply chains; and Market and regulatory drivers. Each theme is complemented by stakeholder feedback and recommendations from our wider consultation.

Marketing, cost and value

The case studies do not provide a consistent message with respect to the potential added value of low or zero carbon housing in the marketplace. The added value that can be attributed to a home varies greatly according to the location, what the local housing market can sustain, and the quality of the product.

Figures quoted for niche housing schemes range from 5% to 20% but these were the exception rather than the norm. Furthermore, housing market values are currently inflated, with the end result that many homeowners are already at the limit of what they can afford.

In most cases the low carbon features of a home contributed to, or formed a key element contributing to the overall quality and innovation of the home product. In low demand areas this can prove to be an important differentiator in order to attract first time buyers, but the low values achieveable mean that the additional costs cannot readily be passed onto the home buyer, and instead may have to be absorbed through the adjustment of land values by the public sector.

There appear to be three scenarios where the additional costs of home improvements, higher specifications, or low carbon energy technologies can be reflected in or absorbed by values:

1. 'Willing to pay' - Where the product is targeted at the niche 'willing to pay' market who wish to buy into a green lifestyle, but also demand a high quality product. Market research by Ipsos-MORI suggests that this could represent at least 3-4% of consumers.
2. High value, high demand - In high value, high demand areas where it can provide market differentiation, for example city centre flats, specialist conversions and large rural/suburban homes. Again, the quality of the product is important for this market, and there could be greater potential to align quality with low carbon performance.
3. Housing market renewal – Where a significant change in values have/could be achieved through intervention in low demand areas. The change in values can be significant enough to generate demand for novel new housetypes, or to pay for substantial refurbishment works, but the upfront capital cost and risk may require public sector support.

At present estate agents do not appear to be in a position, or to be informed enough, to place additional value on the low carbon features of homes, and it appears that instead of achieving an immediate uplift the examples profiled were perceived in general to be a higher quality product, and as such held their value better over time ie. they represented a good investment.

There appear to be few significant barriers to obtaining mortgages or insurance for low carbon homes, with the exception of some cases where methods of construction have been used that are new to the UK market. This position is changing as the market is growing rapidly, and suppliers with track records and accredited products enter the marketplace.

The main barrier appears to be the lack of a mortgage product that can capitalise the potential savings in running costs from a low carbon home

– although the uplift may not be desirable for first time buyers in the currently inflated market with increased nervousness about 'sub-prime' lending.

In the short to medium term it is likely that the housebuilding industry will have to absorb the additional cost of meeting the mandatory CO_2 reduction targets required by the Code for Sustainable Homes. This may be feasible for the Code levels 1-3, with builders using new methods of construction and raising specifications, but for Code levels 4-6 the additional costs of low carbon energy supply are likely to require a different approach.

The capital costs for refurbishment of property in order to meet our 'basic' refurbishment benchmark can be substantial at around £20,000 per property, and are significantly higher than the current levels of investment being made in response to the Decent Homes standards.

This level of investment can be justified where there there is the prospect of a significant enough uplift in the values of property, and where some of this uplift can be clawed back by the developer. However, for many suburban homes this may not be realistic suggesting that a proportion of the cost would have to be absorbed by the owner occupier – potentially requiring a low interest product or a remortgage, assuming sufficient equity was available.

Stakeholder feedback and recommendations

The potential benefits of low and zero carbon homes are not currently understood by marketing staff and estate agents, and as such the evidence is that they are not currently able to market these homes effectively, or to place any additional value on them.

Whilst low or zero carbon performance may not enable significant additional value to be placed on a home – and in many situations marginal values may not allow additional costs to be absorbed – it is likely that it will enable homes to sell quicker, acting as a clear differentiator between similar properties in an area.

Education is required in the marketplace so that marketing staff and estate agents can identify and value the benefits of low and zero carbon homes, and in order to respond to consumer concerns relating to new building and energy technologies.

Consumer information such as the Energy Performance Certificates and Sponge Network's 'Buyer's Guide to A Greener Home' may help to address this gap in consumer and sales knowledge.

Innovation and learning

Many of the projects had been driven by strong personalities within an organisation, or the specific response to a local requirement or a competition. Combined with board level commitment this can help to drive innovation, particularly where they are given the resources and the remit to challenge conventional practices. However, it is clear that in some cases the learning from projects had been lost as key personnel had moved on, with the wider lessons and potential added value not having been captured by their organisations.

