JOSEPH ROWNTREE FOUNDATION

REPORT

BUILDING SUSTAINABLE HOMES

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This report explores constraints and opportunities for building sustainable homes.

It is timely, given the 2014 Standards Review and acceptance of near-zero carbon solutions for new housing. Regulation is the key driver of housing sustainability and should support government policy objectives while minimising negative effects on supply.

The report:

- analyses approaches to achieving sustainability through a literature review, original survey research and case study interviews across seven areas of England;
- includes a novel Sustainability Performance Matrix – testing costed ways of achieving greater sustainability against actual developer behaviour;
- features econometric modelling of supply responses to different levels of sustainability, planning policy and market structure at the level of the firm;
- explores the relationships between regulation, market forces and supply, and identifies consistent patterns of organisational behaviour but significant differences between private developers and registered social landlords;
- highlights the gap between design intention and 'as built' performance and discusses approaches to tacking this problem.

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EXECUTIVE SUMMARY

Sustainability of new homes is important in reducing global environmental impact and promoting health and wellbeing at a local level. Sustainability has improved, but this comes at a cost. Standardising energy efficiency regulations leads to cost-efficient delivery, but wider sustainability can only be achieved by responding to local needs.

About the research

A team from Heriot-Watt University used a range of qualitative and quantitative methods to explore constraints and opportunities for building sustainable homes. This included strong engagement with practitioners through an online survey and interviews across seven case studies in England. Working with Thomas Bethune Property and Construction Consultants, an innovative Sustainability Performance Matrix (SPM) was developed to capture the technical specification and associated costs of a number of approaches to improved sustainability. Drawing on the matrix and validated by practitioner interviews, econometric modelling considered the impact of increased sustainability, firm specific factors and the flow of planning permissions on the supply of new homes.

Key findings and recommendations

- Improving energy efficiency to zero carbon levels will cost an estimated 2.5 to 12.9 per cent per dwelling on site, but offsetting with 'Allowable Solutions' will reduce this cost. Energy-efficient building should conform to a single standard defined in Building Regulations based on a single definition of zero carbon housing.
- On-site provision plus Allowable Solutions is currently the most efficient method to achieve carbon reduction. Local authorities should lead in directing Allowable Solutions to respond to local conditions and to prioritise tackling fuel poverty.

- Standards relate to intent which is not achieved in practice, therefore Building Regulations should be enhanced to include an 'as built' performance standard.
- Skills shortages remain a chronic issue at all levels, from design to construction. There should be investment in training and skills to meet trade and craft shortages and adapt to new practices necessary to improve performance, including design for buildability.
- Modern methods of construction (MMC) should be supported to improve performance and address skills shortages to kick start the market, increase volume and reduce cost.
- Increased land supply with planning consent will more than compensate for reduced supply due to sustainability costs. The study recommends increasing land supply by 20 per cent to help developers meet the challenge of boosting housing supply while achieving a higher sustainability level.
- Non-energy elements of sustainability, such as flood resilience and urban design, should be based on analysis of local conditions and should inform the disposal of publicly owned land.

Background

In response to the question 'How we can build sustainable homes more cheaply?', this research identified the multifaceted nature of sustainability, but recognised energy efficiency and tackling greenhouse gas (GHG) emissions as a key element of government policy and emphasis for those involved in the delivery of new housing. The research examined approaches to the cost-efficient delivery of sustainable housing.

Cost and supply of sustainable homes

This research showed that the cost of increasing sustainability to zero carbon levels would vary depending on which improvement route was followed. Achieving zero carbon on site with a mix of simple fabric measures and technology could increase costs in the range of 2.5 to 4.0 per cent, whereas more significant changes to fabric, which would achieve zero carbon without use of technology could cost around 13 per cent. The mix of simple fabric and technology was unsurprisingly the most favoured improvement route. Government measures announced in June 2014 (UK Parliament, 2014) will allow part of the carbon savings to be offset against Allowable Solutions, giving a combined cost estimated to be less than either on site-only approach.

The research modelled the effect on supply of increasing sustainability to 2016 standards on site. This showed only a small reduction in supply of between 1 and 2 per cent; including Allowable Solutions would mean an even smaller reduction. The impact of increased market concentration and increased land supply with planning permission were considered. Planning was found to have a more significant impact, with an increase of 20 per cent in planning permissions potentially increasing the supply of homes by over 3.5 per cent, more than compensating for the loss in supply due to increased sustainability.

Regulation and standards

Regulation is the key driver of sustainability standards in housing. Developers have been able to keep pace with the phased introduction of stricter Building Regulations (particularly Part L). Nevertheless, in December 2013 all private developers surveyed and four-fifths of registered social landlords (RSLs) believed the 2016 Zero Carbon Standard (ZCS) to be unrealistic.

The additional cost of building more sustainably is not reflected in increased house value or price. This puts pressure on Building Regulations and compliance standards, as these become the determinants of sustainability to which developers adhere – for the most part, developers build to minimum standards. RSLs are generally more likely to innovate, but scheme appraisal based on upfront capital cost means that most RSL homes are built to minimum Homes and Communities Agency (HCA) standards that tend to be higher than Building Regulations. The introduction of a scheme appraisal system that took whole-life costs into account could give RSLs scope to focus more on sustainability. Local authorities can and often do impose development conditions, requiring standards above Building Regulations as a condition of planning consent.

The *Code for Sustainable Homes* (CSH) has been the reference point for local authorities and the HCA in setting sustainability standards above minimum Building Regulations. But as a result of the recent Standards Review, this will no longer be available as a separate standard for energy efficiency.

Other standards, notably *Building for Life* (BfL12) (Birkbeck and Kruczkowsi, 2012), are supportive of wider aspects of sustainable design relating to neighbourhood and place. Such standards cannot be set nationally, without reference to local context. Consideration should be given to developing a new tool, perhaps drawing on CSH and BfL, to assist in setting locally relevant sustainability guidance.

Design and construction

Construction has adapted to meet current building regulations, but this increases costs. There is no technique, construction or production process that, in itself, will enhance sustainability at reduced cost. Additionally, the 'performance gap' that exists between schemes 'as designed' and 'as built' complicates evaluation of sustainability since standards and actual sustainability performance are not the same thing. There is little point in increasing the regulatory design standard and not achieving the intended performance level; this research therefore recommends that 'as built' standards should be incorporated into Building Regulations. This is not a simple matter and will require research into appropriate methods of performance assessment. Its implementation will also undoubtedly cost money at various stages: product specification, design and on site.

Constraints on achieving sustainability and mitigating cost are complex and solutions potentially expensive. There are shortages of skills across industry, and process innovation is poorly developed. Most developers continue to use traditional construction; MMCs are seen as risky and not generally financially attractive and their use limited, despite their ability to provide improvements to 'fabric efficiency', the preferred route to lower carbon emissions. MMCs that are shown by research to be most effective in delivering improved sustainability should be supported, perhaps through the tax system.

Significantly, MMCs are also one means of improving sustainability performance through addressing site-based performance gap issues. The process of manufacturing and fabrication in a quality-controlled environment limits loss of sustainability between design and installation on site that is associated with traditional construction process. This also addresses the traditional skills shortage issue that was a recurring theme through the case study research.

Impact of scale

Volume creates viable markets and reduces risk and uncertainty for suppliers leading to cost efficiencies. Increasing volume is therefore key to mainsteaming product and process innovation and associated cost efficiency, as was seen in the reduction in cost of photovoltaic (PV) technology. Unnecessary local variation in requirements that inhibit the development of standard components and processes should therefore be avoided.

However, the research recognised the importance of appropriate local control of sustainability measures including matters of urban design. The advantages of further market concentration were shown to be limited, and in particular places, especially in inner-city brownfield and rural exceptions sites, niche providers of innovative or strongly vernacular development have advantages in gaining access to land and funding. In addition, the UK self-build sector is weak, and government is exploring scope for expanding this to help meet the shortfall in housing supply.

Land

Availability and cost of land are key to housing supply and sustainability. Consistency and transparency of planning and other regulatory requirements can create a level playing field for those bidding for land so that the price bid by a developer seeking to maximise sustainability is not undercut by another developer for whom sustainability is not as high a priority.

In addition to increasing the supply of land with planning permission, the research recommends use of publicly owned land to improve sustainability. This could also be used to facilitate the development of sustainable places by promoting sustainable transport, flood resilience, accessibility, urban design, mix and density. Based on analysis of local needs and conditions, sustainability could inform disposal of publicly owned land through masterplanning and sustainability-based competition.

Householder costs and poverty

Sustainable homes are cheaper to live in than less energy-efficient housing. Addressing fuel poverty and the affordability of living in a home are key motivations for RSLs to build sustainably. Enhanced neighbourhood sustainability is also expressed in longer-term lettability, reduced void periods and reduced rent arrears. In most cases, private developers do not find similar advantages because purchasers do not tend to pay more for sustainable homes.

Energy efficiency and therefore cost savings for householders are found to be greatest where efficiency does not depend on residents using equipment correctly. This reinforces the appeal and benefits of 'fabric' solutions over technology. Nevertheless, residents still need information about how to get the best out of their energy-efficient homes to keep fuel bills down.

Summary

The report shows that increasingly sustainable homes cannot currently be built more cheaply. It highlights the importance of regulation, and concludes that a mixed approach of near carbon-free housing on site and Allowable Solutions off site may be the most cost-efficient way to reduce carbon emissions. A single energy standard is appropriate to allow volume production for increased sustainability. Local authorities should have a continuing role in ensuring that Allowable Solutions are used effectively and sustainable places are promoted.

1 INTRODUCTION

This research explores how sustainable homes can be built more cheaply through creatively exploring the behavioural, organisational and structural constraints preventing a step change in output and sustainability, and whether these can be overcome. Cost-efficient delivery of sustainable housing is examined. We investigate innovation, highlighting novel approaches, but focusing on those with the potential to become mainstream and to therefore make a significant contribution to the sustainability of England's housing. Energy efficiency is a key component of the research, but this is set in the wider context of environmental, social and economic sustainability.

While we would naturally concur with the accepted definition of sustainable development from the Brundtland Report as development which 'meets the needs of the present without compromising the ability of future generations to meet their own needs' (WCED, 1987, para. 27), the specific definition of sustainable housing development applicable to this research arises from practice experience. While energy efficiency is a central focus, sustainable development encompasses transport, infrastructure, water, flood resilience, drainage, urban design, mix and density, and opportunities for sustainable development vary between urban and rural locations. In addition to concerns for greenhouse gas (GHG) emissions and the global environment, sustainable housing affects the wellbeing of residents, affordable warmth and combating fuel poverty in neighbourhoods which remain popular places to live in the long term, and these elements are integral to our definition.

Delivery of sustainable housing cannot be abstracted from the affordable housing supply shortage. Developers bear some of the cost of providing affordable housing through Section 106 agreements, and also see the cost of sustainability requirements as an extra burden. The result is a tension between delivery of numbers of affordable units and sustainability of schemes that manifests itself in debate over the viability of individual schemes.

Against this background, the research objectives of this study are to identify:

- Which lessons have and have not been adopted from previous and current efforts to reduce construction costs? And why?
- Where can construction or build costs be squeezed further while maintaining the building of good quality, cheap to run and to maintain homes? What barriers are there to achieving this in England, and how can they be overcome?
- How do housing quality standards have an impact on build costs?
- What trade-offs are being made between build costs and housing quality (including fuel-efficiency)? How can any negative impacts of such trade-offs be avoided or minimised?
- How do construction costs in the UK compare with other countries?
- What innovative approaches to design and construction have the potential to reduce build costs, energy bills and maintenance requirements, while increasing the speed and/or scale of building?
- What potential is there to adopt such innovative/non-traditional construction methods? How do they compare to traditional construction methods in terms of speed, scale, cost and quality standards?
- How would such approaches have an impact on construction costs, build quality, environmental sustainability and the number of homes that could be delivered?

Methodology

The research used a variety of methods to answer the research questions.

1. *Literature review.*
2. *Sustainability Performance Matrix (SPM)* – creation of a whole life cost/performance matrix of dwelling designs that meet varying sustainability and quality levels, reflecting differing technology choices.
3. *Online survey of private developers and registered social landlords (RSLs)* – to consider process innovation, modern methods of construction (MMC), life cycle costs, supply chain, customer influences, competition, market, and contextual factors.
4. *Regional case study practitioner interviews* – to examine the behaviour of firms and individuals, constraints and potential for positive change across seven case study areas interviewing local authorities, RSLs, private developers, contactors, designers and suppliers.
5. *Econometric modelling* – to simulate the annual number of new housing completions over an extended forward period under differing assumptions about the costs of producing housing units according to a number of alternative production technologies identified in the SPM and validated by practitioner engagement.

2 LITERATURE REVIEW

Introduction

This review considers the role of the construction/housing industry in addressing sustainability and efficiency in the production of housing. Our interest is in generally affordable housing encompassing mainstream market housing produced by private developers and RSLs.

Over three decades of promoting sustainability leaves this broad term a fiercely contested concept and political objective (see, for example, Harvey, 1996; Choguill, 2007). Sustainability has become a key government objective – the 'purpose of the planning system is to contribute to the achievement of sustainable development' (DCLG, 2012, p. 2) – and the National Planning Policy Framework (NPPF) identifies the 'presumption in favour of sustainable development' as a 'golden thread running through both plan-making and decision-taking' (DCLG, 2012, p. 4).

An acute shortage of housing forms the context for debate over delivery of sustainable housing with a tension between sustainability and numbers. The *Housing Strategy for England* (HM Government, 2011) estimated average annual growth in households of 232,000 per year until 2033, but noted only 115,000 new house completions in 2009/10. Completions reached a low of 107,820 in 2012/13 (GOV.UK, 2013a), a fall from a peak of over 170,000 in 2007/08. A total of 84,420 units were provided by private developers, 22,030 by housing associations and 1,360 by local authorities. The most striking fall since the start of the credit crunch in 2008 was in private sector completions. The house building industry has stated that it could deliver around 140,000 units through traditional construction methods, but because of long-term loss of skills, Miles and Whitehouse (2013) believe that a substantial number will have to be delivered by off-site methods.

Regulation and standards

Regulation is the key driver of sustainability standards in housing. Sustainable development encompasses energy efficiency, location, transport, mixed use, urban design, ecology, drainage and flooding, and government policies such as the eco-towns programme (DCLG, 2009) have sought to produce exemplars of good practice across a wide range of issues. However, responding to the 2002 European Union (EU) Energy Performance of Buildings Directive, the government has focused on energy efficiency to reduce carbon emissions. *Eco-homes standards*, launched in 2000, later replaced by the *Code for Sustainable Homes* (CSH), provided an incentive for improvement in new build (BREEAM, 2013), and Building Regulations Part L has become more stringent, progressively moving towards the goal of 'zero carbon homes' by 2016; the latest 2014 Building Regulations improved energy efficiency by around 6 per cent over 2010 regulations (DCLG, 2013a).

CSH is a voluntary standard but has charted a path from 2007 regulations toward a net zero carbon standard, and has been used by local authorities and the Homes and Communities Agency (HCA) to set requirements above minimum Building Regulations levels. CSH assesses housing developments against a six-point rating scheme, code levels 1 to 6 (DCLG, 2010). Developed by BRE (Building Research Establishment), it assesses individual dwellings over nine categories including energy and CO_2 emissions, but also water, materials, surface water run-off, waste, pollution, health and wellbeing, management, and ecology (DCLG, 2010).

Planning authorities have also imposed energy standards above the minimum legal regulations, and required developers to fund or provide renewable energy through reference to national policy and guidance (DCLG, 2012) as well as local development plans and supplementary guidance. Authorities' role and effectiveness was questioned in the *Housing Standards Review* and their ability to set energy efficiency standards removed (DCLG, 2013b, 2014a).

The recent *Standards Review* also led to the abandonment of CSH as a separate standard (DCLG, 2014a, 2014b; GOV.UK, 2013b) as part of a move to streamline regulation. The government considered that the variety of different standards available 'can add considerably to development costs, project delay, local authority bureaucracy, and put a brake on growth' (DCLG, 2013b, p. 7). This view was supported by the private development industry (HBF, 2013), but while the Housing Standards Review Challenge Panel (2013) agreed with greater integration, it was concerned that withdrawal of support for CSH may increase confusion rather than rationalisation and simplification. The Queen's Speech of 4 June 2014 set out a definition of the Zero Carbon Standard (ZCS) as code level 5 of the CSH to be included in the 2016 Building Regulations (Cabinet Office, 2014).

Organisations seeking government funding for housing must conform to additional quality standards. The Office of Government and Commerce (OGC, 2007) recommended tools such as the Construction Industry Council's Housing Quality Indicator (HQI), first introduced in 2002, which all HCA-funded development must meet. HQIs relate to location, visual considerations, open space, movement, layout, internal amenity and sustainability (HCA, 2011).

HQIs also include conformity to the Commission for Architecture and the Built Environment (CABE) *Building for Life* (BfL) standard that is also supported by the private housebuilding industry through the Home Builders Federation (HBF). Currently available as a simplified *Building for Life 12* (BfL12), the standard contains 12 questions under headings (i) Integrating into the neighbourhood; (ii) Creating a place; and (iii) Street and home. A previous section on design and construction is no longer part of the standard.

RIBA (undated) has expressed concern that housing quality standards are falling in the wake of the credit crunch and recession. Pointing to a minority of buyers who would consider buying a new home, RIBA cites home-owners' view that new housing consists of small 'featureless boxes', and a recent survey report (Ipsos MORI/RIBA, 2013) found that half of respondents in new and older homes were dissatisfied with high heating bills; a third with lack of space; and a fifth with lack of light in their homes. Those in newer homes up to 10 years old were considerably more likely to move to improve space standards than others in older property.

Quality and efficiency

The rhetoric of construction procurement, largely initiated by Egan's *Rethinking Construction* (1998), is typified by improving value for money (VFM), increasing cost *efficiency* and *optimising* whole-life costs rather than cheaper construction. This has resulted in a wealth of 'good practice' and 'best practice'-type guidance and improvement themes, collectively recognised as a change agenda with advice on how to achieve step-change improvement through adoption of processes related to management of the supply chain; collaborative procurement practices; use of innovative contracts such as the New Engineering Contract (NEC) 3 and Project Partnering Contract (PPC) 2000; modern methods of construction (MMC) and constructability. All this is geared toward improving efficiency of the process and the product of construction. Housing, particularly social housing, has been a beacon of activity given its high-volume, repetitive nature.

Funder requirements for 'Egan Compliance' and Lifetime Homes have also improved standards. From the mid-2000s, government funding has focused development on organisations that could spend most effectively, typically allocating resources to a 'lead' housing association on behalf of a consortium through Investment Partnering (NAO/Audit Commission, 2005) and Framework Delivery Agreements with larger suppliers (HCA, 2013a). New affordable housing is therefore being delivered by larger associations working within group structures, operating through procurement clubs or by collaborations among independent organisations with a single 'expert' lead developer. HCA funding seeks to promote quality as an essential element of sustainable development (HCA, 2013b).

Economies of scale have led to savings through efficiency in the supply chain (Miles and Whitehouse, 2013), and high-volume developers typically buy materials and components at a discount using *group purchase agreements*. Scale advantages in research and design (R&D), negotiating with planning departments, developing a land bank and raising capital at competitive rates have led to increased company size, largely by acquisition rather than organic growth (Callcutt, 2007).

Even so, there is little evidence of the step-change improvement envisaged by Egan, with limited and superficial levels of collaboration, little buy-in from key staff, failure of collaboration to go beyond first-tier contractors and a failure to engage with suppliers (Kaluarachchi and Jones, 2007; Morgan et al, 2012). Pan and Gramston (2012) found low levels of compliance with changes to Part L, and Miles and Whitehouse (2013) report that, while there is no shortage of initiatives to promote sustainable housing developments, lessons have been too easily ignored or poorly embedded into working practices.

MMC can achieve better insulation standards and contribute to energy efficiency, with structural insulated panels (SIPs) used for wall, roof and flooring systems becoming common in Europe and North America. Housing has also been almost completely constructed off site through 'pod' technologies, which may provide a quick solution to extreme housing need in highly pressured areas. Pod technology is used as part of modular building systems for bathrooms (BathsystemUK, 2013) or kitchens (PKL, 2013), giving factory-built quality control and speed of erection in times measured in hours. Miles and Whitehouse found extensive use of 'off-site solutions' by 2013, although this included factory-built doors and windows as well as MMC such as timber frame walling systems.

However, use of timber frames peaked in 2009 (Timbertrends, 2010), and Miles and Whitehouse (2013) noted that prefabrication or MMC only played a limited role in the house building industry. Although MMC offers savings in construction time, quality and sustainability, it has higher upfront capital costs, and is not competitive with costs achieved by house builders with efficient supply chains (Miles and Whitehouse, 2013). Significantly, speed of building and quality improvements are not rewarded in the private developer industry where other aspects of finance are paramount (Callcutt, 2007; Miles and Whitehouse, 2013). Miles and Whitehouse recommend shifting this balance by favourable tax treatment of off-site fabrication.

