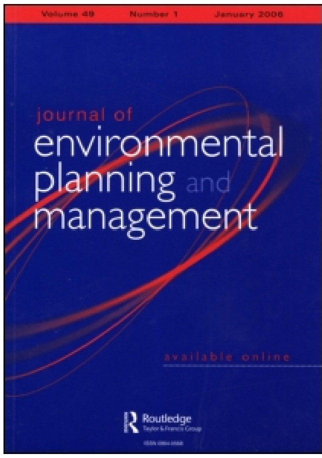

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Green Houses for the Growth Region

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ABSTRACT *The new housing growth programme planned for England and Wales between now and 2016 could provide the government with an opportunity to build housing to significantly higher environmental performance (EP) standards. Equally, if the government continues with its current strategy a great opportunity could be missed. This paper considers and critically analyses the government's approach to ensuring higher EP standards in new housing. Using Greenwich Millennium Village as a case study it assesses the likely outcomes of the approach. It suggests how regulation, fiscal incentives and educational programmes could help to deliver better EP amongst housing and households in the growth region.*

Introduction

Household growth, a growing economy and lack of affordable accommodation in South East England have resulted in the government introducing a new housing programme (ODPM, 2003). This represents the most ambitious housing growth policy since the 1960s (Bennett & Morris, 2006). The growth areas include Thames Gateway, Ashford, Milton Keynes–South Midlands and the London–Stansted–Cambridge corridor. The housing growth programme threatens to have a significant impact on the environment.

A report by ENTEC *et al.* (2004) calculated the environmental impacts of increasing the supply of housing in the UK. For the baseline scenario[1] it found that the construction process would generate 5.7 million tonnes of carbon dioxide, 1.8 million tonnes of waste and would use 9.8 million tonnes of aggregates. During operation new households would generate 9.9 million tonnes of carbon dioxide, 3 million tonnes of waste and consume 0.029 million mega-litres of water annually.

The growth programme seems flawed in terms of environmental sustainability objectives. Development of new units will consume resources, generate waste and emissions both in the construction process and during operation. It could also generate further increase in demand for housing units, having further detrimental environmental impacts. Furthermore, existing capacity in the housing stock is not being fully utilised. Building more units does not address this problem. In April 2005, there were reported to be 91 219 empty homes in London and 91 232 in South

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East England (London Housing Federation, 2006). By utilising spare capacity in the existing stock the environmental impacts of construction at least could be reduced. This is not an argument pursued in the paper, which focuses on how to improve the environmental performance (EP) of new housing stock planned for the growth region.

Efforts are being made to limit the environmental impact of housing growth using various mechanisms including: building regulations, the planning system and the Code for Sustainable Homes. Building regulations were tightened in 2005 to ensure greater domestic energy and water efficiency. Building regulations are mandatory and have already brought about improvements in the energy efficiency of buildings (new-build and existing stock undergoing refurbishment). A building constructed in 2005 is 40% more energy efficient than one built in 2000 (ODPM, 2005a). More recent introduction of measures to increase domestic water efficiency in the building regulations is also expected to result in a reduction in consumption. However, the regulations do not impact on the context in which buildings are set, nor do they tackle other environmental impacts of housing and households including land take, impact on ecology and waste production.

The planning system does tackle these contextual issues. It has introduced planning policy statements (PPS) and design guidance that help to create environmentally sustainable communities.[2] Both policy statements and design guidance are material considerations for planners when considering planning applications for new developments and constructing local development frameworks. Thus these principles should be key in determining planning decisions and integral to all new development. However, past experience suggests that the success of planning as a tool to deliver more environmentally sustainable communities has been mixed, largely because economic and social considerations have taken priority (Rydin, 1992). In addition, planning controls are only effective for new-build development and do not impact on existing housing stock.

The Code for Sustainable Homes (DCLG, 2006c)[3] provides sustainability standards for all new homes. The Code sets standards for a number of environmental objectives including greater energy and water efficiency, a reduction in carbon emissions, use of sustainable construction materials, consideration of wider ecology and waste issues, the inclusion of recycling facilities, cycle spaces and home offices in new developments. The Code was introduced to drive a step-change in sustainable home building practice. It is a standard for key elements of design and construction, which affect the sustainability of a new home. It will become the single national standard for sustainable homes, used by builders as a guide to development, and by purchasers to assist in their choice of home.