Many of the low carbon features of projects reviewed were poorly documented, meaning that it was difficult to profile some of them, and in some case a high turnover of personnel in suppliers as well as developers meant that learning had not been captured.

The role of independent reviews of the innovation and lessons from pioneering projects can be seen as being important in this respect, with INTEGER being a useful and underused example which has the potential for replication. The Good Homes Alliance has a requirement for all members to conduct a minimum of two years of post occupancy monitoring, which will begin feeding back into the market place in 2009.

This tendency towards one-off projects was particularly the case for larger public and private sector organisations – although this situation is changing rapidly in housebuilders and RSLs as tightening regulatory requirements are prompting the allocation of more resources and research into low carbon solutions..

This situation was, however, found to be different in smaller specialist private developers and RSL's who had built their teams around an innovative new product, developed the capacity and knowledge to replicate the product, and in some cases to scale-up the numbers of units.

A number of the projects reviewed highlighted the importance of involving stakeholders in the long-term management of a scheme during the design stage, so that they can become familiar with new building technologies, and anticipate new ways of working or problems that may occur. This is particularly the case for new technologies that may require specialist components, or maintenance contractors, which may not be readily available yet in the UK.

Stakeholder feedback and recommendations

An open book approach is needed in order for the industry to reduce the risk of delivering low and zero carbon performance. Pioneering projects such as INTEGER provide a model, and more recently English Partnership's Carbon Challenge Programme contractually obliges partners to disseminate their learning.

A mechanism is needed to reward the reporting of problems that have been experienced, or technologies that have not worked. The recent case of micro-wind was cited as an example of the need for openness in order to secure consumer confidence and transparency.

Individuals within companies will not be enough to drive low carbon innovations into the mainstream. Management level commitment needs to be matched by the upskilling and capacity building of project managers and local authority officers.

The lack of a consistent basis for comparing the performance of different building and energy supply technologies highlighted the need for an independent low carbon Research & Development centre. This should be publicly funded, but orientated towards the needs of the construction industry.

Technology and supply chains

For the most part a range of key low carbon technologies and building techniques are readily available in the UK market. The barriers to use, however, appear to relate to cost, economies of scale, the availability of installers, and the availability of aftercare support.

Many products are imported, being distributed by a small number of specialist installers, and whilst they may represent the best available on the market they may attract premium prices and require specialist aftercare for which there may not be the current capacity or coverage in the UK. In addition to this, products may not always be suited to the UK market.

The relatively small and immature marketplace, coupled with the need to import products, and even sometimes expertise, as well as the lack of replication in geographical clusters have limited the potential for cost reductions.

This reliance on imports has also exposed UK projects to supply problems and price hikes - caused by demand outstripping supply in countries where the market is growing more rapidly, and for the building technologies a mismatch between supply and demand as new standards raise the demand for new products.

A number of 'winning' and pre-requisite technologies to meet the low and zero carbon benchmarks can be identified from the case studies. Pre-requisite technologies for refurbishment include dry-lining, external insulation and high specification glazing. Emergent 'winning' technologies include solar thermal collectors to meet Code level 3, CHP supplying district heating to meet Code level 4, and biomass boilers and district heating to achieve Code level 5.

There are emerging gaps in the market for technologies to meet the higher levels of the Code for Sustainable Homes. For example, biomass CHP at a scale less than 1 MW is not currently commercially available. West Midlands firm Talbotts are currently developing a product.

Complying with levels 5 and 6 of the Code for Sustainable Homes will for many large housing schemes require the implementation of community heating fuelled by biomass boilers or CHP at significant capital cost. A number of key barriers will need to overcome in order to realise more schemes:

- Design and specification: There is still a limited industry knowledge of design and specification of these systems, largely a result of the limited experience in the UK market.

- Energy Service Company (ESCo) models: Knowledge and access to ESCo and multi-utility models models to reduce the capital costs is also limited, and would benefit from market development.

- Biomass supply chain: Developers are unclear as to whether they can access a secure supply of wood chips or pellets to the appropriate specifications, and long-term management and maintenance of schemes.

The development of ESCo models is likely to be a prerequisite for widespread delivery of Code level 5 and 6 performance. This may require the engagement of the utilities and specialist energy companies, as well as local and regional government in order to provide sustainable infrastructure for larger mixed use development sites.

There still appears to be the need for access to information in order to make performance comparisons for different technologies in the marketplace. For specifiers of technology their first point of reference is likely to be the Low Carbon Building Programme, which provides a list of certified products and installers. Whilst this is a good first point of contact, it does not appear to provide enough certainty for specifiers.