Pilots and demonstration projects

Numerous exemplars of good practice in achieving quality, sustainability and efficiency have been promoted since the mid-1990s by organisations including the Construction Clients Forum, Movement for Innovation (M4I) and the Housing Forum. These and other organisations promoting the change agenda were brought together under the umbrella organisation Constructing Excellence in 2003. By 2013, Constructing Excellence (and its predecessors) had showcased good practice in efficiency and sustainability in 525 demonstration projects in housing and other sectors worth over £14 billion (Constructing Excellence, 2013). These often focused on collaborative practice including selection by value, early involvement of contractors and the supply chain, and developing long-term relationships. Constructing Excellence (2007) has also developed key performance indicators (KPIs) based on Egan principles.

Demonstration and pilot projects have included the HCA's *Designed for Manufacture* competition (DCLG and English Partnerships, 2006) that encouraged development of quality homes for a construction cost of £60,000 from 2005 onwards. Successful consortia increased use of MMC including timber and steel frame construction and innovative components, leading to reduced on-site labour hours, fewer delays and decreased waste, although the introduction of innovative components was initially associated with more delays (HCA, 2010). Success was associated with an integrated team and greater openness (HCA, 2010). Kaluarachchi and Jones (2007) and Morgan et al (2012) reported on less successful collaborations, indicating a skills gap inhibiting innovative construction and procurement. Common problems in the introduction of innovation have been extended lead-in times, a need for improved communication, and absence of leadership or a design champion (HCA, 2010; Kaluarachchi and Jones, 2007; Morgan et al, 2012).

In the AIMC4 (2013) initiative, a number of volume private developers (Barratt, Crest Nicolson and Stewart Milne) developed low-carbon homes to meet CSH level 4. BRE 'Construction Lean Improvement Programme' engineers facilitated interaction between suppliers; collaborative planning was brought in *at the right time* to achieve efficiencies on site; and good quality data collection highlighted areas for improvement. The lean approach was embedded from the beginning, setting common goals and collaboration, contributing to cost and time savings and avoidance of risk, factors missing in other initiatives (AIMC4, 2013; Morgan et al, 2012). AIMC4 used a 'fabric first' approach, that is, focus on the fixed elements of the building rather than technologies, to reduce risk associated with specialist operations. The approach also benefited from consumer focus groups that highlighted the importance of 'in-use' considerations including heating controls and maintenance of filters in heat recovery systems.

Despite successful demonstrations, good practice has been slow to embed within practice. Major studies such as Callcutt (2007), OFT (2008), Pan and Gramston (2012) and Miles and Whitehouse (2013) have all been critical of standards and practices in mainstream development.

Setting standards for sustainable housing, whether through legislation, CSH or any other standard, does not in itself achieve sustainable homes. This is well documented and evidenced as the *performance gap* that sees a substantial difference between design intent and 'as built' performance of homes. Sustainability is 'lost' between conception and completion on site (to say nothing of operation and user issues), and this is made possible by the flawed means of demonstrating compliance through Standard Assessment Procedure (SAP) testing. A substantial amount of research has been undertaken in recent years by the Zero Carbon Hub (ZCH) into identifying sources and developing solutions to closing the gap between design and 'as built' performance (ZCH, 2014a). The problem is complex and responsibility is fragmented as it spans the entire design, fabrication and construction process, and involves all participants, from designers, the supply chain, contractors, site management through to operatives. While ZCH has made substantial progress in identifying, categorising and prioritising contributing factors across the range of design, procurement, construction and testing activities, it is clear that there are no easy or discrete solutions to the problem. It can be concluded that it would take a complete re-engineering of the whole process and unusually high levels of collaboration and integration to address the problems – in short, a realisation of all the post-Egan practices that remain elusive.

R&D (Bell et al, 2010; Dainty et al, 2013) demonstrates how the performance gap can be closed when measures to address the design, procurement, management, technology and construction processes are taken. Such studies raise awareness of the problem and provide potential solutions to wider industry. Case study projects that explore low-carbon performance and housing sustainability within the Joseph Rowntree Housing Trust (JRHT) include Elm Tree Mews and TAP (Bell et al, 2010; Miles-Shenton et al, 2010). Elm Tree Mews' evaluation of whether a low (not zero) carbon scheme could meet design expectations revealed that dwelling heat losses were 54 per cent higher than designed, and identified some of the problems with sustainability technologies that have become more widely familiar – the under-performance spanned procurement, design, installation, technologies – the whole process – and helped inform later research. A demonstration project with a considerably wider sustainability scope is the Derwenthorpe project (Taylor, 2013) that extends beyond energy and technical performance of individual dwellings to include community-level aspects of sustainability and sustainable living, including a biomass community heating system.

A feature of demonstration and pilot projects is that, by their nature, they are not typical of mainstream and volume housing production. They are conceived and constructed under highly controlled and carefully managed conditions, with all attendant levels of detail and quality of workmanship to achieve high levels of performance. They provide lessons, but the real challenge is to replicate the processes, practices and standards of workmanship that lead to such high levels of performance (that is, performing as required by design) on a large scale and at an acceptable cost within a traditional industry constrained by skills shortages. An indication of the difficulty can be seen in a recommendation from the TAP project that ‘a complete set of drawings ... should be compared for consistency to avoid design decisions being made on site.’ An entirely reasonable recommendation in principle, but the practice of ad hoc design decisions and problem-solving due to inadequate detailing at the point of construction is deep-rooted and extremely difficult to avoid. It is reasonable to conclude that the performance gap may narrow in the short to medium term, but sustained effort over the long term will be required if it is to be closed.

The challenge is to improve sustainability and to reduce costs. However, previous evidence suggests that complying with prescriptive codes that improve quality, in this case measured by sustainability performance, increases costs (Muth and Wetzler, 1976, cited in Dainty et al, 2013). Significantly, Rodrigues et al (2012) reported a 26.4 per cent increase in costs for a small UK housing development when designing in compliance with code 4. The same study also reported that code 4 houses attracted a market premium of around 20 per cent – a finding at odds with all the data from this research.

Building industry structure

The Barker Report (2004) identified a serious shortage of the right housing at the right price in the right locations, hampering economic development and contributing to widening social and economic inequalities in the UK. While the government has questioned whether the requirement for sustainable development is stifling the market and reducing supply (GOV.UK, 2010), the market itself may limit supply through creating perverse incentives that lead developers to produce fewer homes than their resources would permit.

Particularly at times of high price inflation, the rational approach for a developer may be to adopt a high price, slow delivery strategy to maximise shareholder value (Callcutt, 2007). Companies can be locked into slow delivery when investors and analysts could invest in their competitors to maximise profit and banks see others as a better debt risk. Nevertheless, a market study by the Office for Fair Trading (OFT, 2008) did not find new housing delivery to be anti-competitive. Instead, the study concluded that there is competition both between developers and with the second-hand market, and that companies face competition within their market areas on most occasions.

There is little or no price premium for increased sustainability, and survey evidence found only around 20 per cent of householders would pay for energy-efficient housing (Callcutt, 2007). Since aiming for high quality receives little reward in the market, the pressure on managers is therefore to meet minimum regulatory and warranty standards (Callcutt, 2007; Miles and Whitehouse, 2013). Nevertheless, although the Royal Institution of Chartered Surveyors (RICS, 2011) noted that sustainability metrics may not be viewed as important in creating a premium, they believed that there may be an increasing emphasis on sustainability in future, particularly if, as has already happened in commercial property, residential investors see corporate social responsibility and sustainability as a business opportunity. Contributory factors to the absence of market recognition of sustainability include lack of customer information before purchase and the overwhelming influence of location and price on purchaser behaviour (OFT, 2008). In 2008, a time-limited adjustment was brought in to exempt the first sale of zero carbon homes from stamp duty land tax to kick start the market, but this was removed in 2012 (CML, 2012; HM Government, 2007) before it could apply to significant numbers of homes. RIBA (undated) put forward the idea of a kitemark for new housing including, for example, information about design quality and space standards.

Social sustainability can be damaged where new build caters overwhelmingly for a limited range of relatively affluent people with little social mixing and an absence of people with disabilities (Bramley and Morgan, 2003). Callcutt sees continued resistance to socioeconomic mixing especially among more affluent purchasers, but greater acceptance of affordable housing in developments since the introduction of Section 106 agreements, aided by the practice of pepper-potting affordable housing throughout the development.

The lack of self-build in the UK is noticeable in comparison with other countries (Duncan and Rowe, 1993; OFT, 2008), with only around 14,000 completions per year (HCA, 2012), although some government initiatives, such as the discontinued Rural Home Ownership Grant in Scotland, have provided a suitable delivery mechanism for some markets (Morgan and Satsangi, 2011). Given the gulf between capacity to deliver and demand/need, Callcutt (2007) and Miles and Whitehouse (2013) supported the creation of opportunities for smaller developers and self-build, and the OFT (2008) mentions the need for small developers and self-builders to get access to small sites that could not otherwise be developed.

The OFT (2008) recommended extension of the Community Infrastructure Levy (CIL) to self-build, and for its timing to be adjusted to aid small developers. The appointment of an enabler to assist with infrastructure and design could also assist 'group self-build'. A potentially significant step has been the HCA development of a 'Custom Build Homes' fund which supports a form of group self-build, and aims to boost a sector that may be complementary to private developer provision (HCA, 2012).

Land

Land accounts for around 40 per cent of the cost of new residential property (Miles and Whitehouse, 2013), and availability and cost of land are key elements in delivering housing. A large land bank can be an indicator of a company's future earning potential. Developers will want an adequate supply of cheaper strategic land to ensure a forward programme without the risk of having to buy more expensive land with planning permission on the market. A good land portfolio will be attractive to investors and beneficial to the overall health of the company (Callcutt, 2007).

Certainty regarding regulation and associated costs is crucial for developers. Where requirements that increase construction costs, such as those relating to sustainability, are known, a developer will reduce the price offered for land to accommodate this wherever possible (Miles and Whitehouse, 2013). However, there is a limit to which this can be achieved, with University of Reading and Three Dragons (2014) noting a 'threshold land value' below which the landowner will not sell. An understanding among policy-makers of the impact of regulation on viability is therefore essential.

Development on brownfield land can be particularly difficult to deliver. Callcutt identifies the cost of land assembly and remediation and time involved in gaining planning consent as additional barriers to sustainable, brownfield development.

To tackle historically low levels of building completions, the government has instituted measures, including a coordinating role for the HCA, to accelerate release of public sector land, which accounts for around 40 per cent of land suitable for development (DCLG, 2011b). Callcutt (2007) recommended that where government has a more direct role in funding or making land available for private sector housing, it could, after a transitional period, require standards for customer satisfaction to be achieved. This proposal was taken up by the previous Labour government in the form of 'core common housing design and sustainability standards', including BfL (Birkbeck and Kruczkowsi, 2012), but the current coalition government decided not to implement these (GOV.UK, 2010) in order to avoid unnecessary burdens on developers.

How do construction costs in the UK compare with other countries?

One of the research objectives was to address the question of how UK construction costs compare with other countries. Although not explicitly stated, underlying this question is whether UK house building costs are 'excessive' compared to other countries (EU and non-EU), and if so, whether there is potential to squeeze costs in adopting the practices of other countries.

Comparing construction costs internationally

Studies to compare construction input costs and prices across different countries are undertaken by international cost consultancies such as EC Harris and Gardiner and Theobold. As EC Harris note (2012), such comparison is a complex issue affected by a number of macro-economic factors – demand, labour availability, commodity prices and inflation. International cost comparison is also complicated by changes in currency exchange rates and (within the EU) volatility of the value of the Euro. The country-specific factors frustrate any evaluation of whether building sustainable housing more cheaply is possible by adopting practice in other countries.

Construction costs in different countries are a reflection of the general economic wellbeing of the countries that drives the level of construction activity through public sector infrastructure programmes or demand from the private sector. To directly address the research question of how construction costs in the UK compare with other countries, according to the EC Harris study (2012), the UK is currently 15th highest out of 53 countries in an international 'league table' of costs. This is an index-based comparison of average costs, and countries move up or down the table according to the health of their economy and specific in-country factors; for example, Greece, Portugal, Spain and Italy have all moved down (Eurozone recession), while Canada, Australia and New Zealand have moved up the table. Outside of Europe, countries with the lowest construction costs, around one-third of the UK, are generally as a result of very low labour costs where the socioeconomic context is completely different to the UK and Europe. Conversely, Qatar is experiencing a huge boom in building and infrastructure investment for the 2022 FIFA World Cup.

Construction: costs and prices

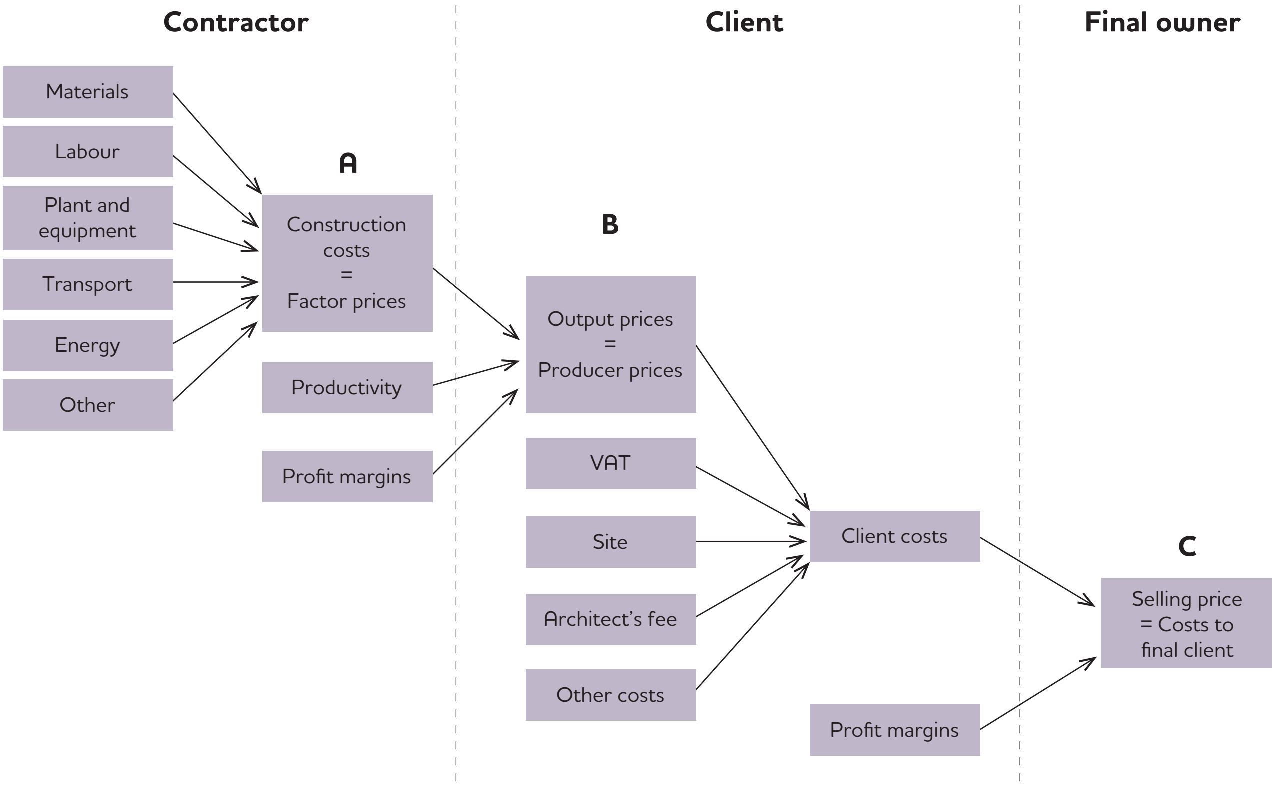
In-country datasets exist for the purpose of monitoring and forecasting costs, prices and market trends within national construction industries. In the UK the foremost source is the Building Cost Information Service (BCIS) produced by RICS, which includes a subset of data particular to housing and public sector housing. There are two main categories of data, and it is important to distinguish between these in drawing any comparisons. The first category relates to *input costs* incurred by contractors in producing the housing, that is, cost of materials, labour, plant and equipment, energy and transport costs (represented as 'A' in Figure 1). The second category relates to *market prices* (tracked by the Tender Price Index) for selling housing to clients – RSLs and developers – and is the more pertinent question for this study (represented as 'B' in Figure 1). Market price for the product ('C' in Figure 1) is obviously linked to input costs, but is more volatile and influenced by the national and regional factors – state of competition, profit levels and market conditions. Figure 2 shows recorded and forecast trends in building costs and housing tender price levels. As the recession has shown, the cost of housing to clients reduces sharply as contractors become much more competitive through cutting costs and profit margins.

The relative importance of construction cost has to be considered in context of price paid for land, fees and contractors' profit margins (represented in 'B') – all influenced by market conditions. Furthermore, building input costs and contractors' tender prices are distinguished from market value and the selling price of housing in the private sector (represented in 'C') which, again, is influenced by the general economy and housing market. In summary, the relationship between construction input costs and sustainability measures (a component of 'A' in Figure 1) and the final value of the house – whether private sector or socially rented sector – is weak.

Construction cost trends for housing across Europe

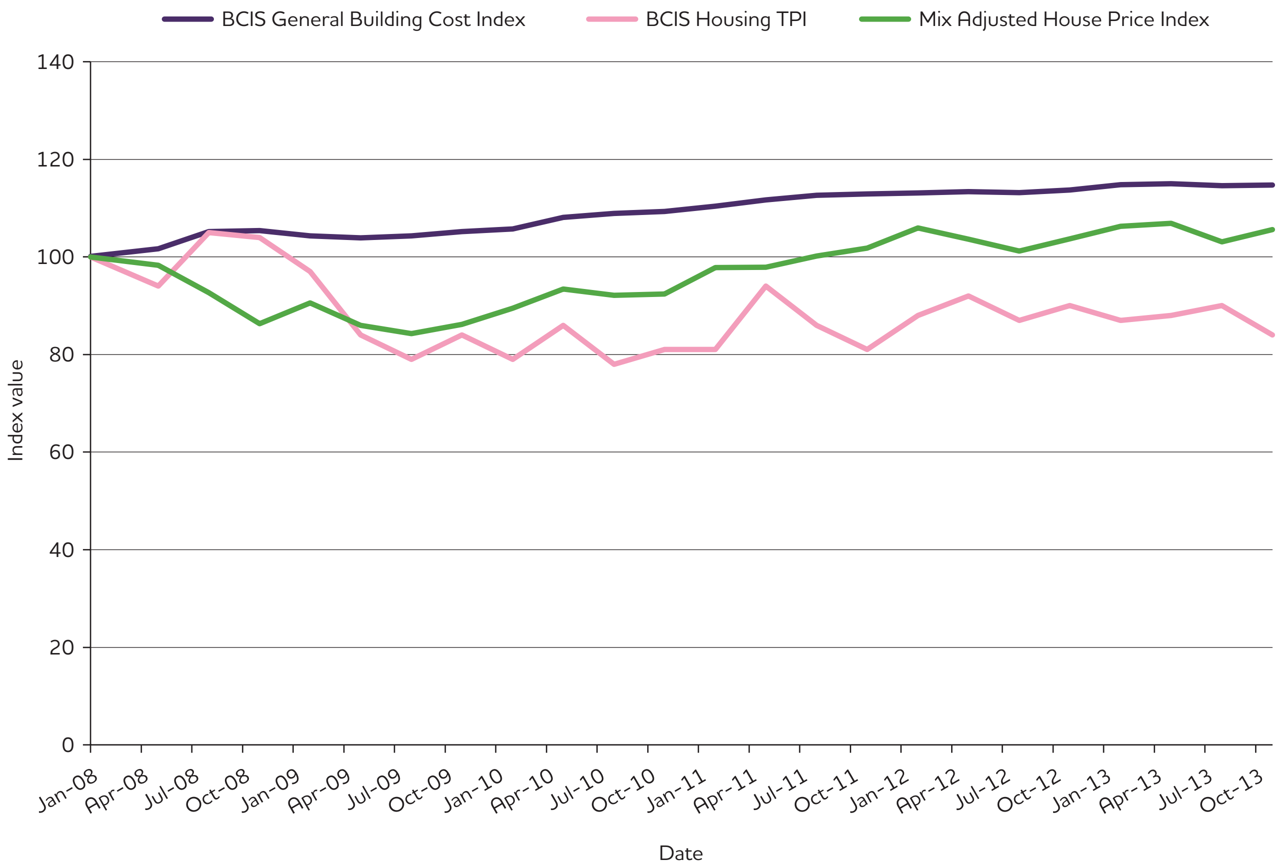
The construction costs index is an EU business cycle indicator showing the trend in the input costs incurred by contractors. Between 2005 and mid-

Figure 1: Relationship between costs and prices



Source: Adapted from Eurostat (http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Construction_cost_index_overview)

Figure 2: Comparing trends in cost and price



Source: BIS

2008, construction costs for housing increased relatively steadily across Europe (28 member states). In the last quarter of 2008 the index began to fall, and reached its lowest level one year later. In total, however, the fall was only 1.2 per cent. In 2010 the index started to increase again, and less than one year later it regained the level it had displayed before the crisis. Since then it has been on a steady upward trend. The development of the construction cost index was mainly influenced by the material cost component, while the labour cost component continued to grow even during the crisis – although at a somewhat slower pace than before.