All publicly subsidised developments in the growth areas (i.e. those funded by English Partnerships, Housing Corporation, etc.) will comply with the code 3-star[4] rating. Compliance is ensured through a combination of financial incentives and targets. Higher EP standards are enforced on a site-by-site basis. However, there is some concern that the 3-star rating imposed on new units is too low if environmental targets are to be achieved (FOE, 2006). There is also concern that some development will remain unaffected by this approach. New-build housing that does not benefit from public subsidy will not have to comply with the code (but will need energy certificates) and nor will the existing stock. The government hopes that higher EP in new-build developments will be stimulated by market demand or investor interest (but there is little evidence to suggest this will be the case) whilst existing stock is unaffected.

The government approach could ensure higher EP in housing constructed in the growth region. Further investigation is needed to determine whether it will result in patchy implementation or improved EP of all new-build stock throughout the region. Greater understanding of the factors influencing the developers' decision to build to higher EP standards is also needed. Once the housing is constructed optimal use of the technologies provided is essential if EP is to be maximised. This depends on effective management, maintenance and resident behaviour. If these issues are ignored, the housing built as part of the growth programme will under-perform.

Therefore, this paper explores the following questions:

(1) Will the government approach result in an improvement in EP of all new-build housing in the growth region?
(2) What factors will influence the developers' decision to build to higher EP in the growth region?
(3) What factors affect the long-term EP of housing and how can they be addressed?

These questions were explored using a demonstration project in Thames Gateway – Greenwich Millennium Village. The project began in 1999 and the first phase of the development was occupied in 2000. The government took a similar approach to securing higher EP housing (HEPH) in Greenwich Millennium Village (GMV) to the one currently proposed for publicly-subsidised developments in the growth region (i.e. financial incentives and regulation on ad hoc sites). The case study provides the opportunity to begin to assess how successful this approach is likely to be in practice, as a tool for creating demonstration projects or for encouraging higher EP in all new-build housing in the growth region.

The research was completed in 2005, for which primary and secondary data were collected (Table 1). Primary data included interviews with the development team[5] and members of the residents association. This provided information addressing all three research questions outlined above. Secondary data provided information about the EP of the development (EP statistics, Countryside Homes, 2003); the operational issues affecting the long-term EP of the development (FRESH, 2003; Simpson, 2003); and factors influencing the residents' purchase decision (FRESH, 2003; Simpson, 2003). The secondary data were used to triangulate the results from the primary data collection. The conclusions drawn from the case study are presented in this paper.

At present, various standards exist for the EP of housing units including: Building Regulations, Ecohomes Rating (EHR), Code for Sustainable Homes (the Code) and 'Z-squared' standard (Table 2).

Building regulations (Great Britain, 2006) impose a minimum EP standard (for energy and water efficiency) on all new-build and refurbished units. This focus on two environmental issues ensures improvements in these critical areas. The regulations focus on the performance of the building rather than those utilising it. The requirements of the Building Regulations set lower standards than the EHR,

Table 1. Data collection

	Government approach to encouraging HEP units	Factors influencing decision to build HEP units	Long-term operational issues
Interviews with development team	✓	✓	✓
Interviews with resident association		✓	✓
Residents survey[a] (Simpson, 2003)		✓	✓
Residents survey[b] (FRESH, 2003)		✓	✓
Environmental performance statistics (Countryside Homes, 2003)			✓

Notes: [a]Residents survey (Simpson, 2003) provides data about factors influencing purchase decision, problems encountered by residents with eco-technology/design in operation.
[b]Residents survey (Simpson, 2003) provides data about problems encountered in operation.

Code or ‘Z-squared’ standard. The regulations are mandatory and performance-based, which allows for greater flexibility in interpretation and potential for innovation.