The lack of a standardised performance and testing regime means that specifiers have varied data on which to base their decisions. The same situation currently applies to installers for micro-generation. In some cases volume housebuilders have established their own test sites and field trials to try and overcome this problem. Emerging accreditation schemes such as the Renewable Energy Associations REAL Assurance scheme for installers could have a stronger role to play in the future.

In many cases the barrier to increasing economies of scale are likely to be the need for education and skilling of design professionals, including architects and engineers, and existing construction contractors to efficiently integrate new building and energy technologies into the design and development process.

Stakeholder feedback and recommendations

Whilst the Cyrill Sweet report on the costs of compliance with the Code for Sustainable Homes has provided for a useful starting point, the costs are the subject of many caveats, and in some cases have been revised upwards by subsequent reports.

The costs and risks associated with the planning process, which can require subsequent redesign of schemes where development briefs were not clear, together with a push for more creative urban design, do not always support the cost effective use of Modern Methods of Construction.

There is extensive experience already available across the European Union in the implementation of low and zero carbon building and energy technologies. The majority of the technologies are already available and are tried and tested.

Technologies that have worked in other countries may not, however, always be appropriate in the UK – for example, heat pumps are used extensively in Scandinavia where grid electricity is from low carbon sources – and the options that may be applicable to a site should be assessed early on in the development process.

The testing and quality assurance of any low carbon building or energy technology brought onto the UK market is vital in order to meet the needs for due diligence by insurance and mortgage providers.

The manufacturers and installers of low carbon building and energy technologies require certainty of UK-wide and regional demand for products and services before they will invest in manufacturing or assembly in this country. This approach has formed the basis for successful market development programmes in countries such as Germany.

With the onset of the Code for Sustainable Homes providing increased certainty of demand, there could still be the potential to establish indigenous manufacturing. This could focus on winning technologies that will be needed to ensure compliance eg. solar thermal collectors, biomass boilers, high performance glazing, Modern Methods of Construction.

The selection of technologies as the focus for manufacturing or assembly in the region should focus on aligning the skills required with the West Midlands existing skills base eg. metal fabrication.

Code levels 5 and 6 will require new thinking from the industry in order to deliver the standards. There will need to be a shift from short-term sale of homes to the long-term delivery of energy services.

Business models will be needed for the delivery of site-wide communal technologies, such as Biomass CHP supplying District Heating, and distributed micro-generation technologies on many homes, such as solar photovoltaics. This could include the involvement of utilities, or the establishment of new Energy Services Companies (ESCos)

Consideration needs to be given as to how consumers will be engaged. For communal systems such as District Heating and private wire electrical networks to be acceptable mechanisms are needed to ensure that energy prices remain competitive. The perception of a lack of choice also needs to addressed.

Standardised agreements for the use of roofspace would be needed in order to roll-out an ESCo model for micro-generation technologies such as solar photovoltaics. The experience of housing schemes in countries such as the Netherlands and German cities such as Berlin may help to inform the development of this model.

Roofspace agreements between households and utilities/ESCos for micro-generation installations could be enforced through local planning policies using, for example, Local Development Orders or a Local Authorities Wellbeing Powers under the Local Government Act.

Market and regulatory drivers

The case studies illustrated a range of different drivers for improved performance which, in the absence of strong regulatory pressures, have created the circumstances in which low carbon homes have been delivered. The key drivers we were able to identify include:

- Land-ownership – Where public sector owns land and can set specific conditions and standards during the procurement of private sector and RSL development partners eg. Wolverhampton Council, English Partnerships at Upton (Northampton);

- Planning requirements – Where planning authorities have taken the lead in establishing requirements for new housing schemes to meet low carbon standards, which can include on-site renewables and CO2 reduction targets eg. London Borough of Croydon.

- Social housing providers – Where Councils, HAT's, HMR Pathfinders, and RSL's, driven by social objectives, have a longer term interest in ensuring that homes meet Decency Standards, that tenants energy bills are minimised in order to maintain rental income, and in the Whole Life Cost of maintaining schemes eg. South Shropshire Housing Association, Accord Housing Association, Castle Vale Community Housing Association.