Summary

There is a tension between increasing supply to overcome an acute housing shortage and increasing sustainability. Although sustainable housing has a variety of social, economic and environmental components, many encompassed within BfL and HQIs, legislation has focused primarily on energy efficiency and the 2016 ZCS. CSH has underpinned stricter building regulations and has been used as the basis for higher standards to be imposed by local authorities and the HCA. The *Housing Standards Review* and subsequent government action and legislation has led to the definition of zero carbon at CSH code level 5 including Allowable Solutions which will be contained in 2016 Building Regulations.

Building more sustainable homes has a cost, and efficiency in the development process has not led to a step change in quality or cost; MMC plays a relatively small part in house building. Land is a key cost element, and there are limitations on the extent to which land costs can be squeezed without adversely affecting supply, although government, as the largest single landowner, can accelerate supply. Information has been presented on international input and output cost comparisons between the UK and a range of other countries. However, as performance is closely related to in-country conditions, drawing conclusions between the efficiency of the UK and other countries would require further research involving analysis and comparison of case study cost data at scheme level. It is not possible to draw lessons about the efficiency of the UK construction industry relative to other countries using published cost data because of the many factors that influence costs.

3 SUSTAINABILITY PERFORMANCE MATRIX (SPM)

Objective

The Sustainability Performance Matrix (SPM) was created to provide a quantitative underpinning that would inform the case study and the econometric modelling phases of the project. The aim was to define a series of plausible benchmark dwellings that were then used to provide indicative, quantitative information to describe the impact of changes in sustainability regulations (principally Part L and fabric energy efficiency, FEE) on:

- design/technology changes relative to dwellings designed to meet the 2010 Building Regulations
- associated changes in build costs relative to dwellings designed to meet the 2010 Building Regulations.

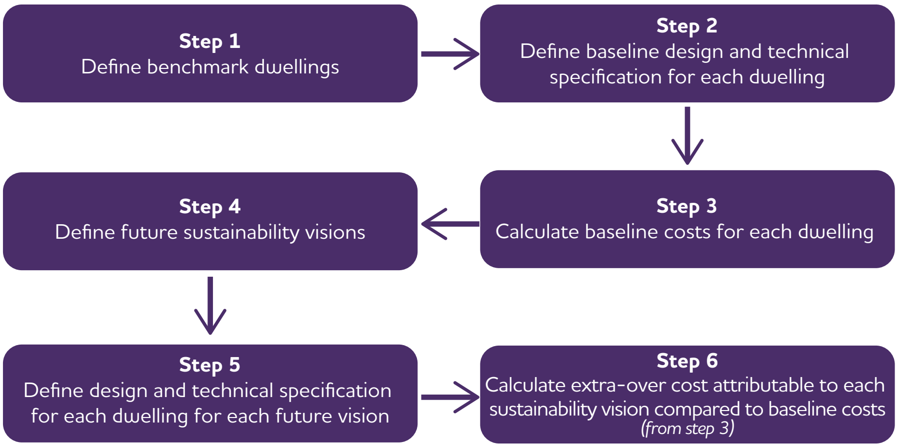
Procedure used to create the Sustainability Performance Matrix

The flowchart shown in Figure 3 indicates the procedure followed to create the SPM and to produce the required build cost data. To ensure that the cost data was computed using conventional quantity surveyor (QS) procedures and reflected current industry costs, the research team collaborated with Thomas Bethune Property and Construction Consultants to calculate baseline costs for each of the benchmark dwellings, and to estimate the costs for additional technologies identified for inclusion in the house designs to meet different visions of sustainability.

Step 1: Define benchmark dwellings

The creation of the SPM requires in the first instance that benchmark dwelling designs be defined that are representative of current new build homes designed to comply with 2010 Building Regulations. However, a key aspect that is likely to have an effect on broader definitions of sustainability and subsequently on housing supply is space or floor area. For two of the benchmark dwellings, namely, the semi-detached three-bedroom five-person house (SD-3b5p) and the two-bedroom three-person flat (2b3p),

Figure 3: Flowchart describing the evolution of the SPM



three different space standards were defined (see Table 1). The last of these was the German space standard that was reported by RIBA as being the most generous among European standards. All nine dwellings (four flats and five houses) included in the SPM are shown in Figure 4.

Step 2: Baseline technical specification

Industry standard design and technology options were selected for each of the benchmark dwellings such that they would meet Part L and Part F of the 2010 Building Regulations. The overarching design and technology strategy followed is shown in Table 2.

Step 3: Baseline costs

The baseline costs varied from £1,232/m^2 for the 2b3p-STD flat to £1,501/m^2 for the 1b2p-STD flat. Average costs for the flats and houses were found to be similar (see Figure 5).

Table 1: Space standards included in the SPM

Notation	Description
STD	Average floor area for dwelling type built between 2007 and 2012[a]
HIGH	The floor area stipulated by English Partnerships in 2007
GER	German Space Standards, 2007 (Rich, 2011)

Note: [a] This was calculated using a combination of a Heriot Watt dataset and the RIBA Case for Space data (Rich, 2011).

Figure 4: Dwelling types included in the SPM

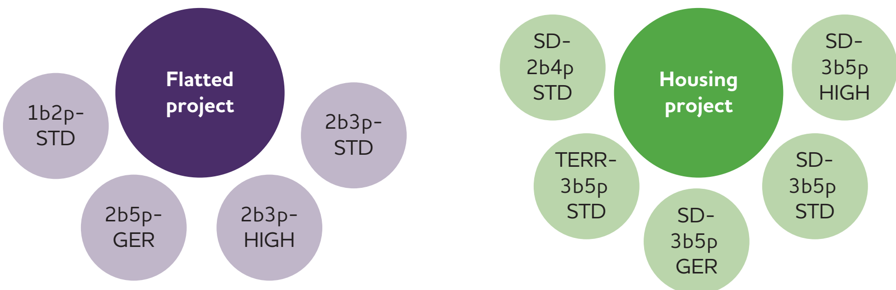
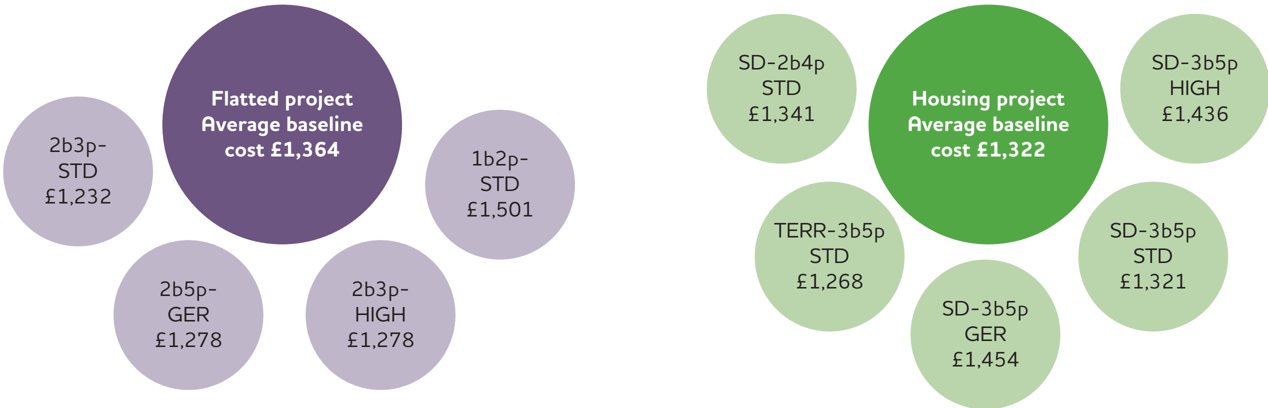


Table 2: Overarching design and technology strategy

Element	Description
Construction	Brick and block, 150mm partial fill cavity
Insulation	75mm Kingspan Thermo wall TW50
Ventilation	Natural with trickle vents and extract fans in wet rooms
Glazing	Double
Heating	Gas condensing boiler with radiators
Renewables	None

Figure 5: Baseline construction costs for the dwelling types included in the SPM



All cost information in £/m² floor area

Step 4: Defining future sustainability visions

A range of aspects could be considered when defining future visions of a sustainable built environment. The context for this project was taken from projected changes to Part L and Part F of the English Building Regulations expressed by the target emission rate (TER) for a specific dwelling and projected changes to the fabric energy efficiency (FEE) metric currently included in the CSH. The sustainability metrics used here reflected the definitions used to describe routes to net zero carbon buildings prior to the Queen's Speech in June 2014 (Cabinet Office, 2014) (see Table 3). The 2016 narrative is further expanded through the 2016 EF definition to explore the implications of regulating for non-renewable generation design options coupled with higher levels of FEE. The performance of dwellings meeting this definition is largely mandated by design options that ostensibly will last for the lifetime of the building. Achieving higher echelons of sustainability through the use of technology that has lifetimes significantly lower than that of the building (for example, solar PV) contains significant jeopardy associated with longevity of energy savings attributable to the dwelling design.

Step 5: Technical specifications for each sustainability metric

The assessment of alternative technologies and designs that could be used to achieve each regulatory point was carried out using SAP software. In this manner, a prudent approach was taken as design and technology options were constrained by those included in either SAP or SAP Appendix Q, that is, had gained regulatory approval in 2013. The overarching design and technology strategies that were followed to achieve the sustainability metrics are described in Table 4.

Table 3: Sustainability metrics used in the study

Sustainability definition	TER reduction (% of 2007 figure)	FEE achieved
2010	25.0	n/a
2014	29.5	52
2016	70	46
2016 DF (deep fabric)	70	27

Table 4: Technical specifications and extra-over costs for each dwelling at each sustainability matrix point

	Design and technology description strategy for each sustainability metric		
Element	**2014**	**2016**	**2016 EF**
Description	Small changes Like today	Small changes Like today with PV	Large changes More like Passivhaus than today
Construction	Brick and block (aerated concrete), 150mm partial fill cavity	Brick and block (aerated concrete), 150mm partial fill cavity	Brick and block (aerated concrete), 250mm partial fill cavity
Insulation	75mm Kingspan Thermowall TW50	100mm Kingspan Thermowall TW50	200mm Kingspan Thermowall TW50
Ventilation	Natural with trickle vents and extract fans in wet rooms	Natural with trickle vents and extract fans in wet rooms	MVHR
Glazing	Double	Double	Triple
Heating	Gas condensing boiler with radiators, flue gas heat recovery	Gas condensing boiler with radiators, flue gas heat recovery	Gas condensing boiler with radiators, flue gas heat recovery Enhanced boiler controls
Renewables	None	Solar PV	None
Other	None	Waste water heat recovery	Passivhaus standard thermal bridging, floors and doors

Step 6: Calculating extra-over costs at each sustainability point

Depending on the design/technology solution being proposed, the calculation of extra-over cost followed one of two routes:

- The cost procedure evaluated the price differential between the technology or design solution that was being proposed to meet the revised metric and the option from the 2010 dwelling design that was being replaced, for example, revised wall construction.
- The cost procedure evaluated the capital cost of the design/technology solution that was being proposed in the instance where it represented an additional item, for example, solar PV.

The design/technology changes that were selected to permit the dwellings to achieve the 2014 Regulations attracted extra-over costs equivalent to less than 1 per cent of the 2010 build costs (see Figure 6 and Table 5). It is likely that these, in time, would be absorbed by learning rates associated with volume increases within the supply chain.

Figure 6: Extra-over cost by dwelling to achieve additional sustainability

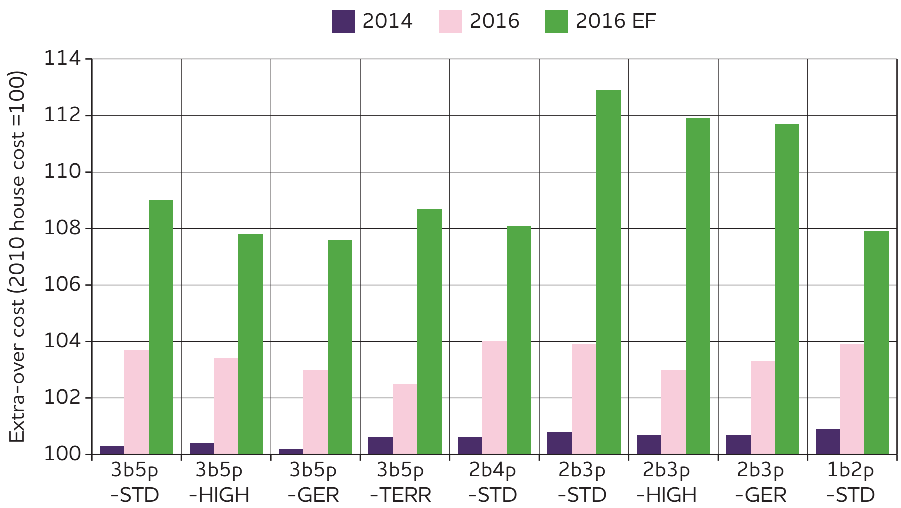


Table 5: Extra-over cost (£/m^2) by dwelling type

	Houses					Flats			
	3b5p-STD	**3b5p-HIGH**	**3b5p-GER**	**3b5p-TERR**	**2b4p-STD**	**2b3p-STD**	**2b3p-HIGH**	**2b3p-GER**	**1b2p-STD**
Floor area (m^2)	86	93	100	86	73	60	66	70	44
2010 base costs (£/m^2)	1,321	1,436	1,454	1,268	1,341	1,233	1,278	1,278	1,501
2014 extra-over cost (£/m^2)	4	6	4	7	9	10	9	8	13
2016 extra-over cost (£/m^2)	49	49	43	32	53	48	38	43	59
2016 extra-over cost – DF (£/m^2)	119	112	111	111	109	159	153	149	118

Note: DF = deep fabric

Achieving the 2016 SPM using simple fabric choices, coupled where appropriate with solar PV, resulted in an increase equivalent to between 2.5 and 4.0 per cent of the 2010 build costs. Solar PV is an interesting technology to consider due to the impact of Chinese manufacturing as a market entrant in 2010, leading to price reductions of circa 75 per cent in 18 months. This has allowed PV to be used to reduce the cost of regulatory compliance, permitting house builders to continue to use conventional construction methods. As a consequence, flats overall were marginally more expensive than houses because it was assumed that solar PV could not be fitted, and more extensive changes to the building fabric were required.

This can be compared with the 2016 EF option where construction costs increased by between 7.6 and 12.9 per cent. This result underlines the additional cost associated with purely fabric-based solutions that require the house designer to migrate from existing construction techniques. The differential in extra-over cost found previously between flats and houses disappears as a consequence of both dwelling types having to achieve higher levels of FEE and not use the lower-cost solar PV option as part of their design.

It was found that the provision of additional floor area was not a determinant of additional extra-over cost regardless of the sustainability metric being achieved. The relationship between regulatory target and floor area is not straightforward, and as a consequence, increasing the floor area will not always result in increased extra-over cost as might have been expected. Clearly, with most site layouts, smaller numbers of dwellings will be built on a given site that is likely to have a large impact on site viability.

Recent studies on the cost of meeting higher sustainability standards

The research team engaged a chartered QS consultancy (Thomson Bethune) to advise on the costing of the SPM detailed in this chapter. This cost analysis adds to the body of related sustainability cost studies which use similar methods of establishing base and extra-over costs for housing that have been published, most recently by Sweett (ZCH, 2014b), and an earlier study by the Department for Communities and Local Government (DCLG, 2011a) on the cost of building to code. Comparing these cost studies there are some variations in cost estimates, attributable to the fact that identical 'like for like' comparisons are not being undertaken. Assumed specification of house types and specifications are similar but not identical, and price data also changes over time as a result of market conditions. However, the additional 'extra-over' cost estimates of achieving higher sustainability standards relative to base dwelling costs are of a similar scale, and lead to similar conclusions, particularly when this study is compared to the ZCH study. The DCLG study was published in 2011 and does not provide for such useful comparison, as standardised approaches to achieving code level 4 were 'difficult to assess' at that time, and there was 'too little experience for common approaches to be identified' for code levels 5 and 6. This is indicative of the rapid and ongoing changes that affect sustainability in the housing sector.

Both studies (Heriot-Watt University and ZCH) conclude that minimising additional costs of meeting the 2016 ZCS involves the use of significant solar PV. Advanced fabric solutions (toward Passivhaus) are, and will continue to be, more expensive.

The studies also arrive at the same conclusion that an approach that involves Allowable Solutions in achieving zero carbon compliance will be cheaper than solely technical (fabric and technology)-based approaches. As such, there is little incentive for developers or industry to develop design and technology solutions beyond code 4 equivalent compliance.

Case study interviews

Feedback relating to the SPM

For the purposes of the fieldwork, the SPM was simplified into a sustainability flowchart comprising two base case dwelling types, a flat and a house, and three levels of sustainability – 2010, 2014 and 2016 regulatory standard (see Figure 7). This offered a sufficient level of detail to provoke discussion with interviewees on the technologies and associated costs of meeting enhanced sustainability standards. The research team were seeking to understand the extent to which the pathways to sustainability on the flowchart represented the views of industry, local authority and housing practitioners, and to identify whether other measures were being considered. The research team were also seeking views on the costings

Figure 7: Sustainability flowchart

NOW

	Existing specification
Houses	Indicative base cost £1,350/m²
Flats	Indicative base cost £1,250/m²

NEAR

2014 specification

	Technology descriptor		Extra-over costs	
Houses	Technology descriptor	Simple fabric + boiler controls	Houses	£7/m² (c 1% increase)
Flats			Flats	£11/m² (c 1% increase)

FUTURE

2016 vision – 70% reduction in CO_2 emissions
Simple fabric

			Extra-over costs	
Houses	Technology descriptors for housing	Simple fabric; Boiler controls; PV	Houses	£45/m² (c 3.3% inc)
Flats	Technology descriptors for flats	Simple fabric; Boiler controls; Heat recovery	Flats	£50/m² (c 3.7% inc)

2016 vision – 70% reduction in CO_2 emissions
Extreme fabric

			Extra-over costs	
Houses	Technology descriptors for housing + flats	Passivhaus fabric; Boiler controls; Ventilation; Heat recovery	Houses	£112/m² (c 8.3% inc)
Flats			Flats	£107/m² (c 1% inc)

prepared by the QS consultants and research team, particularly the extra-over costs of achieving higher sustainability levels mapped out on the flowchart, and whether these matched the experience and expectations of the respondents.

The feedback from the case study interviews indicated that the SPM provided a good representation of how respondents were already addressing or expect to address higher sustainability requirements in new build housing. No significant technical or design omissions that would be mainstream in the next five years were highlighted. Rainwater harvesting, biomass and district heating are three technologies cited by interviewees that were not considered in the SPM. Of these, only district heating attracted positive as well as negative views.

Similarly, the baseline and extra-over construction costs were considered to be sound based on the feedback from the range of interviewees. A pertinent observation was that ranged cost estimates, rather than presenting single point estimates, would have been more appropriate.

Key findings relating to the SPM

The feedback from the case study interviews was positive with respect to the technology choices, design trajectory and costs used in the SPM. The extra-over costs associated with achieving the 2014 Regulations compared to 2010 dwelling designs was found to be less than 1 per cent. The use of solar PV substantially reduces the extra-over costs of achieving proposed 2016 Regulations by allowing house designers to continue to use traditional brick and block construction techniques. However, the lifetime of solar PV is substantially lower than that of the building. Extra-over costs of achieving 2016 Regulations using solar PV were found to range between 2.5 and 4.0 per cent.

Achieving a 2016 regulatory position that had a requirement for higher levels of FEE and no recourse to solar PV would require fabric solutions that approach the Passivhaus standard. Extra-over costs were found to be much higher, ranging between 7.6 and 12.9 per cent. Assuming that the use of solar PV will be less prevalent, the costs of achieving higher echelons of sustainability in flatted developments will be higher than in housing. Building to higher space standards were not found to result in additional extra-over costs associated with dwellings meeting higher levels of sustainability.

Exploring the impact of using Allowable Solutions to achieve the Zero Carbon Standard

Analysis in the previous sections was based on design and technology options (on-site solutions) for meeting higher sustainability standards, that is, it didn't explicitly explore approaches to 'offsetting' through Allowable Solutions. Shortly before the publication of this research, a definition of the Zero Carbon Standard (ZCS) was set out which includes the firm decision that the long deliberated Allowable Solutions will be implemented (Cabinet Office, 2014) and mandated by the 2016 Building Regulations. This section explores the costs and potential implications of developers using Allowable Solutions to comply with the ZCS of sustainable housing in the light of this emergent definition.

The ZCS has been defined as code 5 in the CSH, taken here to mean zero emissions from regulated energy consumption (DCLG, 2010). It is further assumed that the ZCS will be accompanied by a requirement for the dwelling to meet the full FEE level (ZCH, 2012).