Ecohomes rating (EHR) is an environmental assessment method for homes launched by the Building Research Establishment in 2000. It covers a range of environmental impacts of housing and households (including transport, energy, pollution, materials, water, land use, ecology, health and well being) with the emphasis being placed on materials and energy. There are four possible ratings: pass, good, very good and excellent. One criticism of the EHR system is that it seeks to address too many criteria for EP, some of which cannot be tackled effectively through building regulations, either because they should be dealt with in the wider context (e.g. transport) or because they require change in household behaviour.

The EHR also adopts a performance-based approach, which gives greater flexibility to developers wishing to achieve a rating and allows for greater innovation in design and technology. The disadvantage with this approach is that it may lead to poor performance in some areas (Gann *et al.*, 1998). Developers have also highlighted difficulties in implementing the scheme because it is too complicated, flexible and they lack expertise to interpret it effectively. Developers feel this combination of factors makes the process more risky.

The EHR assessment is not mandatory. Thus privately financed development is not required to adhere to the rating system. However, the Housing Corporation has required an EHR for all housing it has funded since 2003. The rating required, from the initial pass, has increased year on year. In 2005 the Housing Corporation required a ‘very good’ rating for any new-build scheme receiving finance through the National Affordable Housing Programme. It is estimated that 70 000 affordable homes will be created through this programme between 2006–08 (Wilson & Smith, 2006). In 2005 almost 1500 developments (both housing association and private) achieved an Ecohomes rating, which equates to 40 000 units (Wilson & Smith, 2006).

The EHR has now been superseded by the Code for Sustainable Homes. The Code is very similar to the EHR in that compliance is voluntary (with the exception of schemes subsidised by public funds) and it adopts a performance-based approach.

Table 2. Environmental performance standards for housing

	Building regulations 2006	**Ecohomes (EHR)**	**Code for sustainable homes ('the Code')**	**'Z-squared'**
Issues covered	Energy and water efficiency	Energy, transport, pollution, materials, water, land use and ecology, health and well being	Energy/CO_2, waste, pollution, materials, water, surface water run-off, management, ecology, health and well being	Zero fossil energy and zero waste
Ratings achievable	Pass/Fail	Pass, Good, Very Good, Excellent	1*, 2*, 3*, 4*, 5*, 6*	Pass/fail
Level of compliance	Mandatory	Voluntary	Mandatory for publicly subsidised development, otherwise voluntary	Voluntary
Environmental performance	Lowest standards	Ratings similar to Code (EHR very good equivalent to code rating 3*)	Ratings similar to Ecohomes	Equivalence to Code 6* for waste and energy/CO_2

The Code builds upon the EHR in a number of ways. It introduces minimum standards for energy and water efficiency at every level of the Code, therefore requiring high levels of sustainability performance in these areas for achievement of a high Code rating. The Code uses a simpler system of awarding points, with more complex weightings removed. Both innovations help developers to implement the Code more effectively. The Code includes new areas of sustainable design, such as Lifetime Homes, inclusion of composting facilities and cycle parking.

The Code has a 6-star rating system. The first star is the most basic (and corresponds to performance rating above current Building Regulation standards, whilst 6-star rating denotes zero-carbon[6] development with state-of-the-art technology. For publicly-subsidised units a rating of 3-star is mandatory, whilst for privately-funded units compliance is voluntary as with the EHR. There is no exact read across between the Code and EHR. However, the Code 3-star rating approximates to the Ecohomes 'very good' rating 2005.

'Z-squared' is an unofficial rating developed by Bioregional and Zed Architects for their developments. The standard is based on achieving zero fossil fuel use and zero waste production in their developments. In terms of waste and energy this approximates to the 6-star rating of the Code. Achieving 'Z-squared' does rely on altering behaviour of residents living in 'Z-squared' communities. It also relies on suitable services and resources being available in the wider community to service developments (e.g. public transport, waste recycling and biomass).

The difference in EP between units built to these various standards is marked. A study completed by James & Desai (2003) found a significant difference in the EP of units built to the Building Regulation standards (Great Britain, 2002) when compared to units with an EHR of 'very good' (equivalent to 3-star rating of the Code). Significant savings in terms of carbon dioxide emissions (32%), water consumption (39%) and waste production (4%) were made in homes rated 'very good' (Table 3). The ecological footprint[7] of those living in units built to a 'very good' standard was also reduced by 4%.