- Housing market renewal – Where the need to improve and raise the value of the existing housing stock has been driven by public subsidy and repaid by an uplift in values, and where affordable warmth and product quality have been aligned in order to justify overall improvements in the SAP rating of properties eg. Northmoor (Manchester), Chesterton (Newcastle under Lyme)

- Corporate Social Responsibility policies – Where mainstream housebuilders or property investors driven by CSR policies have committed to respond positively or on an open book basis to the standards being set by the public sector eg. Haslam Homes (Wolverhampton)

- Pioneering specialist eco-housebuilders
  Where new entrants to the market have deliberately sought to disrupt the market by pioneering a new, high quality product with a community and green lifestyle focus, that is designed from the outset to be low carbon, and where the builder has targeted households who are willing to pay more for environmental performance eg. Ecos Trust, Living Villages.

- Pioneering mainstream housebuilders
  Where new entrants to the market have sought to differentiate themselves by developing a high quality mainstream housing product that is designed from the outset to be low carbon, and to generate added value eg. Gusto Homes, Kingerlee Homes

- Energy Service Company partnership
  Where mainstream housebuilders or property investors have entered into partnerships or supply agreements with specialist Energy Service Companies (ESCo's) in order to finance the additional cost of on-site heat and power generation 'off-balance sheet' eg. Barratt Homes with Utilicom (Hatfield and Southampton)

Whilst the Code for Sustainable Homes is beginning to drive change in the industry, the drivers we have identified are still likely to be relevant and important in growing a low carbon housing market, alongside effective enforcement of the Code for Sustainable Homes by Building Control, and the effective use of Energy Performance Certificates to drive market advantage and differentiation.

The ability of Local Authorities to resource the latter is emerging as a potential problem, and was identified by SHAP2 programme. To some extent the cost and resourcing of Code compliance may be offset by the use of accredited assessors paid for by developers. However, new resourcing and capacity building are likely to be required in order to effectively enforce robust detailing standards, manage the new requirement for sample testing and scrutinise overall compliance.

Stakeholder feedback and recommendations

Local Authorities and public sector bodies need to take a stronger lead in establishing clear development briefs for sites, based on a strategic approach to the low carbon infrastructure and standards expected on each site.

Clear agreements on development briefs and standards are vital if the costs and risks associated with the planning process are to be minimised, particularly in order to deliver the increased RSS housing numbers, and in order to mainstream low carbon innovation.

There is the need for consistency across the region in seeking to establish standards for low and zero carbon housing through planning policies set out in the RSS and in LDF's.

The notion of low carbon innovation being treated as an 'abnormal' cost that can adversely affect the capital receipt for the sale of public sector land should be challenged.

Capacity building is needed to develop the knowledge of the technical teams within mainstream developers and housebuilders. In addition, Local Authority Development Control and Strategic Planning Officers need to raise their own knowledge of low and zero carbon energy strategies and solutions.

5.Building and energy technologies

Fundamental technologies required to deliver low carbon homes

SHAP benchmark	Building technology	Energy technology
'Basic' upgraded homes	Building fabric • High specification glazing • Improved insulation/airtightness: - Internal insulation and dry-lining - External insulation	Fit-out • Low energy lighting and appliances • Hot-fill washing machine Heating and ventilation • Condensing gas boilers • Biomass boilers • Solar thermal collectors Communal systems • Combined Heat and power (gas-fired) • Biomass boilers • District heating network
'Current' new-build homes	Building fabric • Improved insulation/airtightness • Timber wall panels/integral insulation	Fit-out • Low energy lighting and appliances • Hot-fill washing machine Heating and ventilation • Condensing gas boilers • Combined Heat and Power (gas-fired) • Mechanical ventilation/heat recovery

SHAP benchmark	Building technology	Energy technology
‘Advanced’ new-build homes	Building fabric • High specification glazing • Improved insulation/airtightness: - Aerated block work/thermal mass - Timber wall panels/integral insulation	Fit-out • Smart metering • Low energy lighting and appliances • Hot-fill washing machine Heating and ventilation • Condensing boilers • Mechanical ventilation/heat recovery • Passive ventilation/heat recovery Solar systems + • Thermal collectors • Photovoltaic modules • Photovoltaic roof-tiles Communal heat/power systems • Combined Heat and Power (gas-fired) • District heating network
‘Future’ new-build homes	Heating and ventilation • Underfloor heating • Mechanical ventilation/heat recovery • Passive ventilation/heat recovery Building fabric • High specification glazing • Improved insulation/airtightness - Aerated block work/thermal mass - Timber wall panels/integral insulation	Fit-out • Smart metering • Low energy lighting and appliances • Hot-fill washing machine Solar systems + • Thermal collectors • Photovoltaic modules Communal heat/power systems • Biomass boilers • Combined Heat and power (biomass)* • District heating network Near-site electricity generation • Small-scale wind turbines