There will be two routes to meeting ZCS:

- Route 1: The dwelling meets code 5 and full FEE.
- Route 2: The dwelling meets code 4 and full FEE and the additional CO_2 emissions are met through allowable solutions ('offsetting').

Allowable Solutions describe a method of assigning an economic value to the regulated CO_2 emissions attributable to the dwelling design that are higher than the ZCS. However, information on the way in which it is likely to be calculated has been published (DCLG, 2013b; Cabinet Office, 2014). The additional CO_2 emissions attributable to the dwelling are multiplied by a set development lifetime to produce a lifetime residual emissions figure. The set development lifetime for calculating CO_2 emissions is 30 years (DCLG, 2013a). This lifetime CO_2 figure is then multiplied by a cost of residual CO_2 metric. The high and low cost of a lifetime tonne of CO_2 are taken to be £36 and £90 (DCLG, 2013b; HM Government, 2013).

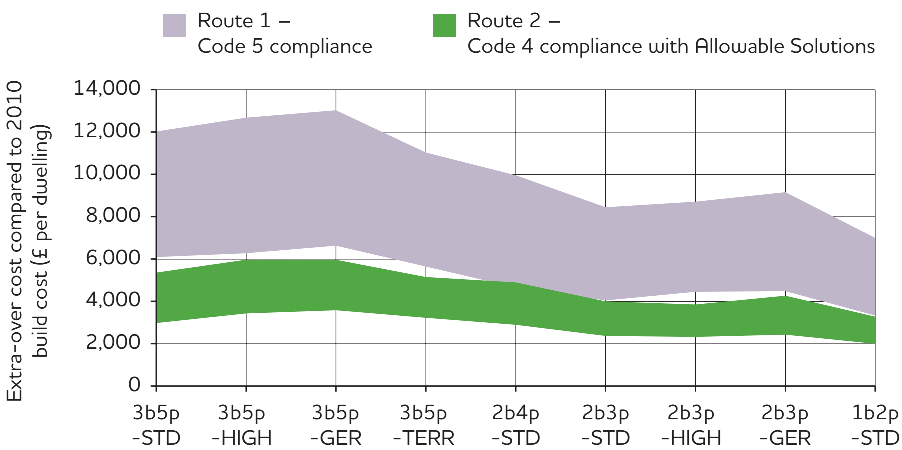
The research reported here sought to compare the additional build costs that would be incurred by meeting the ZCS by following Route 1 and Route 2. The analysis was extended to explore the effect that the design and technology choices that underpinned compliance via Route 1 and 2 might have on household fuel bills and fuel poverty.

Figure 8 shows the extra-over cost (compared to the build costs of house designs compliant with the 2010 Building Regulations) of achieving the ZCS using Routes 1 and 2. The extra-over costs associated with designing the dwelling to achieve code 5 (Route 1) occupy a broad range depending on whether the design encompasses predominantly fabric technologies or whether it uses simple fabric choices with solar PV, the latter option representing the least extra-over cost. This is similar in nature to the distinction between the sustainability metrics 2016 and 2016 EF used in the SPM analysis.

The extra-over costs associated with meeting the ZCS via Route 2 also occupy a range associated with the cost metric applied to lifetime CO_2, that is, either £36 or £90 per lifetime tonne of CO_2.

The extra-over costs associated with following Route 2 compliance were always found to be lower than the estimates for Route 1 compliance. At the higher end of the CO_2 price, simple fabric solutions coupled with solar PV may become cost-competitive. If the price point of CO_2 is defined at the low

Figure 8: Extra over-cost associated with achieving 2016 compliance by differing routes compared to the build costs for achieving 2010 regulatory compliance



end of the cost band, then it is likely that the Allowable Solutions route will always be followed and Code 4 compliance will represent the end point for zero carbon dwelling designs. Fabric solutions that approach the Passivhaus standard are always likely to remain cost-prohibitive unless the cost of CO_2 is increased to approximately £300 per lifetime tonne, that is, more than three times the upper limit proposed in the government consultation (DCLG, 2013b).

Effect on household utility bills

The house designs used to achieve these differing regulatory standards are likely to result in different outcomes for householders with respect to utility bills. These can be estimated by employing the following assumptions:

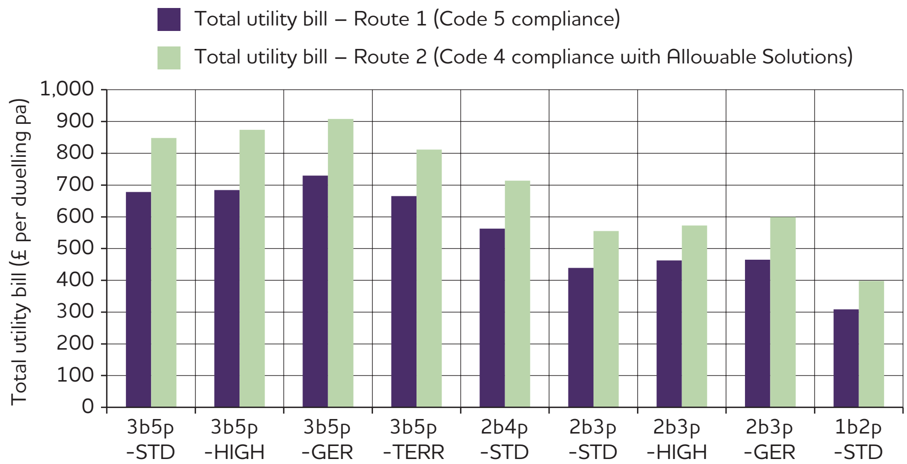
- Annual space heating consumption is equivalent to the FEE standard achieved for the specific house design.
- Annual electricity consumption is given by the algorithms used in SAP for lights, appliances and cooking (DECC, 2014a).
- Annual energy consumption associated with domestic hot water consumption is given by the algorithms used in SAP (DECC, 2014a).

It is assumed that PV is deployed in the properties without a feed-in tariff, the only fiscal benefit to householders being associated with use of generation by the property, that is, PV generation used by the dwelling = 0p/kWh. The research team estimated the extent to which household electricity demand was coincident with solar PV generation using an algorithm developed for the TARBASE project with Birmingham as the dwelling location (Jenkins et al, 2012).

Gas and electricity bills are calculated using the average from the Department of Energy & Climate Change (DECC) for 2013 (£0.0486/kWh and £0.1520/kWh respectively) (DECC, 2014b).

The total utility bill (gas and electric) for the 3b5p semi-detached dwelling was £678 for the design methodology that centred on deep fabric compared to £848 for the house design that used Allowable Solutions (see Figure 9). When all the benchmark dwellings are considered, the impact on household utility bills of the house designer adopting the Allowable Solutions approach would be to increase utility bills by an average of £142. While this will have a negative impact on fuel poverty, the impact is likely to be small, as only 2 per cent of households in highly energy-efficient dwellings were reported to be

Figure 9: Estimated total household utility bills for benchmark dwellings achieving 2016 regulatory compliance using different routes



in fuel poverty in 2011 compared to 11 per cent of the total number (DECC, 2013).

Estimated scale of Allowable Solutions payments

It was possible to estimate the scale of the Allowable Solutions payments that would be required by developers for the benchmark buildings considered here to meet ZCS. They were found to range from £860–£1,690 (average of £1,300) when the cost of CO_2 metric is £36 per lifetime tonne and £2,137–£4,225 (average of £3,245) when a lifetime tonne costs £90. Assuming a house build figure of 150,000 completions per annum, these funds could generate £195–£487 million. This could, for instance, be used to apply solid wall insulation to between 32,500 and 81,000 dwellings assuming an average installation cost of £6,000 per dwelling (Hopper, 2013). This is likely to have a more profound impact on fuel poverty than legislation that mandated on site compliance with the ZCS.

The cost of CO_2 will be critical in determining whether house designers en masse will seek to develop fabric and technology solutions that address the ZCS. If the CO_2 price is set at the low end of the range indicated, then it is likely that housing designs will not be developed to meet performance standards beyond code 4.

This will have a significant impact on the innovation strategy employed within the housing supply chain, and it is therefore imperative that the cost of CO_2 be set quickly by the government to allow the industry, the supply chain and the investment community to plan for 2016.

Data generated using the benchmark dwellings considered here indicates that dwellings designed to achieve compliance following the affordable solutions approach will have utility bills that average circa £699 pa. This was found to be circa £140 more expensive than if the dwellings achieved compliance via attainment of the code 5 performance standard.

It is plausible that mechanisms could be designed to disperse Allowable Solutions funds such that the route to compliance for the new built sector in 2016 exerted significant downward pressure on fuel poverty in the existing housing sector. This could be achieved, for instance, by creating a dispersal procedure that proffered preferential status on measures that directly addressed fuel poverty.

Summary

Building homes to higher standards of sustainability currently costs more money.

The increased cost of achieving the 2014 regulatory standard is relatively minor (less than 1 per cent compared to the 2010 baseline) and achievable through fabric design solutions.

The additional cost of achieving the 2016 Building Regulations, relative to the 2010 baseline, was more significant. This ranged between 2.5 and 4.8 per cent when a solar PV technology approach is adopted. This is currently the most cost-efficient technology-based solution allowing house designers to continue to use traditional construction techniques. However, solar PV, in common with all 'bolt-on' technologies, gives rise to future maintenance issues.

The additional cost of achieving the 2016 Building Regulations using advanced building fabric technologies with higher levels of energy efficiency would be substantial, ranging between 7.6 and 12.9 per cent. The advantage of a fabric-based approach is that sustainability is 'built in' and maintenance-free.

The Allowable Solutions route to achieving zero carbon compliance will be cheaper than solely technical site-based approaches. As such, there is little incentive for developers or industry to develop design and technology solutions that go much beyond 2014 regulatory compliance.

Approaches to fabric design, rather than applying systems or renewable technologies, are the universally preferred approach to improving sustainability standards of housing.

The widespread scepticism of technology solutions results from poor experience of their performance in practice and the risks associated with unproven technologies.

Solar PV is the most acceptable of all technologies due to the maturity and reliability of the systems, and because they don't require any householder interaction in their operation.

4 QUESTIONNAIRE SURVEY ANALYSIS

Introduction

An online questionnaire survey of private developers and RSLs was undertaken between November 2013 and January 2014. The survey addressed the research objective 'to learn from existing attempts to reduce construction costs while maintaining or improving standards.' The analysis looked at drivers and obstacles to sustainable development and the standards that are currently being achieved. Planning and Building Regulations were identified as key drivers, with some concern over the impact of planning on supply, and the impact of the planning system was explored further. As indicated by the questionnaire results and discussed elsewhere in this report, achieving the minimum regulatory requirement at the minimum cost is a key consideration, and this chapter goes on to examine the range of approaches taken to improve efficiency of delivery, and which of these have been the most effective.

The sample frame was a mailing list of over 800 members supplied by the National Housing Federation, and 55 companies contacted on the researchers' behalf by the HBF. There were a total of 118 responses; 146 RSLs have a development allocation in the current HCA development programme (although some are developing on behalf of others, and the overall number of developing RSLs can be taken as around 200). Eighty-eight RSLs responded to the survey, representing a return rate of around 44 per cent; 23 private developers responded (42 per cent return), and seven responses were neither private developer nor RSL, or could not be identified.

Figure 10 shows a good spread of respondents to the questionnaire, with RSLs in every region and private developers everywhere except the East of England. The largest number of RSLs (18) was in London, and there were more private developers (8) in the South East than in any other region. Three developers had a head office in Scotland and one in Wales. Figure 11 shows the spread of organisation size.

Drivers of sustainability

The questionnaire set out a number of different factors, and asked respondents whether these were drivers of sustainability for their organisation. As reported in Figure 12, the survey highlighted the importance of Building Regulations and planning requirements as drivers of

Figure 10: Location of head office by organisation type (number)

Figure 11: Units completed in 2012/13 by organisation type (number)

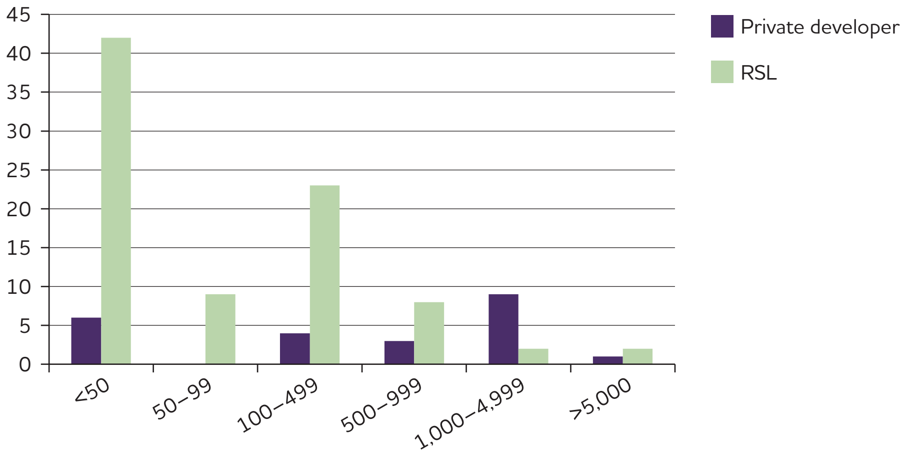
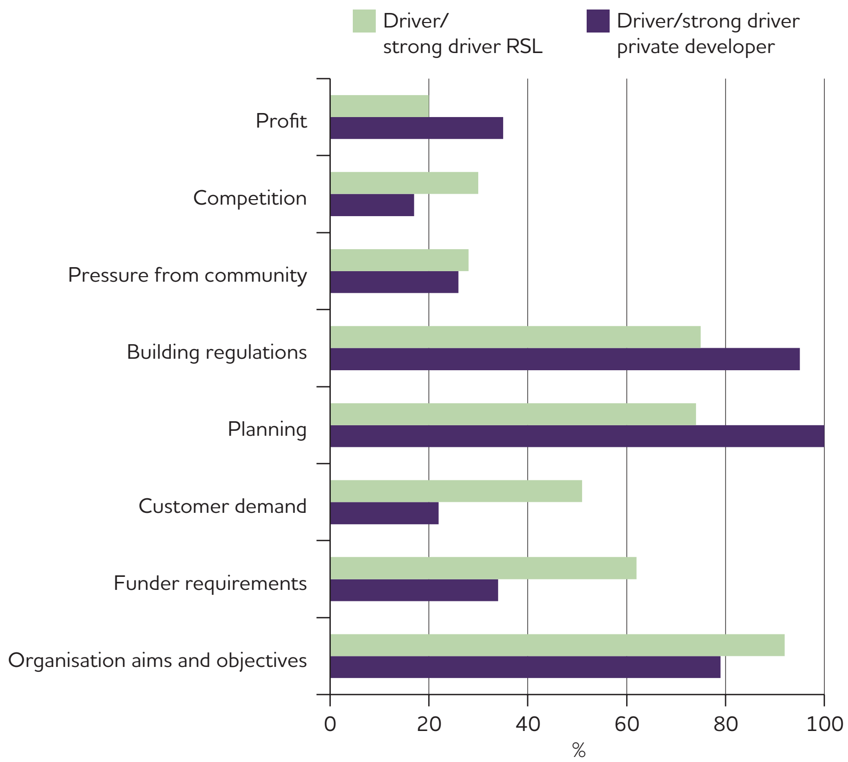


Figure 12: Drivers of sustainability (%)



sustainability. This supports the message that emerged from the literature review, and concurs with findings of interviews reported on in Chapter 5.

Planning was a significant driver for both RSLs and private developers – the most highly rated driver for private developers, with 100 per cent considering this a driver or strong driver. Building Regulations was a driver for both types of organisation, particularly for private developers. It is surprising that around 10 per cent of RSLs did not consider Planning or Building Regulations to be drivers of sustainability. As would be expected from the literature review, customer demand was not commonly cited as a driver of sustainability in the private sector, although it was given greater prominence by RSLs. Around half of RSLs and a little over a fifth of developers saw customer demand as a driver or strong driver of sustainability. No private developers that responded to this survey thought that purchasers were aware of and willing to pay for the benefits of low-energy housing, while 18 developers (78 per cent) disagreed or strongly disagreed with this statement. Many RSLs sell properties either as low-cost owner-occupation or market sales, and 61 per cent (of the 76 who answered this question) believed purchasers were unwilling to pay for the benefits of low-energy housing.

Competition was generally not seen as a strong driver of sustainability. Developers are not competing with one another to provide sustainable housing. This is understandable given the lack of customer demand mentioned above. In keeping with the lack of a price premium reported on elsewhere in this report, it is unsurprising that profit was not a strong driver of sustainability. The HCA has specific requirements for sustainability in terms of CSH levels, and 60 per cent of RSLs saw funder requirements as a driver or strong driver of sustainability. Surprisingly, almost a fifth of RSLs did not think funder requirements were a driver at all.

In addition, five RSLs each suggested one other driver not mentioned on this list. Four of these related to creating affordable, sustainable tenancies and one simply to 'do the right thing'. These comments fit well with the social values of RSLs and interview analysis in Chapter 5, where it is noted that addressing fuel poverty can be part of a comprehensive approach to housing affordability. Moreover, 92 per cent of RSLs and 79 per cent of private developers indicated that their organisational objectives were drivers of sustainability. This is consistent with the view that values are important drivers of sustainability, albeit constrained by market considerations (discussed below in relation to obstacles).

Current levels of sustainability

The questionnaire survey considered the development standards achieved in developments completed in 2012/13. These projects obtained planning permission prior to the latest, 2014, Building Regulations, but results will indicate whether 2010 Building Regulations levels and the higher levels of sustainability expressed through CSH code levels 3 to 6 are being achieved. It should be noted that only around 50–60 RSLs were able to answer any of these questions, with fewer still, 34 RSLs, answering questions about higher levels of CSH compliance (codes 5 and 6). As there may be an element of self-selection by those who have achieved higher levels of sustainability, one should be cautious in extrapolating from these figures.

Nearly all private developers (90 per cent) had built some projects to 2010 standards, and for 45 per cent of these, this represented a majority of their developments. A similar proportion, 86 per cent, of RSLs had built to 2010 standards, and 70 per cent had built the majority of their developments to this level.

An overwhelming majority of both RSLs and private developers had built at least some of their schemes to code levels 3 and above, with code 4 being built by around two-thirds of both RSLs and developers, while only small numbers had built to levels 5 and above. Ninety-five per cent of private developers had built to code level 3, 65 per cent to code 4, two developers had built to code level 5 and one to code 6. Among RSLs, 89 per cent had built to code 3, 69 per cent to code 4.

Increasing sustainability

Respondents were also asked to estimate the approximate cost of moving from their current standards to 2016 standards. The result for this question is shown in Figure 13.

Seventy per cent of private developers believed that the cost per unit of moving to 2016 standards would be more than the highest level specified in the question, that is, more than £7,500 per unit. In contrast, only 13 per cent of RSLs believed it would cost more than £7,500, with the most common estimate (22 per cent) being between £5,000 and £7,500. Half of RSLs and a quarter of private developers could not estimate how much it would cost to get to 2016 standards.

Wider aspects of sustainability

Recognising the importance of other elements of sustainability, developers were asked whether they incorporate BfL12 standards and higher accessibility standards such as Lifetime Homes. Figure 14 shows that an overwhelming majority of RSLs build to BfL12 standards. Around half of private developers use BfL12 usually or always, and over a third sometimes incorporate it.

The survey also explored whether developers were building beyond the minimum accessibility standards (see Figure 15). Once again, RSLs were more likely to build beyond the minimum standard required by building regulations.