Large savings in terms of carbon dioxide emissions (99%), water consumption (65%) and waste production (76%) could be made by accommodating residents in 'Z-squared' units. The ecological footprint of those living in 'Z-squared' units was 38% less than those living in a unit built to Building Regulation standards (Great Britain, 2002). Thus, building new accommodation to 'Z-squared' or 6-star standard is likely to have a radical impact on the EP of housing and households.

These calculations showed that household environmental awareness also influenced the quantities of waste going to land fill and the ecological footprint of households. However, CO_2 emissions (from energy use in the home) and water consumption remain the same regardless of household environmental awareness, the argument being that to a large extent these savings are made passively through technological fixes rather than actively by behavioural change. It could equally be argued that the way in which households utilise these technologies also influences potential to make resource savings. In practice, awareness of how to optimise the use of these technologies is important (although not accounted for in these calculations). Thus, it is important to tackle resident behaviour if the full EP potential of new units is to be achieved.

Table 3. Resource savings in units with different environmental performance ratings

	Scenario 1[a]	Scenario 2[b]	% change Scenario 1 to 2	Scenario 3[c]	% change Scenario 1 to 3	Scenario 4[d]	% change Scenario 1 to 4
CO_2 emissions from energy use in home (tonnes/household/annum)	3.057[e]	2.064[f]	−32%	2.064[g]	−32%	0.005[h]	−99%
Water use (litres/household/day)	312[i]	191[j]	−39%	191[k]	−39%	110[l]	−65%
Waste sent to landfill – kg/household/year	957[m]	920	−4%	720	−25%	227	−76%
Ecological footprint (hectares per person)	5.448[n]	5.229	−4%	4.84	−11%	3.405	−38%

Notes:
[a]Scenario 1 typical UK resident in unit built to 2002 building regulations.
[b]Scenario 2 typical UK resident in unit built to ecohomes 'Very Good' standard.
[c]Scenario 3 environmentally aware resident in unit built to ecohomes 'Very Good' standard.
[d]Scenario 4 resident living in 'Z-squared' community.
[e]Figure for CO_2 per person calculated by Stockholm Environment Institute, multiplied by DEFRA figure of 2.33 persons per household.
[f]Figure for CO_2 per person calculated by Stockholm Environment Institute, multiplied by DEFRA figure of 2.33 persons per household.
[g]Figure for CO_2 per person calculated by Stockholm Environment Institute, multiplied by DEFRA figure of 2.33 persons per household.
[h]Figure for CO_2 per person calculated by Stockholm Environment Institute, multiplied by DEFRA figure of 2.33 persons per household.
[i]Figure for water use per person for metered dwelling from OFWAT, multiplied by DEFRA figure of 2.33 persons per household.
[j]Bioregional estimate based on BRE Ecohomes data and DEFRA figure of 2.33 persons per household.
[k]Bioregional estimate based on BRE Ecohomes data and DEFRA figure of 2.33 persons per household.
[l]Bioregional estimate based on average of best performing homes at BEZED (monitored data).
[m]Bioregional estimate based on average waste data, BRE Ecohomes data and SEI input.
[n]Figure estimated by BDG using SEI ecological footprint data.
Source: James & Desai (2003).

A further study (ENTEC *et al.*, 2004) calculated the resource savings that could be made if all units built in the new housing programme between 2015–16 were built to a 'very good'/3-star standard and 'excellent' standard (Table 4). Accommodating population growth in either 'very good' or 'excellent' accommodation could be beneficial environmentally. The greatest reduction is seen in the quantity of carbon dioxide produced during occupation. Comparing 'very good' or 'excellent' units demonstrates that the key difference between the ratings is in terms of carbon dioxide produced in occupation and during the construction process. In both instances carbon dioxide production is significantly lower in 'excellent' rated units. The quantity of aggregates used in construction is also significantly less.

This Table demonstrates the minimum savings that could be made by introducing higher EP standards for new housing, as the calculations are based on the lowest estimates for housing growth and EHR (which sets less stringent targets for both water and waste than the Code). However standards set by Building Regulations for energy and water efficiency have improved since 2002, which may also impact on scale of savings calculated. Regardless, these findings demonstrate the importance of improving the EP of new-build particularly at the start of a major growth programme.