Figure 13: Cost of moving to 2016 Building Regulations standard

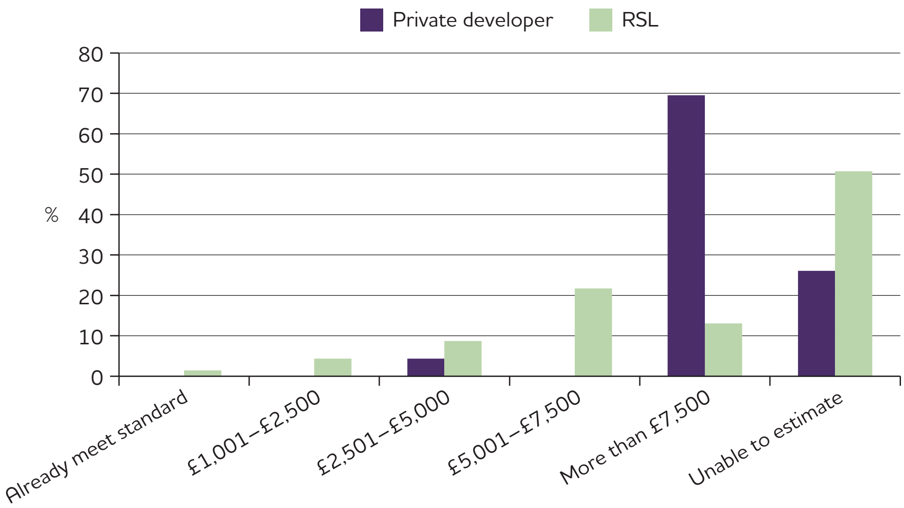


Figure 14: Frequency of incorporating Building for Life standards (%)

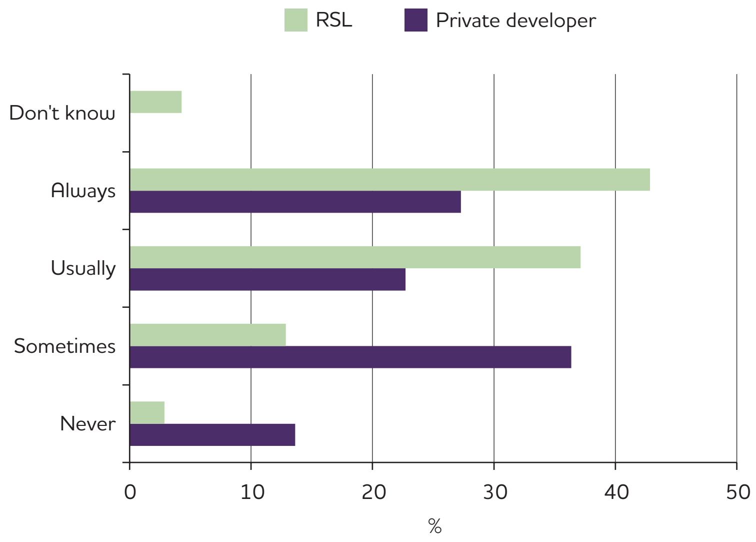
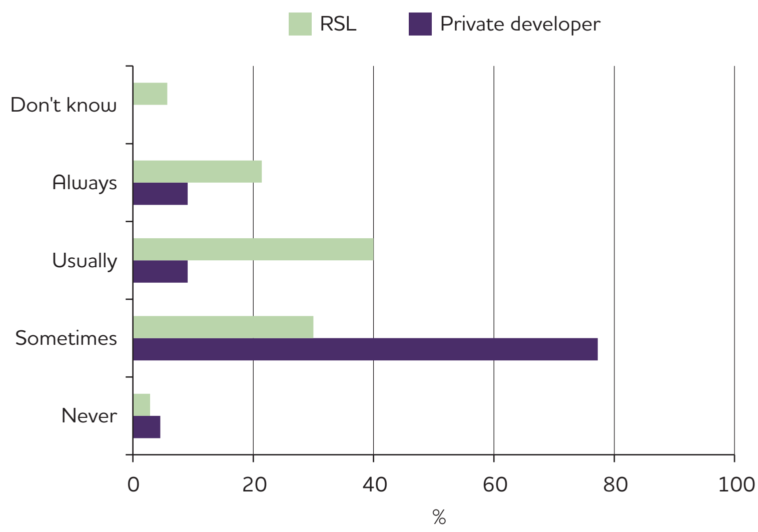


Figure 15: Frequency of development beyond Building Regulations accessibility standard (%)

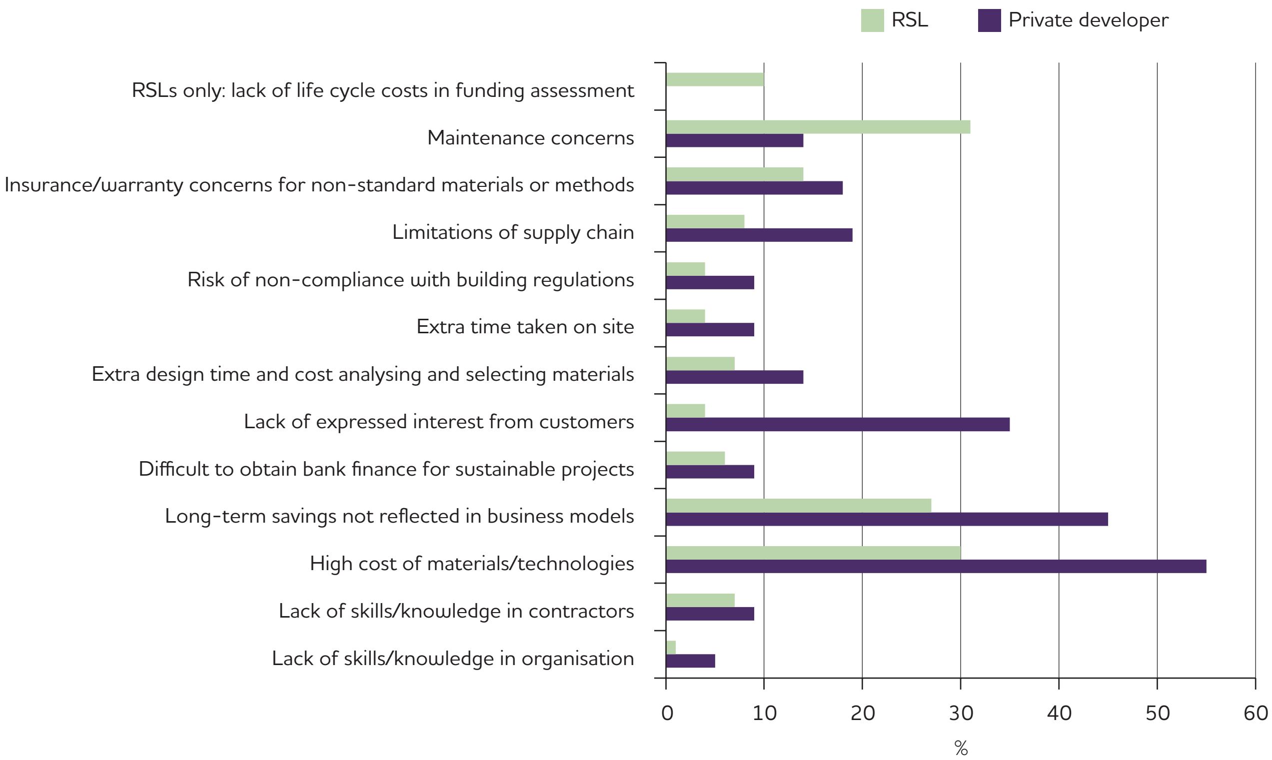


Obstacles to achieving sustainability

The survey considered those factors that have been a barrier to developing sustainable housing (see Figure 16). The high cost of materials and technology was the most common factor, mentioned by over half of private developers and 30 per cent of RSLs. The next most common obstacle was that long-term savings from sustainability are not reflected in business models. Together these are important considerations as they discourage upfront spending which would reduce long-term energy use that would show up positively in a life cycle costing model.

The lack of customer interest in sustainability was also a common factor for private developers, reinforcing the short-term focus of their business models. On the other hand, the risks of new technology are reflected in maintenance concerns which are seen as an obstacle by RSLs which retain ownership and long term responsibility for properties.

Figure 16: Obstacles to achieving sustainability (%)



Impact of government regulations

Only a minority, 26 per cent, of private developers and 42 per cent of RSLs thought sustainability regulations had a positive impact on design, suggesting that, from a design perspective, most private developers and RSLs question the value of regulation.

Developers must meet regulations in order to develop, and in Chapter 6, the impact of sustainability requirements on supply is modelled, showing a relatively small impact. Around half (52 per cent) of developers thought government regulations relating to sustainable construction were too stringent, compared with only 25 per cent of RSLs. However, in line with our modelled results, a minority of private developers (30 per cent) or RSLs (44 per cent) believed that government sustainability regulations reduced the number of dwellings that they could produce.

There was scepticism about the ability to meet the government's 2016 zero carbon target, although it should be borne in mind that the survey took place before the June 2014 Queen's Speech which clarified some of the issues that were of concern to survey respondents. Almost all developers – 22 out of 23 (96 per cent) – felt the target was unrealistic. Eighty per cent of RSLs thought the target was unrealistic, although 8 per cent thought it was realistic, with the remainder unsure. Some felt that there was insufficient time for change, some highlighting that the planned step changes on the road to 2016 had not happened. A number believed there was still too much uncertainty and lack of clarity over the definition of zero carbon, including Allowable Solutions. Costs were seen as prohibitive, sometimes accompanied by concern over reduced grant funding. There was scepticism about unproven and expensive technology, with some concern about the difference between design and performance. Lack of recognition for sustainability in property value and a general lack of incentives were seen to undermine developer commitment to zero carbon goals.

Planning and sustainability

The literature review indicated that the role of the planning system in promoting sustainability is controversial. Many questioned the efficacy of policy, and the government has raised concerns that it inhibits the supply of new homes. The questionnaire survey therefore explored the impact of national and local planning policies relating to sustainability on the production of sustainable homes and the supply of housing. Views on the impact of national planning policies were fairly similar for RSLs and private developers (see Figure 17).

More respondents in both categories believed that national planning policy improved sustainability than felt it did not, although a significant proportion were ambivalent about its impact. Thirty-nine per cent of private developers thought national planning policies improved sustainability of homes, while only 17 per cent disagreed, but a large proportion (44 per cent) neither agreed nor disagreed. A slightly larger proportion of RSLs (43 per cent) thought national planning policy improved sustainability, but a slightly larger proportion, 23 per cent, disagreed.

Fewer private developers or RSLs believed that local planning policy improved sustainability (see Figure 18). The responses were the same from both types of organisation, with around a third believing that local planning

Figure 17: National planning policy improves sustainability of developments

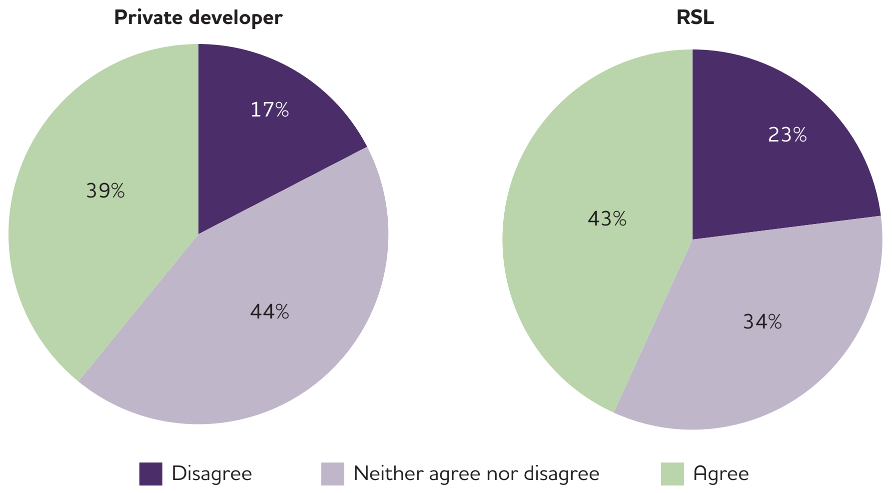
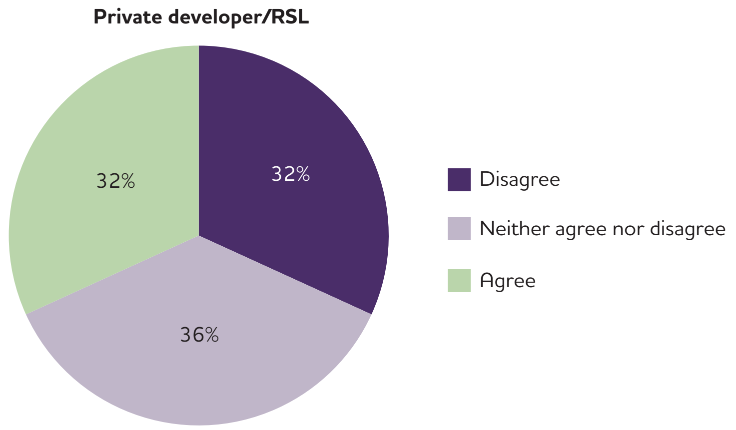


Figure 18: Local planning policy improves sustainability of developments



policy improved the sustainability of development, and the same proportion disagreeing with this statement.

Fifty-seven per cent of private developers and 42 per cent of RSLs believed that national planning policy on sustainability restricted their ability to increase the supply of new housing (see Figure 19). Respondents were more negative about the impact of local policy on supply than they had been regarding national planning policy. Seventy-nine per cent of private developers believed that local policy restricted their ability to increase supply, as did 59 per cent of RSLs (see Figure 20). This data supports the views expressed by developers in interviews that there is a tension between planning requirements and delivery of sustainable housing. This appears to be the case for fewer RSLs, but still a clear majority.

Figure 19: National planning policy restricts ability to increase supply

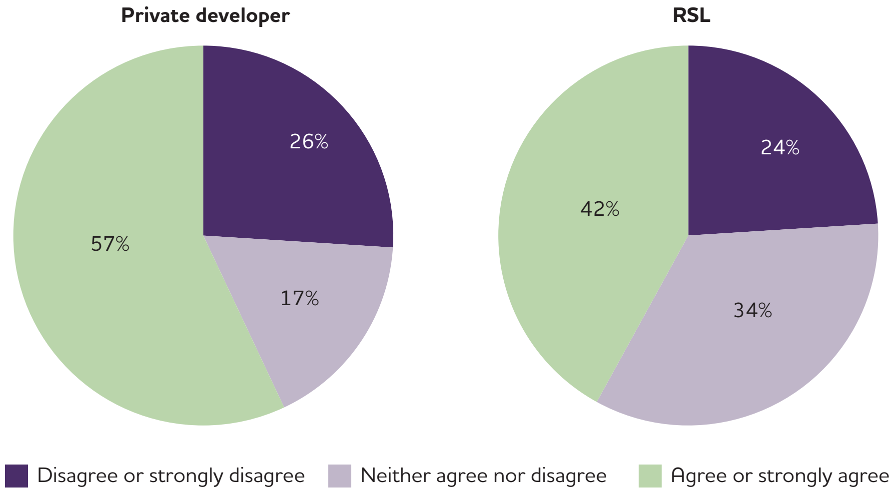
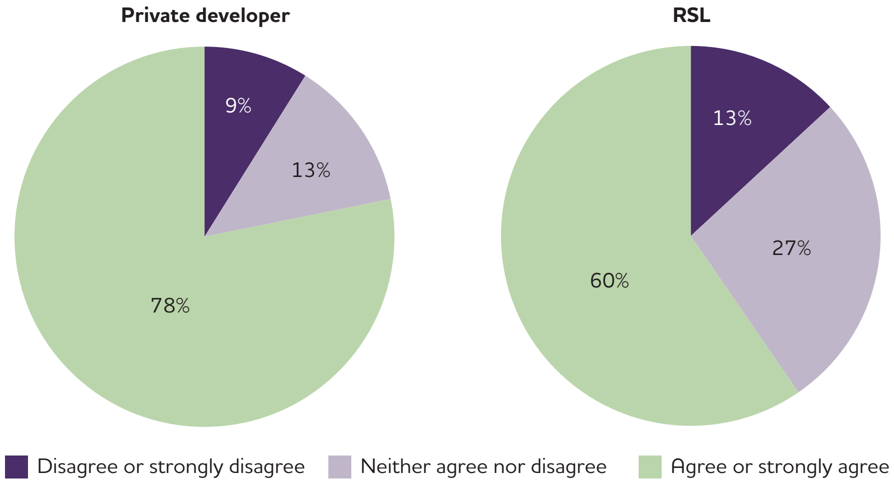


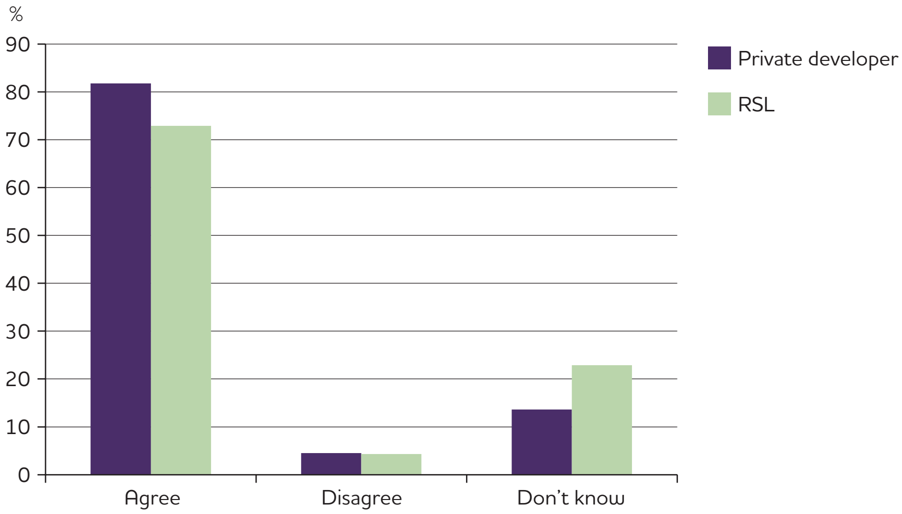
Figure 20: Local planning policy restricts ability to increase supply



Design and construction: improving development efficiency

The literature review highlighted the link between sustainability and the change agenda in construction, design and development processes. In Chapter 3 the SPM identified a number of improvement routes that were available to developers, including fabric and technology solutions. Figure 21 highlights that

Figure 21: Always consider fabric first (%)



a large majority of private developers and RSLs would consider a 'fabric first' approach before looking at technological solutions.

This fabric approach is consistent with the views expressed earlier in this chapter regarding high cost and maintenance concerns related to technology. Indeed, in response to an open question on which approaches had been the most successful in reducing costs, the second most common recurring theme, mentioned eight times, was that a fabric first approach was the most cost-effective measure. Some respondents explicitly stated that technology should be avoided, and two were very concerned about being forced by planners to adopt renewable technologies when they believed these were unnecessary or poor value for money. Others stated that fabric plus some technology – PV, timber frames or an efficient heating system – had been the most successful.

Table 6 draws on the literature on construction innovation, and asks which of various approaches had been attempted to improve efficiency. The literature identifies many examples of demonstration projects, but also points to limits to the extent to which innovation has become common practice.

Table 6: Approaches to increasing development efficiency (%)

	Demonstration/pilot		Mainstream	
	Private developer	RSL	Private developer	RSL
Supply chain partnering	9	14	70	31
Life cycle cost analysis	39	13	4	44
Innovative construction contracts	22	17	4	14
MMC	30	22	39	33
Sustainable consultant selection criteria	22	6	30	30
Sustainable supply chain selection criteria	26	8	30	32
Collaboration with other developers	26	11	26	40
Bulk procurement	9	8	57	26
Membership of procurement group	4	7	0	36
Framework agreements with contractors	9	2	30	47
Innovative financing arrangements	9	10	9	15

The survey therefore asked whether initiatives had been used only in demonstration or pilot projects, or whether they had been mainstreamed.

Mainstreamed by 70 per cent of private developers, supply chain partnering was the most common approach, highlighting an emphasis on development process in the sector. Perhaps surprisingly, only 31 per cent of RSLs partnered. However, almost half of RSLs and 30 per cent of private developers used framework agreements, and such agreements will normally have a collaborative element. Partnering, team integration and framework agreements were most commonly cited as the most successful methods of reducing costs (mentioned in some form by 16 respondents). Two more went further, and stated that bringing development in-house was the most effective route. Conversely several respondents were strong advocates of tendering.

As noted earlier, MMC is associated with high performance standards but is not incentivised in the market at present due to its upfront cost. MMC was a mainstream activity for 39 per cent of private developers and 33 per cent of RSLs, indicating that innovative construction approaches were common, although only used by a minority of developers or RSLs. A further 30 per cent of private developers and 22 per cent of RSLs had used MMC in demonstration/pilot projects.

Forty-four per cent of RSLs claimed to use life cycle analysis in their mainstream schemes, even though this is not formally a factor in RSL project appraisal. Only one private developer used this regularly, but 39 per cent had tried it in demonstration/pilot projects. This, perhaps, indicates an understanding of the value of life cycle costing, but underlines the lack of market incentives or business models to support it, particularly in the private sector.

Four respondents saw volume procurement, economies of scale and standardisation as effective in reducing costs. MMC, including off-site construction, was also mentioned four times. One respondent specifically referred to the Passivhaus system and three to efficiency initiatives including AIMC4.

Summary

Planning and Building Regulations were identified more often than any other factors as key drivers of sustainability by private developers, and were second and third most commonly mentioned factors for RSLs, followed by funder requirements. For RSLs, organisational objectives were the most common driver of sustainability, and there was an indication that this was frequently linked to concern for affordability and fuel poverty. Organisational objectives were also very significant drivers for developers.

A minority of private developers and RSLs believed Building Regulations restricted their ability to increase supply. However, the local planning system was much more commonly seen as a restriction on supply: viewed as such by 79 per cent of private developers and 59 per cent of RSLs.

Although Building Regulations and the planning system are drivers of sustainability, regulation is seen as too stringent, and zero carbon target as unrealistic. Nevertheless, there has been movement towards meeting regulatory standards. Both RSLs and private developers commonly met CSH level 3 requirements, and around two-thirds of each had built some developments to code level 4. Higher standards, code 5 and 6, had only occasionally been met. Nearly all private developers estimated the cost of moving from the current to 2016 (zero carbon) standards as in excess of

£7,500, the highest figure offered by the questionnaire, whereas the most common estimate for RSLs was between £5,000 and £7,500.

Sustainability or quality standards unrelated to energy efficiency are frequently met in both RSLs and private developer sectors, although this is more common for RSLs. Over four in five RSLs and over half of private developers usually or always built to BfL standards, and two-thirds of RSLs but less than one in five private developers usually or always building beyond minimum accessibility standards.

A fabric approach to sustainability is seen as the most cost effective, although there is room for some technology, particularly PV, timber frames and efficient heating systems. Business models mostly do not reward a life cycle cost approach, and the high cost and risk reduce the attraction of a technology approach. A few respondents mentioned volume and economies of scale as successful approaches to efficiency. Only a minority of developers used MMC, again, partly in response to capital costs.

5 CASE STUDY EVIDENCE

Introduction

Interviews were carried out across seven case study areas, giving a geographical spread around England, with a range of housing markets based on house prices and incomes. The interviews examined the behaviour of firms and individuals, constraints and the potential for positive change, and provided an opportunity to test the assumptions in the SPM. Views were sought from local authorities, RSLs, private developers, consultants and suppliers.

Although case studies were area-based, most organisations operated beyond a single local authority area, and their wider experience was also discussed. To encourage a candid response, all interviews were anonymous. While it is necessary to describe the general location of the local authorities to demonstrate the range of housing markets covered, the individual authorities are not identified, and no responses are attributed to a specific local authority. The local authorities were located within the Berkshire area, Lincolnshire/Norfolk, Greater Birmingham, Greater Bristol, Inner London, Tyneside, and North Yorkshire. Cities, towns and rural areas were included.

Building Regulations and the 2016 zero carbon target

There was strong support among all interviewee groups for using Building Regulations as the main driver to higher energy standards because of its centrality in climate change policy. This was facilitated by gradually increasing stringency within Part L of the Regulations to reduce GHG emissions with the aim of all new homes being 'zero carbon' by 2016.

The gradual approach was seen to have been successful, allowing developers and the supply chain time to adapt to standards that would not have been possible when the process started around 2006. "An incremental approach has been successful over a number of years – the ladder was ideal" (private developer). During this period, the cost of technology has also reduced, although not to an extent where a technology-led approach is the preferred route for achieving the zero carbon target.

There are conflicting views on whether momentum has been lost in moving towards zero carbon because of relatively small recent changes in the 2014 Regulations. Reinforcing the survey findings, several interviewees doubted that zero carbon could be achieved by 2016, some developers citing

2019 as a more realistic target, and one suggesting 2015 as an intermediate target for full fabric efficiency. A contrasting view from some developers was that an intermediate step was a distraction, and that there should be one big push to 2016.

The definition of zero carbon has changed since it was first introduced, removing unregulated energy (including appliances), and now referring only to regulated energy (heating, hot water and lighting). A further change was to allow part of the energy savings to be met by off-site provision, known as 'Allowable Solutions'. Although not as yet specified, these may include the provision of renewables and possibly retrofitting energy improvement measures to existing housing. Uncertainty over how offsetting would work was also cited as a factor that would make the 2016 target date unachievable. Views on offsetting were mixed – some developers, RSLs and local authorities saw it as an unhelpful 'watering down' of the standard, while others were more supportive: 'This change to "carbon offset" is not a fudge because ... you could have more impact on CO_2 by spending that money more effectively in upgrading properties.' (private developer)

Building Regulations have worked alongside local and national planning policies and non-statutory guidance such as the CSH. There was support from several developers for abandonment of CSH as unnecessary red tape, and incorporation of standards in the Building Regulations alone. Most developers thought that differences in planning regulation between authorities led to inconsistency. While not averse to national standards provided they were high enough, local authorities wished to retain their autonomy in setting sustainability requirements. A private company welcomed the use of Building Regulations as a non-political method to solving technical problems.

Code for Sustainable Homes

While building regulations have been the biggest driver of change, CSH has been an important standard used across the industry. Planning policy refers to minimum required code levels. The HCA was generally viewed as having a positive influence on standards, with the current round of HCA funding requiring a minimum of code level 3 and, in London, RSLs must meet code 4.

Local authorities, most RSLs and some private companies, including some mainstream developers, were positive about CSH because it provides a consistent, well-understood standard. CSH also facilitates certainty in discussion because it is a common language used by developers, the supply chain and planners. A private developer wondered what would take its place among planners, and suggested that, rather than causing inconsistency, it gave a common currency across boundaries: "What do planners use [instead of CSH] – do they come up with 152 local versions of what sustainable development is rather than one national one that everyone understands?"

Conversely, some developers and RSLs saw CSH as an unnecessary layer of bureaucracy, taking up time and adding administrative costs. "It is music to my ears if we can get rid of ... the Code. If you need to do these things, you can do them within the building regulations" (private developer). Even some interviewees who were in favour of retaining CSH felt that at high levels (5 and 6), some elements, relating, for example, to transport, were a distraction from the job of creating more energy-efficient housing. However, others believed that it was the wider aspects, such as those relating to flooding and drainage, that meant that Building Regulations could not adequately replace CSH.

Planning system

The planning system is at the heart of housing delivery, and is a mechanism for implementing many elements of public policy. The role of planning includes the protection of greenbelt and open space while facilitating development to meet housing need. Authorities view sustainability more widely than energy efficiency, considering issues such as location, mixed use, drainage and flooding, and, as highlighted in London, the effects of the urban heat island on indoor comfort and air quality.

Planning authorities must identify sufficient land for a forward allocation of housing to meet need and demand. A rural authority considered the need for infrastructure (road) development to be the main constraint in bringing forward sufficient land. HCA ATLAS (Advisory Team for Large Applications) has a role in supporting large-scale housing development to meet sustainability objectives. One case study developer considered that no suburban new build could be sustainable because of its location relative to sustainable transport, and promoted compact inner-city development, while an RSL championed rural exceptions sites in villages.

RSLs and private developers all favour quicker, less bureaucratic decision-making, although time taken in planning decisions was seen to have relatively minor cost implications compared to other issues such as land costs. Some RSLs and private developers suggested fast-track or light-touch planning consent for highly sustainable development (for example, energy-efficient or high-scoring BfL) could act as an incentive to increase standards, perhaps combined with a performance league table of development performance. It was also suggested that preference could be extended to self-build/custom build to increase overall delivery.

The extent to which sustainability should be determined by local planning policy is contested. Although authorities have a variety of strategic and site/development-specific tools available, including masterplans, the key factors are land release policy, sustainability policy, often contained in the 'Core Strategy' setting out local authority priorities within the Local Plan or Local Development Framework, and Section 106 agreements specifying contributions from particular developments.

Planning authorities typically set sustainability standards in excess of Building Regulations, usually code 3, sometimes code 4, and according to one developer, occasionally at code 5. This will no longer be possible once the new Building Regulations come into force. The NPPF requires local authorities to support renewable and low carbon energy production, and they often specify around 10 to 15 per cent to be generated from renewable resources such as PV within new housing schemes or using CHP (combined heat and power).

Developers' principle concern is that planning requirements should be consistent, and there is strong support among developers for national standards and for removing local variation. They complain that variation inhibits efficiency, innovation and volume procurement, leading to higher costs. There were also complaints that some local policies were out of date, placing emphasis on technology solutions to inefficient buildings rather than improved fabric.

On the other hand, local authorities value their freedom to set requirements which are locally accountable and relate to their specific needs.

An authority noted that its car-free policy, brought in in response to local conditions, was accepted by developers and eased new development by reducing neighbour objections. Contrasting with the survey response where most thought that regulation was too stringent, two private companies suggested that planning standards were not high enough and not defended sufficiently, making it difficult to compete with companies which were content to set low sustainability standards.

Developers often contest sustainability requirements, especially where they believe them to be unsupported by rigorous evidence. Planners therefore need to have sufficient skills and resources in policy development and implementation, interviewees commenting that discussions with developers focus increasingly on viability. For developers there is a sense that sustainability is one of a number of competing planning demands on sites which reduce their ability to develop profitably: "Do we want more affordable housing, do we want more sustainable housing, do we want an education contribution, library contributions? It isn't a bottomless pit – it's a balancing act, and it all comes back to viability" (private developer). To engage in these discussions, planners need access to viability appraisal skills as well as technical and general planning skills. Authorities that had successfully implemented and defended sustainability policies had created sustainability teams, but found that these were losing resources and staff in recent rounds of budget cuts.

Authorities recognised competing priorities, with affordable housing provision being the highest priority in most cases. Local authorities sometimes felt intimidated into backing down on sustainability requirements, fearing loss of appeals and impact on their performance rating. Some were reluctant to push too hard on contributions from developers in case they lost out on development to other areas. The market also played a part in levels of sustainability that local authorities could insist on – an authority taking a robust stance operated in a very high demand area where developers were very keen to build and it consistently exceeded its delivery targets.

A number of local authorities believed that central government sustainability policy was 'being watered down', and that the authority needed freedom to enforce higher standards where these had been established through robust policy over a number of years. They felt that their position was being weakened by central government presumption in favour of sustainable development – which several took to mean virtually any development – and by the potential for loss of autonomy in setting sustainability standards as a result of the *Housing Standards Review*. "We … have staff and an industry which is adjusted to a certain level – you can fight to maintain it rather than break through to it" (local authority). Some called for greater support from planning inspectors, and feared that they were increasingly likely to lose planning appeals on sustainability grounds. A common view among authorities was that they would support consistency of national standards, provided that these were sufficiently high.

Land

The availability and cost of land is a determinant of the level of supply and has an impact on sustainability but, in line with the literature reviewed earlier, case study interviewees pointed to limits on the planning system's ability to deliver more land for sustainable homes. Market and landowner expectations are also key factors in the availability of land for housing; in most cases, landowners do not have to sell land if they are not being offered the amount they perceive their land to be worth. Since there is a limit to the extent to which land values can be depressed, increased development costs beyond this limit will either squeeze developer profits or increase the price of housing. As there is no price premium for sustainability, there is concern that increasing standards may decrease supply.

Expectations of land value are driven by the very high returns that have historically been available. Institutional landowners, for example, may have a certain asset value against the land in their accounts, and would have to accept a write down in their assets and potentially on their share value if they sell at a significantly lower price. Although there was a significant fall in land prices with year-on-year falls of almost 20 per cent across England (HCA, 2013b) they had stabilised by 2011, with some price increases in London (VOA, 2011).

At present developers face strong competition for land, and RSLs have found it difficult to compete to buy land directly on the market in many areas, increasing their reliance on Section 106 schemes. One private developer commented that competition remains fierce, with "seven developers chasing a piece of land and [the owner] expecting £1,000,000 per acre." Developers frequently cited competition for land as a constraint holding back sustainability because a developer going beyond minimum standards would be vulnerable to being underbid by another developer that was willing to invest more in land acquisition and minimise build costs.

Developers and local authorities agreed that certainty and transparency in statutory and local authority standards would assist responsible developers to compete on level terms for land with those who were willing to produce a basic product with lower levels of sustainability. A consistent and relatively high standard means all developers seeking planning approval have to include higher sustainability performance in their viability calculation and, using a residual value approach to development costs, land prices could be expected to fall. However, while there is consensus that this reduction in land cost would occur to some extent, private developers, RSLs and local authorities were concerned that some landowners would refuse to sell at a lower price, and the effect would be to reduce the supply of land.

As discussed, RSLs are often unable to compete directly for private sector land. However, RSLs can gain access to land in rural exceptions sites where landowners are in a weaker position because the land is not allocated for housing and competition is constrained. Here, higher sustainability standards may be possible provided that the RSL can bring in sufficient funds through grant or other resources. Indeed, higher sustainability standards have been found to increase access to land in some cases in both rural and urban areas. An RSL interviewed as part of this study found that providing sustainable housing, especially in developments which are sympathetic to the local vernacular, assists in gathering essential support at the parish level for building on exceptions sites. A private company found that a development model based on providing sustainable development assisted in gaining access to local authority and government-owned land for regeneration.

The HCA, working with government departments, agencies and local authorities, has an expanded role in driving the government's aim to increase land supply, and can encourage public landowners to use their land to support sustainable development. Private developers and RSLs believed that government-owned land could be used to incentivise sustainable development. Suggestions included giving land free, land at a reduced cost, or with deferred payment, to developers who showed that their performance in a sustainability league table, or a specific scheme proposal, met an approved sustainability benchmark. A development of this idea was that government-owned land could be allocated on the basis of an independent valuation and combined with a sustainability-based competition. Another developer suggested giving preferential access to public land to the largest developers as they can deliver more housing more efficiently, a point explored later, in Chapter 6. Yet another suggested that self-build, including the 'custom build' scheme, could be prioritised on publicly owned land.

The market – competition, pricing and investment

Competition, particularly competition for land, is a key determinant of private developer behaviour. Companies are concerned that if they build to a high sustainability standard that is not reflected in the house price, this will reduce their ability to pay for land, and they will be outbid by other firms and will not obtain land on which to develop. Developers' approach to quality is therefore led by regulation – they will build what they have to build to get planning permission and a building warrant. "Unless mandated by building regulations or other legislation we won't do it. When you want to do something better than competitors – you can't sell them because people still look at how much it costs" (private developer).

Clarity of requirements provides a level playing field and reduces the risk of developers being undercut by competitors who will build to lower standards. Building Regulations are clear, and developers value clarity in planners' sustainability requirements, including a statement of CSH levels. A few private companies orient their businesses around sustainable standards rather than compliance, and fill niche markets. There is some evidence that within cost constraints, some of the larger developers are also trying to establish themselves as sustainable developers.

Competition in the investment market also has a bearing on the amount private developers can spend on build quality/sustainability. Residential development is only one of many sectors in which investors can invest, and if profits are squeezed, shareholder returns will fall and investment will go elsewhere, decreasing the number of homes that can be built. This is a feature of the open investment market, but is also a concern for developers that are part of a company group involved in a number of different sectors in addition to housing.

Some private companies with a different business model where sustainable development is a central aim attract investment specifically because of their sustainability credentials. Despite investor emphasis on profit, one company found investors with a broader view than simply looking at the bottom line for every investment. Working to provide sustainable development, the company operates in a context where ethical and sustainable investment has grown significantly over recent years, supported by external forces such as the UN Environment Programme Finance Initiative (UN EPFI).

Some companies find that higher-quality/sustainability maximises returns within a niche market, predicated on getting access to land which was owned by the public sector or others who had a connection to a neighbourhood and for whom sustainability, rather than just a return on assets, was a consideration. This was translated into project design and performance appraisal based on sustainability indices. By embedding sustainability within the company ethos it was claimed that sustainable development could be delivered more cheaply than if it was an add-on to its designs and processes. These companies were able to attract investment, position themselves favourably for framework agreements and gain access to public sector land.

Notably, one of the companies was privately owned and therefore not driven by shareholder returns.

It was notable that RSLs and private developers had posts such as 'sustainability coordinator', that some referred to a 'sustainability team' and some had achieved ISO 14001 sustainability accreditation. Private developers produce corporate responsibility and sustainability reports highlighting good practice and performance improvement in areas such as emissions and waste. Some saw positioning their brand sustainably as providing market advantage. Nevertheless, mainstream private developers were clear that their overriding company objectives were profit and shareholder value.

In RSLs, the work of a sustainability team could extend to asset management of existing stock, with a focus on tenant comfort and affordability, working alongside development and maintenance teams, for example, in retrofit of PV systems. RSLs were concerned with financial performance, but were distinct from most private developers in stating that their objectives in pursuing sustainable development were to create affordable homes that would be easy to heat and live in, and would contribute to a reduction in fuel poverty.

Local authority commitment to sustainability was also evident in organisational structures and employment of officers with skills in sustainability. Authorities with high levels of skills and backing from a senior management and council cabinet level took a more robust approach to enforcing sustainability. This was reflected in a willingness to defend policies against appeal.

Householder attitudes and behaviour

Sustainability is lower on customers' list of demands than location, price or size. Interviewees confirmed that sustainability is not a high priority for householders, and they do not pay extra for sustainability. Householder reluctance to pay for sustainability is also reflected in assessed value that prevents purchasers obtaining a higher mortgage for an energy-efficient property.

It was noted in the literature review that RICS believed that sustainability might become more valued by customers through time. Some developers indicated that there was more customer interest in sustainable housing, but this did not translate into higher prices. Some potential purchasers may have more interest in sustainability than others, with a highly sustainable scheme attracting a higher than normal proportion of 'asset-rich and cash-poor empty nesters' because of reduced fuel costs.

Householder use of technology is problematic. Where efficiency is dependent on householders' action, this is not generally successful, according to developers and RSLs. Several interviewees expressed concern that householders' behaviour would adjust to negate the environmental benefits of energy efficiency by leaving the heat on longer and living in higher temperatures, or by diverting savings to other energy-using consumption such as travel. A more benign effect was experienced by an RSL that discovered significantly reduced rent arrears in a social rented Passivhaus development, indicating that energy efficiency is producing the affordability benefits which were the goals of almost all RSL interviewees.

Customer education is widely believed to be an important factor in increasing demand for energy efficiency and effective use of energy-efficient homes. A developer suggested increasing the prominence given to

Energy Performance Certificates (EPCs) in brochures, in sales offices and on websites. Several RSLs produced newsletters and organised events and home visits to encourage energy efficiency. Interviewees speculated that stamp duty or council tax could be used as incentives to purchase sustainable homes.

A private company noted that wider dimensions of sustainability, such as good urban design, were difficult to include in initial valuations of new homes, but that this asserted itself as a well-designed neighbourhood gained in popularity over a number of years. This advantage was also recognised by RSLs who wanted homes to remain popular and in demand over the long term.

Design and construction

Improved sustainability has required new approaches to construction, but the recession has been a factor in limiting their implementation. The challenge of achieving sustainable development reinforced the attraction of partnering which was widely recognised as deepening the level of understanding and commitment to shared goals. Lack of skills and fragmentation of the industry pointed to the need for a collaborative approach, encouraging learning and buy-in to sustainability objectives throughout the team.

However, a number of RSLs and private sector companies stated that they had ceased to use partnering, and a contractor had found that framework agreement opportunities had dried up during the recession, replaced by an emphasis on lowest capital cost tendering. At the same time, developers had continued to seek contractor and subcontractor buy-in and improved performance, offering continuity of work if they performed well rather than formal partnering: “For the last two to three years they have learnt what we want and you can’t just go back to a tender process and say thanks for your hard work and everything we learnt we are going to pass onto someone else because they are a bit cheaper” (private developer).

There was a remarkable consensus among private developers, RSLs, planners and other interviewees that a ‘fabric first’ approach was preferable to technology-led solutions to energy efficiency. “If you do it in the fabric, then it lasts the lifetime of the building. If you do it with renewables it only lasts the lifetime of the renewables” (private developer). Fabric first involves achieving high levels of airtightness, combined with good ventilation to provide a pleasant and safe indoor air environment. Developers’ experience indicated that CSH level 4 is achievable with fabric without renewable technology. Often the only reason developers include technology is to meet planning requirements for renewable energy, usually with on-site PV. As discussed in Chapter 3, preferences for moving closer to zero carbon housing without Allowable Solutions involve a mix of fabric and technology.

A further impetus for seeking fabric efficiency is that it is cheaper and more reliable than renewables. “If you have technology you have to design the house around it to a certain extent, and that adds cost” (private developer). Individual technologies, especially PV, have reduced in price, in part as a consequence of increased demand to meet Building Regulations and CSH requirements. It is anticipated that other technologies will also become cheaper as demand grows. Where technology is used, low tech is preferred to make it easy for householders to use.

There is also more risk in using technology, and developers, and even more so, RSLs, need to have confidence in their long-term efficacy, maintenance and reliability. No matter how well the renewable technology works, it will need to be maintained, adding to life cycle costs and reducing sustainability. Although the number of companies able to maintain and service technology has increased, skills in this area are still in short supply with, for example, an RSL finding it very hard to find cover for maintaining ground source heat pumps. Lack of maintenance options can also be a turn-off for owner-occupiers.

Case study interviewees referred to lack of skills and knowledge at all levels of the supply chain – developers, designers, contractors, subcontractors and suppliers – as significant barriers to achieving more sustainable housing. There had been a fall-off in apprenticeships and training generally within the industry during the recession. It was suggested that there was insufficient focus on energy modelling and performance in design training in the UK compared with European practice, resulting in consultants contracting out activities such as SAP testing, although, conversely, one RSL found that increasing numbers of consultants with certification in SAP and in Passivhaus were approaching them for business.

Nevertheless, most interviewees believed that despite these shortcomings, skills had improved to some extent, as consultants and the supply chain had become familiar with producing housing to CSH levels 3 and 4. However, effort was being put into "demonstrating compliance through shortcuts and workarounds rather than meaningfully embedding it [sustainability on site] or embedding it within design" (architect). As a consequence, a significant 'performance gap' remains between *designed* performance and *actual* performance. The intentions of Building Regulations are said to be undermined by design detailing, difference between factory and on-site performance of materials and working practices such as accepting cold bridging of cavities.

At the same time, production of traditional materials had declined, and a recent upturn in activity had resulted in shortages of bricks and concrete blocks, causing developers and contractors to look overseas, and in some cases, driving them towards alternatives such as timber frames. Overall, there was a belief that the industry was not geared up to produce large increases in housing numbers envisaged by the government because of materials supply and skills shortages. One company suggested that in the medium to long term 'custom building' could fill a gap that speculative development could not.

Responses to the performance gap had involved training on individual schemes, including all members of the team from management down to 'toolbox training' of site operatives for contractors and subcontractors. At an industry level, initiatives include a joint Supply Chain Sustainability School involving a number of contractors and the Construction Industry Training Board (CITB).

Given that industry performance is led by regulatory compliance, several RSLs and private sector companies also suggested that the most effective way of bridging the performance gap was through including 'as built' performance in building regulations. It was realised that there would be costs involved at all stages of the development process, and that achieving this would be a challenge. It was, however, noted that in the construction of Passivhauses, where certification is dependent on post-completion performance, the industry has managed to bridge the performance gap, albeit at a cost.

Private sector companies and RSLs had successfully used the Passivhaus system – it had achieved the low energy bills claimed by the producers. The key to its success related to it being a whole system. This required commitment of resources for design and construction that were beyond the norm for other developments. Impressively, even using a Design and Build contract with more limited site supervision, the performance gap was able to be closed in an RSL Passivhaus development visited in one of the case studies.

There were mixed views on MMC and off-site construction. Some developers were firmly in favour of traditional methods, claiming equivalent performance to factory-build. They reflected the view that traditional construction was tried and tested and MMC more risky. Others contradicted this view, believing that MMC allowed higher standards to be achieved. A consultant for a supplier believed there had been improvement and the mainstream off-site product was "nearly there". However, lack of clarity and certainty – in adopting CSH and in local authority requirements – had constrained innovation and willingness of suppliers to invest in volume construction.

A crucial factor limiting off-site construction was that it was more expensive than traditional methods. However, lack of on-site skills, increasing labour costs and shortage of traditional materials were pushing developers towards MMC. Home manufacturers providing custom build (self-build) were mostly using off-site manufacture, demonstrating that where there is a premium on speed, MMC may have an advantage over traditional methods.

Standardising processes and products was seen as the way to achieve volume procurement and cost savings that could be redirected into sustainability and quality while maintaining profit. PV technology was cited as an example of a specific product where volume had reduced cost. A contractor saw standardisation of component parts allowing common process and practice on every site to be the most important potential development. Standardisation was also seen to have risks if a single volume supplier was used, and a contractor or developer became too dependent on it. A rural RSL avoided standardisation, seeing their individuality as a selling point, and standardisation as a risk to access to rural exceptions sites.

Summary

There was strong support for using Building Regulations as the only standard for energy efficiency provided this was set at a high enough level so that gains already made were not lost. Overall, Allowable Solutions are supported, and these should be directed towards reducing carbon emissions most efficiently in the context of local conditions. There is a need for continuing involvement of planning authorities in setting wider sustainability objectives. There is a limit to which privately owned land costs can be squeezed to keep the cost of housing down, and there is a case for increasing the release of publicly owned land and using this to facilitate wider sustainability goals.

There is a reluctance to turn to technological solutions, and a fabric approach to sustainability is preferred. Although 'designed' building standards are being achieved, a gap between this and 'as built' performance was identified by interviewees. Improved skills, new ways of working and use of MMC can begin to address this gap. In general, standardisation to allow volume production of components and consistent working practices is required. However, there are circumstances such as rural exceptions sites where volume is not appropriate, and smaller-scale, bespoke development is more appropriate.

6 MODELLING SUPPLY AT THE LEVEL OF THE FIRM

Overview

The motivation of this strand of the research is an attempt to disentangle the separate influences on housing supply of industry structure, firm-specific factors (such as capital intensity and the cost of borrowing), and the planning system. The imperative for this work flows from a long-running debate on whether housing developers are able to recoup from consumers the higher construction costs associated with higher-quality or more energy-efficient design and construction. As discussed in Chapter 2, there is insufficient evidence in the literature to convincingly argue that lower energy bills follow through to higher consumer demand (or occupation demand in the non-residential sector). Developer experience of the lack of customer response to improved energy efficiency was also highlighted earlier in this report.

In a perfect market, the occupiers of more energy-efficient buildings would pay more for them to reflect the potential financial gains arising from that efficiency. In standard neoclassical (that is, 'traditional') economic thinking, processes of arbitrage would eliminate occupier savings in energy bills comparing more with less efficient premises because occupiers would bid up differential rents or prices to the point of indifference. However, we do not live in a perfect world – housing and real estate markets are imperfect and inefficient. Occupiers have imperfect information about the properties they occupy, and the potential alternatives. Even well-informed occupiers may not fully understand the financial implications of less energy-efficient building designs. Even if they do, the relatively low cost of energy relative to rental and employee salary costs mean that commercial occupiers may have minimal concern (see Pellegrini-Masini and Leishman, 2011; Leishman et al, 2012). As discussed in Chapter 4, developers' experience is that they are constrained in their ability to recoup additional capital costs of energy-efficient new homes, as these are not accounted for in the valuation system on which customer mortgages are calculated.

Therefore, our starting position in this strand of work is that housing developers may face a reality in which higher development costs associated with more sustainable design and construction methods do not filter through to higher end user value, either at all, or in full proportion to those higher costs. Assuming that all firms are homogeneous, as assumed in simple neoclassical models, we can consider the potential impacts of stronger energy regulation on housing supply by considering three competing hypotheses:

- H1: All other things being equal, there is no relationship between the energy-efficiency element of construction costs, and end use values (that is, prices).
- H2: All other things being equal, additional energy efficiency-related construction costs feed through to a less than unitary increase in end use values.
- H3: As above, but higher costs result in at least unitary higher end values.

However, in addition to asking which of these hypotheses has robust statistical support, it is worth considering whether housing developers (as firms) really are homogeneous as assumed in simple neoclassical models. There are several reasons for supposing that the reaction of a firm to a shift in costs relative to prices might depend on what type of firm we are considering. For example, the typical land holding relative to annual output (land bank) is not uniform but differs between firms. So, firms' assessments of the cost of land relative to non-land inputs may also vary. Second, capital intensity may differ between firms with a greater focus on higher density development compared with those focusing on lower density development. Third, production technology may differ between firms, or firms may face more than one possible production function.[1] As a simplistic example, there may be a choice between off-site and on-site fabrication. Fourth, smaller firms may have more restricted access to capital, or more expensive lines of credit, than larger firms.

The degree to which local authorities are pro-development or resistant to further development (that is, overall 'planning stance'), the abundance of housing land supply, and the balance between greenfield release and brownfield components of land supply, may each also influence the behaviour of firms in relation to a shift in costs relative to values. In other words, a firm operating in two locations but with similar costs and organisation in each location may end up behaving differently depending on planning and land market conditions.

Research questions and approach

As suggested at the end of the previous section, our research approach concerns three related questions:

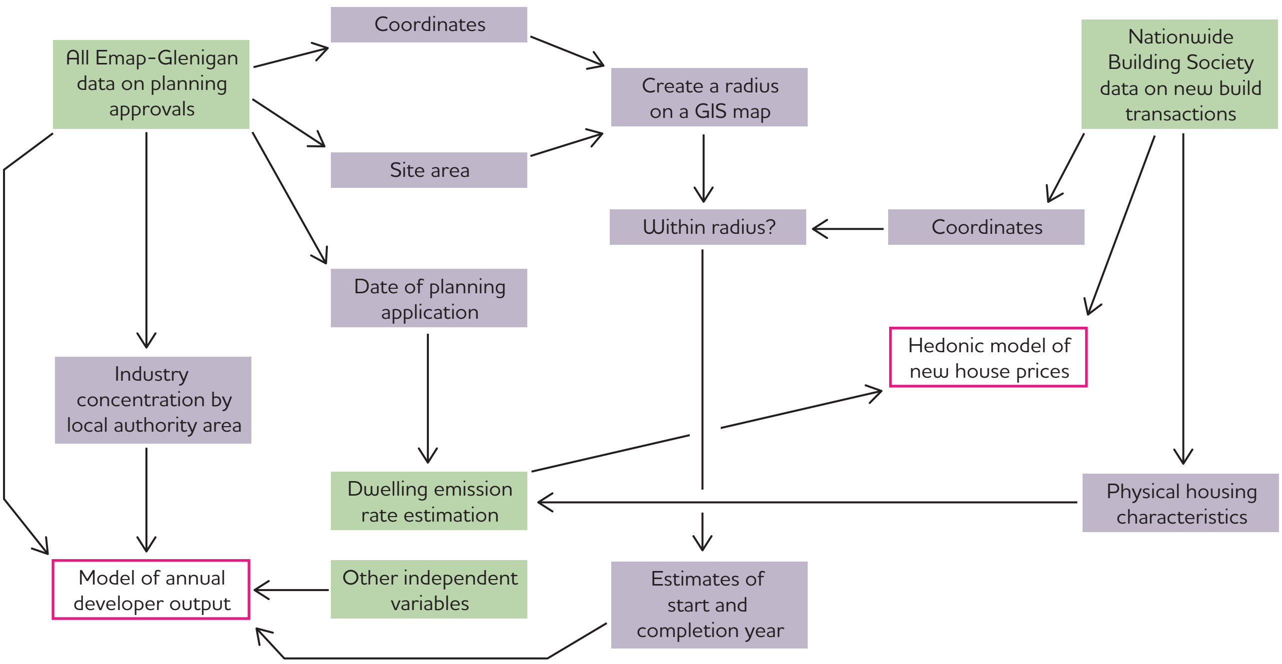
- Where there is evidence that developers have adopted different energy efficiency standards, and controlling for all other factors, is there any evidence of impact on end use values? And can this be quantified robustly?
- If the relationship between energy efficiency-orientated construction costs and higher end use values is lower than unitary, or nil, can we robustly quantify the relationship between a rise in energy efficiency-related construction costs and annual output at the level of the typical firm?
- How do firm-specific factors, industry structure and factors such as 'planning stance' condition our results to question 2 above?

We address question 1 by examining the results of an hedonic regression model of new build house prices in the UK. We assembled a unique dataset by combining transaction data supplied by Nationwide Building Society, with Emap-Glenigan data on planning applications and a predictive tool designed to estimate energy consumption with respect to building regulations, building design and size (the 'sustainability matrix'). The logical processes involved in the assembly and coding of the resulting dataset are summarised in Figure 22 below:

As demonstrated in Figure 22, the dataset covers a span of eight years, and has UK-wide coverage. However, it does not represent the population of all new build transactions, but is simply a sample based on all new build transactions that were financed with a Nationwide Building Society mortgage. In practice, this would only be potentially problematic if it were the case that this particular lender was strongly associated with certain property types, designs or locations. This issue has not been identified as a problem in any other published study based on the dataset. Moreover, the rich detail that exists in the dataset makes it a valuable resource for addressing the questions raised earlier in the chapter. The dataset has a unique feature – the dwelling emission rate (DER) can be estimated and, critically, separated from the transaction year. The dataset contains many transactions in which the DER was set by the award of planning permission several years before the construction and sale of the dwelling. Therefore, in a given year in this dataset there are transactions of new build dwellings attributable to more than one set of building/planning standards. This degree of independence between the DER and calendar year makes it possible to estimate the relationship between DER and transaction price *independently of time*.

Appendix A provides more detail on the methodological steps summarised in Figure 22. It also sets out the detailed econometric results, and provides definitions of each variable. The important points to note are that the results are universally in keeping with expectations in that positive dwelling attributes are significant and correctly signed – parking spaces, garages, floor area all add value, while flats are worth less than all housing types included in the analysis. Most importantly, the natural log of the DER variable is statistically significant. More accurately, the analysis found that the log of the DER variable (denoted as LDR in Table A in Appendix A) was not significant

Figure 22: Relationships between key datasets, estimations and models



for flats – only for new build houses – and the coefficient varies slightly between house type.

Appendix A provides an explanation of the statistical methods used to estimate the model of house prices. It also summarises a second model designed to evaluate the predictive accuracy of the modelling approach overall. The main conclusion of that exercise is that the predictive accuracy of the model is relatively poor, despite the fact that there is a statistically significant relationship between the DER and house prices.

Therefore, it is important to acknowledge that there are mixed messages in the results summarised in this chapter so far. Overall, the results allow us to comment on research question 1. We do find a statistically significant relationship between new build house prices (not flat prices) and the DER. This operates in the expected direction – higher energy consumption is associated with lower transaction prices. We can attribute this finding to the unique properties of the dataset collected for this study, and it is an important finding. However, given that the explanatory power of the model is not very impressive overall, our conclusions must be tenuous. Furthermore, the qualitative data from the interviews did not corroborate this quantitative model finding, that is, there was no clear view that improved energy efficiency resulted in improved house prices. This also leads us to be cautious with this finding.

We now turn to research questions 2 and 3. These are addressed by extending a framework that has been tested mainly in the context of North American housing markets to the UK (see Sirmans et al, 1979; Färe and Yoon, 1981; McDonald, 1981; Thorsnes, 1997; Epple et al, 2010; an early version of this work was reported by Leishman, 2012). The modelling framework focuses on individual developers and aims to explain, then predict, annual output levels. The model builds on the work reported by Leishman (2012) by acknowledging that developers are unlikely to be able to costlessly compensate for poor availability of land by increasing capital intensity, or vice versa. This effect, known as 'variable elasticity of factor substitution', is captured by including land prices, land supply and the cost of capital in the model. Table 7 shows that the flow of planning permissions is a positive determinant of output, while a greater share of greenfield sites in the overall land supply acts to reduce output. Construction costs reduce output, as might be expected. Meanwhile, we further extend the Leishman (2012) results by including a measure of developer market share, measured at local authority level, and an indicator of firm-specific production technology. The latter is proxied by the firm-specific mean build rate observed from the Emap-Glenigan planning permission data.

The model embeds a number of assumptions about the nature of the housing development industry and its interactions with planning. For example, by defining the dependent variable as completions at site level, we are assuming that developers are at least partly in control of the size of development sites. By including variables such as house prices and construction costs, there is an implicit assumption that developers pursue larger/smaller sites depending partly on the values of these variables. By including a developer's market share and typical build rate in the model, we are reflecting that internal or firm-specific factors or 'production technology' may have an influence on the annual number of completions being generated on each development site. However, neither the size of a development nor the number of annual completions generated from a site are fully within the control of developers. The planning system has an influence on the number and size of development opportunities coming

Table 7: Site-level model of annual output

Variable	Coefficient	z statistic
Constant	8.229	10.39***
Log median price	0.433	3.61***
Log upper quartile price	−0.582	−5.35***
Log construction cost per unit	−0.113	−2.75***
Log developer market share	0.324	16.50***
Log flow of planning permissions	0.288	7.97***
Log proportion of sites greenfield	−0.471	−9.35***
Developer mean build rate	0.131	42.56***
Random effects		
Flatted development (confidence interval)	0.361	1.095
Local authority effects (confidence interval)	0.275	0.347
Model performance		
Wald chi-sq	3185.8***	
LR test vs linear regression (chi-sq)	416.5***	

Note: Dependent variable is the natural log of completions measured at site level.

through the system. The results in Table 7 show that the following factors are associated with higher site-level completions:

- median house price level
- developer's local authority level market share
- supply of land with planning permission
- developer's typical build rate.
  A number of factors are associated with lower output levels:
- upper quartile house price
- construction costs per unit
- proportion of sites in the supply of land that are greenfield.

Appendix A also provides some further detail about the predictive performance of the model summarised above. The main conclusion is that the model, estimated for more than 2,000 sites involving more than 900 developers and based on a five-year period, has a strong predictive performance. This, of course, gives us confidence in its use in a simulation context, as explored in the next section.

Simulating the impact of higher sustainability on supply

This section brings together the results shown in the previous section by feeding the econometric results into a simulation. The simulation approach follows three steps. First, in order to establish a baseline, we assume that there are no positive price effects associated with higher sustainability standards. We feed the expected rise in construction costs associated with three sustainability options into the developer-level model of output. More specifically, we compare the model predictions with a baseline after inflating the 'cost per unit' variable according to the sustainability matrix (Chapter 3). This step naturally predicts lower annual output per firm which, when aggregated to national level, also translates to lower new build supply.

We then ask what structural or planning changes would offset or more than offset the predicted drop in new supply resulting from higher construction costs.

Table 8 shows the predicted overall impact of each sustainability option on supply for the UK overall. It is important to bear in mind the assumptions that feed into the simulation. We assume that all developer and local authority-specific values remain at their 2007 levels, inflate construction costs according to the sustainability matrix, and then re-predict the 2007 output level for every developer in each local authority area in the UK. We then aggregate these predictions and compare to the baseline. The prediction is that the 2014 sustainability scenario would have a negligible effect on supply, while the other two scenarios have a noticeable, but still very small, predicted impact.

We now turn to the next step to the simulation exercise. This involves examining a combination of higher costs through more sustainable construction methods, together with some other change in market conditions. Table 9 focuses on two types of 'market conditions' – market structure and the supply of land with planning permission.

The results suggest that an industry structure involving fewer but larger developers would be sufficient to offset the small reduction in supply predicted by higher construction costs (looking at the most expensive of the three sustainability options). It is also interesting to note that the elasticity of the planning variable is much higher than that of the market structure variable. Overall, the results suggest that either the market, through slightly higher rates of industry concentration, or the state, through modestly higher levels of housing land supply, should be able to compensate for the higher costs associated with building more sustainably.

It should be noted that this model does not consider alternative scenarios that are discussed in the qualitative elements of the report. These include the potential for increasing RSL output through adjustment of grant or other

Table 8: Predicted supply effects based on output model

Sustainability option	Compared to baseline (%)
2014	–0.10
2016	–0.71
2016 EF	–1.74

Note: EF = extreme fabric (extremely efficient external wall design solution).

Table 9: Predicted composite cost/market structure of planning supply effects based on the output model only

Sustainability scenario	Composite change in supply (%)
Move to 2016 EF but market share of largest two developers increases by 20%	0.22
Move to 2016 EF but market share of largest two developers increases by 50%	3.09
Move to 2016 EF but flow of planning permissions rises by 20%	3.57
Move to 2016 EF but flow of planning permissions rises by 50%	10.44

Note: Percentage increases refer to percentages of existing variable values, not straight percentage additions.

elements affecting their capacity, and separate approaches to supply such as expansion of self-build delivery.

Summary

This chapter summarises extensive and quite complicated data analyses designed to shed light on two quite simple questions:

- Do new dwellings with lower emissions rates have higher values compared with those identical in every other way, but with higher emissions rates?
- If construction costs are driven up in the process of lowering emissions rates, then what is likely to happen to new housing supply?

In relation to the first question, the analysis found that there is a statistically significant relationship between the DER and new build housing transaction prices. This is an important finding because few, if any, previous studies have reported such a relationship. But it is important to note that the scale of the effect reported by the statistical analysis is very modest indeed. The discussion earlier in this chapter also notes that the qualitative research yielded no triangulation of these quantitative findings.

The analysis of supply suggested that an increase in construction costs associated with an increase in the sustainability of new homes would lead to a reduction in supply of less than 2 per cent. In fact, if the improved sustainability were to lead to an increase in the sales prices of those new homes, the simulation actually predicts a rise in supply of nearly 3 per cent. However, reflecting the relatively weak econometric results associated with this 'sustainability price effect', we have chosen to omit that effect from the analysis of supply. This strengthens our confidence in the results.

The analysis continued by asking what structural or planning changes might mitigate the posited reduction in supply that might result from having higher sustainability standards. The flow of planning permissions, and the market share of the largest developers, were chosen as exemplar policy levers. The analysis found that an increase in the flow of planning permissions of around 20 per cent would mitigate the reduction in supply owing to higher sustainability standards. A substantial increase in the market share of the largest developers would do likewise. The results suggested that a 50 per cent increase in the share of the largest two developers would be necessary (for example, if the largest two developers had a joint market share of 40 per cent, then it would be necessary for this to rise to 60 per cent to mitigate the reduction in supply).

These findings are very much in keeping with economic theory, which acknowledges the potential importance of scale effects in determining output in an industry or for a firm. The findings also reflect on casual evidence that the UK house building industry has become much more concentrated since the 1970s, and this tends to confirm the idea that companies are able to find advantage in scaling up. There have, of course, been many previous studies emphasising that the flow of planning permissions and availability of land for development are key determinants of new housing supply. This chapter connects these findings to the sustainability agenda for the first time, by explicitly acknowledging that increasing land supply may offer societal benefits provided that the increase in supply is designed to mitigate the negative supply effects arising from stronger sustainability standards in new build housing.

7 CONCLUSIONS

Introduction

In response to the question 'How can we build sustainable homes more cheaply?', this research identified the multifaceted nature of sustainability, but recognised energy efficiency and tackling GHG emission as a key element of government policy and emphasis for many participants in the delivery of new housing. While energy efficiency is the main focus of this research, links to transport, infrastructure, water, drainage and density of development are important, and opportunities to make development sustainable vary between urban and rural locations. In addition to concerns for the global environment, sustainable housing affects the wellbeing of residents – affordable warmth and combating fuel poverty in neighbourhoods that remain popular places to live in in the long term are integral to our definition.

The study was asked to learn from existing attempts to reduce construction costs while maintaining standards, and why these efforts have not led to an increase in house building. However, the situation in practice is not that existing standards must be maintained, but that higher standards are being demanded by government, particularly through Part L of the Building Regulations and the 2016 zero carbon target. In June 2014 the government announced that the zero carbon target could be met by achieving CSH code 4 on site with off-site 'Allowable Solutions' bringing this up to code 5.

Building homes to higher standards of sustainability currently costs more money. The additional cost of achieving the 2014 Building Regulations standard was found to be very small (less than 1 per cent), relative to the current 2010 baseline for dwelling designs. The additional cost of achieving the 2016 Building Regulations, relative to the 2010 baseline, was more significant. This ranged between 2.5 and 4.0 per cent when a solar PV technology approach is adopted. This is currently the most cost-efficient technology-based solution allowing house designers to continue to use traditional construction techniques. However, solar PV, in common with all 'bolt-on' technologies, gives rise to future maintenance issues.

The additional cost of achieving the 2016 Building Regulations using advanced building fabric technologies with higher levels of energy efficiency would be substantial, ranging between 7.6 and 12.9 per cent. The advantage of a fabric-based approach is that sustainability is 'built in' and maintenance free.

An approach to achieving zero carbon compliance that involves Allowable Solutions 'offsetting' would be cheaper than any combination of fabric and technology-based approaches. As a consequence there is currently little incentive for developers or industry to develop design and technology solutions to meeting sustainability standards much beyond the 2014 Building Regulations.

Regulation and standards

Sustainability standards in the house building industry, particularly in energy efficiency, are largely regulation-led. To date, consumers are unwilling to pay a price premium for sustainability, and the valuation system does not adequately reflect it, leading developers to adopt least-cost approaches to meet mandatory sustainability requirements. In short, there is no benefit to them in spending more than necessary, as this simply reduces their profitability and shareholder return. RSLs have mainly conformed to the standards set by the HCA, and are constrained by appraisal based on initial capital cost.

A caveat should be added that corporate objectives of organisations also have an impact on sustainability. RSLs have social as well as financial efficiency goals and, with support from the HCA, some promote Passivhaus and other sustainability innovations. In the private sector, some niche providers seek out funding for sustainable developments. Nevertheless, mainstream developers that seek to improve sustainability as an element of corporate social responsibility are constrained in going beyond regulation, in most cases because of competition and concern for shareholder value.

The CSH has complemented Building Regulations and given a clear, widely understood pointer to the direction of travel to 2016. However, it is also an extra layer of bureaucracy, and the government's move to abolish it and encapsulate all sustainability elements within a single set of building regulations was attractive to many.

Planning authorities have a role in setting local sustainability levels. The case for dwelling energy efficiency levels varying between local authority areas is not strong. The motivation to retain this discretion through specifying different CSH levels is laudable – those authorities that have the political will, the planning officer skills and, most importantly, sufficient demand not to frighten off development, maximise emissions reduction in their area. However, developers put forward a legitimate argument that the disruption caused outweighs the benefits. Planning authorities interviewed in the current research supported the move to a single standard for energy efficiency *provided that it was set at a sufficiently high level*.

All of the fieldwork for this research was completed before the government announced details of the definition of the 2016 zero carbon target. A majority of private developers and a quarter of RSLs thought regulations were already too stringent, and 95 per cent of private developers and 80 per cent of RSLs believed the target to be unrealistic. Interviews also highlighted concern with uncertainty over the nature and level of allowable offset solutions.

On the other hand, econometric modelling undertaken in this project indicates that increased sustainability has only a very small negative impact on output. Improvements to 2014 were modelled to show a supply reduction of only 0.1 per cent. The highest impact of meeting the 2016 standard would be with an extreme fabric approach, but this is still only 1.74 per cent, and the most likely option, a mix of fabric and technology, shows a 0.7 per cent fall in output.

As discussed in Chapter 3, and drawing on the experience of participants in the research, this research supports the principle of a single energy standard for housing. Moreover, bearing in mind the current additional costs of achieving zero carbon (defined as code 5) on site, we also support the proposed minimum level of on-site provision accompanied by Allowable Solutions. However, these solutions must be appropriately targeted based on local knowledge, and should prioritise measures that address fuel poverty.

This requires a continuing role for local authorities in directing the use of Allowable Solutions most effectively. Local authorities should have regard for the most efficient way to reduce carbon emissions in the use of Allowable Solutions. While this may direct Allowable Solutions to retrofit existing buildings to increase their energy efficiency, it is also consistent with NPPF requirements for local authorities to maximise opportunities for renewable and low carbon energy production in their area. Using Allowable Solutions in this way can address developers' concerns about inconsistency of cost requirements across local authority areas, but it is vital that Allowable Solutions are protected and cannot form part of the negotiation process where local authorities seek contributions for affordable housing or other requirements as part of Section 106 agreements.

Achievement of zero carbon homes will not be the end of the quest for sustainability; sustainability is broader than energy efficiency. Local authorities should promote sustainability as part of an approach to creating sustainable, successful places. Sustainable development must consider issues such as location, transport, mixed use, urban design, drainage and flooding, which are best dealt with at a local level responding to local conditions. In developing policy and implementation in individual schemes, planners increasingly need to have, or have access to, scheme viability assessment and other technical skills. The HCA also has a role in promoting public policy in this wider agenda in regulating and funding RSLs.

While creating standards that respond to local conditions and needs is essential, developers will be able to act most efficiently in meeting these standards if there is a common language surrounding what is expected. This could be based around a revised BfL, possibly incorporating aspects of CSH. This can help coordinate local-level action through local authorities, the HCA, private developers and RSLs.

Recommendations

- Energy-efficient building should conform to a single standard defined in Building Regulations and based on a single, agreed definition of zero carbon housing.
- Local authorities should direct the use of Allowable Solutions responding to local needs and conditions, prioritising fuel poverty and maximising efficiency of carbon reduction. Allowable Solutions should not be negotiable against any elements of planning gain, such as affordable housing.
- Local authorities should continue to promote non-energy elements of sustainability related to sustainable transport, flood resilience, accessibility, urban design, mix and density, based on analysis of local needs and conditions.
- Local authorities must have the skills to assess and defend sustainability and affordable housing contributions in the context of scheme viability.
- The HCA should continue to promote sustainability in pursuit of wider public policy goals.
- RSL investment appraisal should include 'through life' cost and performance evaluation of schemes.
- Revised guidance should be created to incorporate existing standards such as BfL and the non-energy elements of CSH to provide a framework for locally sensitive sustainability policy.

Design and construction

Since Egan, and spurred on by the introduction of CSH and the 2016 zero carbon target, a number of product and process innovations have been attempted. In mainstream development, approaches to fabric design, rather than applying systems or renewable technologies, are the almost universally preferred approach to improving sustainability standards of housing. There is widespread scepticism of technology solutions as a result of poor experience of their performance in practice and the risks associated with unproven technologies. Solar PV is the most acceptable of all technologies due to the maturity and reliability of the systems and because they don't require any householder interaction in their operation.

Partnering, framework agreements and other forms of collaborative working are the most common process innovations. However, framework partnering has not resulted in reduced costs and, as borne out in our survey and case study interviews, some developers and RSLs have resorted to lowest capital cost-based tendering in a competitive market. A further constraint on the effectiveness of this approach has been lack of depth of partnering in the supply chain by excluding suppliers and subcontractors. Nevertheless, the survey found that 70 per cent of private developers and 31 per cent of RSLs regularly engaged in some form of partnering. Good practice found in this research has included briefing of senior staff from partner organisations at the start of projects, and 'toolbox training' of site staff to disseminate project goals and how their practice can undermine or facilitate achievement of these objectives.

There is some evidence of product innovation with the use of non-traditional housing solutions, especially in the very highly pressured London area, including pod housing and off-site fabrication. A significant minority – between 30 and 40 per cent – of questionnaire respondents used MMC for mainstream developments – many of these in London, where there is a preponderance of flatted developments. However, this has not fed through into widespread use of MMC among private developers and RSLs in other parts of the country. In general, MMC is not currently commercially attractive compared with traditional methods, although on-site skills and material shortages are making MMC a more viable alternative taken up by some developers.

All parties to the development process have become familiar with building to higher specifications, whether this is CSH level 3 or Part L of the 2014 Building Regulations. However, private developers, RSLs and designers all identified a 'performance gap' between designed standards and those achieved in practice. Specification alone does not guarantee the achievement of Building Regulations level performance, and the development process must also be geared towards *achieving* sustainability in practice rather than merely demonstrating design compliance. There is a compelling case to consider adding an 'as built' requirement to Building Regulations. This is not a simple matter and will require research into appropriate methods of assessment. Its implementation will also undoubtedly cost money at various stages – product specification, design and on site – but there is little point in increasing the regulatory design standard and not achieving the intended performance level.

Significantly, MMCs are also a means to improving sustainability performance through addressing site-based performance gap issues. The process of manufacturing and fabrication in a quality-controlled environment limits loss of sustainability between design and installation on site that is associated with a traditional construction process. This also addresses the traditional skills shortage issue that was a recurring theme through the case study research.

Recommendations

- Standards are related to intent that is not achieved in practice. Building Regulations should therefore be enhanced to include an 'as built' performance standard. The method of assessing performance should be reviewed and implemented in 'as built' regulations to demonstrate compliance where it matters.
- Skills shortages remain a chronic issue at all levels, from design to construction. There should be investment in training and skills to meet current trade and craft shortages and adapt to new practices necessary to improve performance, including in design for buildability.
- MMC should be supported to improve the performance of new homes and to address the issue of skills shortages, for example, through favourable tax treatment to kick start the market to increase volume and further reduce cost. Research should be carried out into the most suitable bundle of MMC measures that should be supported in this way, based on their contribution to carbon reduction.

Impact of scale

Volume creates viable markets and reduces risk and uncertainty for suppliers leading to cost efficiencies. Increasing volume is therefore key to mainsteaming product and process innovation and associated cost efficiency, as was seen in reduction in cost of PV technology. With regard to process, over a third of RSLs surveyed sought to take advantage of economies of scale through membership of procurement groups. However, there is evidence from previous studies that bulk procurement initiatives fail to bring cost benefits where planning and implementation, crucial to success, have been deficient. Initiatives such as AIMC4 are demonstrating the synergies achieved when process and product innovations come together. Variation in planning and other requirements across local authority areas undermines volume and is an obstacle to achieving these efficiencies.

Nevertheless, our research shows that greater concentration of development among larger developers would have only a small positive impact on the supply of new housing, increasing the share of the largest developers by 20 and 50 per cent respectively, resulting in increased supply of only 0.2 and 3 per cent. Given the relatively small benefits, intervention in support of greater concentration which would decrease competition and lead to less housing variety would not be justifiable. Moreover, in particular places, especially in inner-city brownfield and rural exceptions sites, niche providers of innovative or strongly vernacular development have advantages in gaining access to land and funding. In addition, the UK self-build sector is weak, and the government is exploring scope for expanding this to help meet the shortfall in housing supply.

Recommendations

- Planning authorities should not impose conditions on development that are not justified by local factors.
- The government and funding agencies such as the HCA should recognise the benefits of large-scale development, but also continue to support smaller and niche providers, and explore self-build alternatives.

- Research should be carried out into the funding market for sustainable development, and how such funding can be maximised in the housing sector.

Land

Availability and cost of land are key to housing supply and sustainability. Quantitative modelling carried out for this project indicated that flow of land had a higher impact on supply than any other modelled variables including sustainability. Increasing the flow of land with planning permission by a relatively modest 20 per cent was seen to increase supply by around 3.5 per cent, more than compensating for even the greatest predicted falls in output due to increased sustainability.

Increasing sustainability increases developer cost. In the developer business model, since there is no price premium for sustainable housing, developers trade off sustainability against the amount they can bid for land, and this tends to result in developers building to the standard set by regulation. Consistency and transparency of planning and other regulatory requirements can create a level playing field for those bidding for land so that the price bid by a developer seeking to maximise sustainability is not undercut by another developer for whom sustainability is not as high a priority.

Nevertheless, there is a limit to the amount a developer can squeeze the price paid for land before a threshold land value will be met, below which landowners will not sell. This could result in a fall in supply of new housing. However, our modelling of increasing levels of sustainability suggests that the effect of increasing sustainability to 2014 Building Regulations levels would be to reduce housing supply by only 0.1 per cent. In addition, the government could play a role in increasing land supply as it is estimated to own around 40 per cent of developable land.

Publicly owned land could also be used to promote other sustainability gains. Sustainable transport, flood resilience, accessibility, urban design, mix and density based on analysis of local needs and conditions could inform the disposal of publicly owned land through masterplanning and sustainability-based competition. A number of mechanisms could be envisaged to achieve this. For example, land could be valued independently, and competition for the land then based entirely on a quality/sustainability competition, or there could be pre-qualification of bidders based on previous sustainability performance.

It is harder to intervene to encourage more *private* land to come forward if landowners believe that it is to their advantage to hold on to their assets. This could be done through some form of subsidy to sustainable development, but that is arguably a poor use of taxpayers' money. A more acceptable approach may be to try to address the lack of premium paid for sustainability.

Recommendations

- An increase in supply of land with planning consent will more than compensate for reduced supply due to the additional costs of increased sustainability. We would recommend setting an objective of increasing land supply by 20 per cent to help developers meet the challenge of boosting housing supply while achieving a higher sustainability level.
- Consistent and transparent regulation and requirements to create a level playing field for companies bidding for land should be ensured.

- Sustainability should be prioritised over maximising financial return on assets in public land disposal through masterplanning and sustainability-based competition.

The market, householder costs and poverty

Consumers do not attach a high priority to sustainability in their home searches. Stamp duty and council tax banding based on sustainability could be explored as a means of influencing consumer behaviour. Additionally, giving greater prominence to EPCs and potentially other sustainability attributes in sales and marketing material could also help increase householder awareness of the economic benefits of sustainability.

Consumer use of technology is problematic. Where efficiency is dependent on householders' action, this is not generally successful, according to developers and RSLs. The preferred 'fabric first' approach rather than the use of technology can support residents in gaining maximum benefit from their energy-efficient home, although several interviewees expressed concern that householders' behaviour would adjust to negate the environmental benefits of energy efficiency. There is a need for education so that people make better use of sustainable homes. This can be carried out by RSLs for their tenants, and general public information may play a part.

Nevertheless, sustainable housing is cheaper to live in. Householders can live in more comfortable, warm conditions, with lower overall household bills, and one of the case study interviewees reported decreased rent arrears in a sustainable development. Sustainability can be part of a strategy to improve affordability and decrease fuel poverty.

Recommendations

- Developers and the government should act to increase public awareness of the financial benefits to incentivise the purchase of sustainable homes.
- Education programmes should target ways to live more energy efficiently.
- 'Fabric first' energy efficiency measures should be used, minimising the need for householder involvement in energy efficiency.
- Affordable housing providers should include energy efficiency in developing affordability strategies.

NOTE

1 A production function is an equation used in economics – it sets out the relationship between a combination of production inputs such as land, labour and capital, and the resulting output, such as number of units of housing produced.

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APPENDIX A

Technical annex relating to supply modelling

This provides more detail on the definition of variables feeding into the quantitative analyses summarised in Chapter 6. It also provides more detailed statistical results, with some supporting discussion on estimation approaches and steps taken to validate the results.

Figure 22 in Chapter 6 summarises the logic underpinning the hedonic model of new house prices. Grid coordinates or X, Y coordinates, were available for observations in two datasets: planning approvals (extracted from Emap-Glenigan data) and new build house transactions (from the Nationwide Building Society dataset). By creating a circular zone or buffer around each Emap-Glenigan data point in a geographical information system (GIS), we were able to associate each new house transaction with a specific planning application. This then allowed us to assess the planning application date associated with each new house transaction. Of course, the actual transaction date will have been much later than the date of planning approval. Information on the physical design of each new house, together with the planning application date, allowed us to estimate the dwelling emission rate (DER). This variable was then transformed to natural logs, to normalise the data, before being multiplied by dwelling type dummy variables (dummy variables or binomials have two values – zero or 1 – with the latter denoting the presence of an attribute or effect). Interacting the DER variables (denoted as LDR after transforming to natural logs) with dwelling type variables essentially allows us to obtain a different emissions rate coefficient for each of the main property types.

The model includes a number of independent variables that are commonly included in hedonic regression models (these are referred to as 'other independent variables' in Figure 22). Nevertheless, the hedonic model summarised in Table A is relatively simple given that the main physical variables included are parking space, single garage, double garage, floor area and property type. As shown in Table A, the LDR variable was not significant for flats, and a slightly different coefficient was obtained for each of the other main property types.

In addition to the variables shown in Table A, the model estimations experimented with various other predictors including number of bedrooms, number of public rooms, the square of these variables, number of bathrooms and heating type. These predictors dropped out of the estimation either because they were not statistically significant, or their coefficients were not robust. The resulting model is based on a smaller number of predictors than

Table A: Hedonic regression model of new house prices

Variable	Coefficient	z statistic
Constant	11.277	31.37***
Dummy variable 2001	0.197	1.94**
Dummy variable 2002	2.239	28.47***
Dummy variable 2003	2.300	28.06***
Dummy variable 2004	1.732	19.85***
Dummy variable 2005	−0.618	−6.48***
Dummy variable 2006	−0.463	−5.16***
Dummy variable 2007	−0.457	−4.82***
Parking space	1.809	27.64***
Single garage	1.005	14.73***
Double garage	1.060	9.62***
Floor area sq m	0.0045	5.84***
Dummy variable flat	−0.712	−2.2**
Detached × LDR	−0.229	−2.55**
Semi-detached × LDR	−0.222	−2.43**
Terrace × LDR	−0.224	−2.41**
N	4,447	
Regions	11	
Local authorities	350	
Wald chi-square	3,920.1***	

Notes: Dependent variable is the natural log of transaction price.
LDR denotes natural log of dwelling emission rate in $KG/CO_2/m^2$.
*** means significant at 1%; ** at 5%.

appears in some published hedonic models, but the results are stable and robust.

Although not shown explicitly in Table A, the estimation method used to construct the model summarised in Chapter 6 was a multilevel ('xtmixed' in Stata) fixed and random effects model. This allows the estimation of effects or specific variations in outcomes that are associated with temporal, spatial or structural dimensions in the dataset. In other words, if there are specific and consistent differences between years, local authorities/regions, or companies, then these factors can be estimated. The multilevel estimation approach is particularly useful for controlling for potential biases that occur when dealing with large-scale datasets covering many spatial units or time periods. It is put forward by Leishman (2009) as the preferred method for dealing with housing systems comprising complex, interlinked markets and submarkets. However, one major drawback is that the overall model performance is more difficult to evaluate than the results of an ordinary least squares (OLS) regression. For this reason Table B summarises an OLS regression of the original dependent variable (log of transaction price) on the fitted values (predicted values) obtained from the model summarised in Table A. This is done to provide an easily accessible assessment of the predictive performance of the model summarised in Table A.

We can see from Table B that the adjusted R-square is less than 0.50. Given that the dataset covers a span of eight years, and the model design captures regional and local variations in prices, we can say that it is unlikely that there are substantial uncaptured temporal/spatial effects. The relatively poor empirical performance of the model is therefore likely simply to

Table B: Summary of price model predictive performance

Variable	Coefficient	*t* statistic
Constant	−0.051	−0.25
Fitted values	1.004	63.52***
N	4,447	
F statistic	4,034.63***	
Adj R-square	0.4757	

reflect that a small number of predictors were statistically significant in the original model (shown in Table A). A greater number of physical, quality, environmental and neighbourhood variables in the hedonic model would no doubt have improved the explanatory power of the model, should these have been available.

Having made that point, what is more important than the explanatory power of the model is the issue of bias (omitted variable bias, in particular). Is it likely that reliance on a small number of predictors, resulting in relatively low explanatory power, has caused bias in the estimated DER/LDR variable coefficients? Given that the primary determinants of emission rates are property type, size, construction method and Building Regulations, it is highly unlikely that the emissions rate would be correlated with any of the unobserved variables that could potentially have been included in this model. In conclusion, we can be confident that the omission of some variable(s) useful to predicting price had not introduced bias to the estimated emission variable coefficients.

Testing the predictive performance of the site-level output model

For the same reasons as discussed earlier, Table C reports the results of an additional OLS regression of the original dependent variable on the fitted values obtained from the multilevel model shown in Table 7 in Chapter 6. It shows an adjusted R-square of just over 0.76, which can certainly be regarded as a very strong predictive performance given the largely cross-sectional nature of the dataset (2,363 observations over five years – 2004 through 2008). The dataset included information on 940 developers, 877 of which were involved in five or fewer developments in the dataset but accounted for 1,163 of the observations. There were 49 developers involved in 6–20 developments accounting for 467 observations. Finally, 14 developers were involved in 20+ developments, accounting for 733 observations. The largest two developers were responsible, between them, for 234 observations.

Table C: Summary of output model predictive performance

Variable	Coefficient	*t* statistic
Constant	−0.235	−4.63***
Fitted values	1.057	86.98***
N	2,339	
F statistic	7565.13***	
Adj R-square	0.764	

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