A material flow analysis for South East England (Barrett *et al.*, 2003) found the ecological footprint to be 55 million global hectares per year, which equates to 6.8 global hectares per person (UK average is 5.35 global hectares per person). The actual available productive area on earth is 1.9 global hectares per person. Thus each person in the South East consumes three to four times more than the recommended annual allowance. Even with vastly improved building performance (e.g. 'Z-squared' rating), the target of 1.9 global hectares per person cannot be achieved (Table 5). However, building to an EHR 'very good' or 'Z-squared' standards would reduce an individual's ecological footprint to two to three times more than is globally available.

This should be considered when setting minimum mandatory EP standards for housing. These findings suggest that a minimum 6-star rating (equivalent to

Table 4. Annual environmental impact of housing projections at year 2015–16[8]

	Construction			**Occupation**		
Standards	**CO_2 (million tonnes)**	**Waste (million tonnes)**	**Aggregates (million tonnes)**	**CO_2 (million tonnes/yr)**	**Waste (million tonnes/yr)**	**Water metered (millions megalitres/yr)**
Building Regulation (2002)	5.7	1.8	9.8	9.9	3	0.029
'Very Good'	5.4	1.6	9.3	5.9	2.5	0.025
'Excellent'	4.8	1.5	8.8	4.4	2.2	0.024

Source: ENTEC *et al.* (2004) study into the environmental impacts of increasing the supply of housing in the UK.

Table 5. Variation in ecological footprints with unit type and level of resident awareness

	Ecological footprint (global hectares per person)
Typical resident in typical new UK home built to 2002 Building Regulations	5.448
Typical resident in typical new UK home built to EHR 'Very Good'	5.229
Environmentally aware resident in typical new UK home built to EHR 'Very Good'	4.840
Environmentally aware resident in Z-squared home	3.405
Target footprint	1.9

Source: James & Desai (2003).

'Z-squared') should be achieved in new-build housing in South East England as a step towards reducing the ecological footprint sufficiently. The findings also suggest that residents will need to made aware of the environmental impacts of their lifestyle and how to address these impacts and utilise the technologies provided, if significant changes in domestic resource consumption, emissions and waste production are to be achieved.

It should be noted that although the four growth areas (and more recent growth points) are likely to bring long-term strategic housing provision on a scale not seen in the UK since the 1960s and early 1970s, the contribution of new homes should not be overstated given the poor EP of the existing stock. Thus it is important that existing stock is retrofitted with technologies that can increase household resource efficiency. However, the government claims in terms of carbon-dioxide emissions, cost-effective changes to existing homes would only save 7 MtC per annum (17% of all housing-based emissions, which is less than a quarter of what is needed—Rydin, 2007). Thus, there is a need to tackle the EP of new-build and existing stock if environmental targets are to be achieved.

Innovation in Housing

The EP of housing is an important but neglected topic in housing studies. Furthermore, the research that has been completed predates the government's Sustainable Communities Plan (ODPM, 2003). Thus, there has been little consideration in the academic literature of the potential environmental impact of the housing growth programme and how this could be tackled. There has also been a tendency for much of the debate in housing and planning to be centred on neighbourhood and the environment rather than house and household.

The practice-based agenda for the EP of housing is operating well in advance of the theory (Brown & Bhatti, 2003). This has been demonstrated by more recent improvements in the construction industry (Construction Task Force, 1998; Gann *et al.*, 1999), the introduction of the Affordable Warmth Programme (Charles Barnett and Associates, 1999) and guidance produced for registered social landlord's (RSL) on how to incorporate environmental issues into policies and practice (Brown *et al*., 1999). With the government's current interest in the EP of housing (particularly in terms of carbon emissions), the gap between academic activity in this area and current practice is growing.

To date the degree of innovation in the housing industry has been limited. Path-dependency in the industry stifles innovation. Path-dependency is largely generated by the market but is also reinforced by well-established construction processes, supply chains, delivery systems and sources of finance (Asibong & Barlow, 1997; Barlow, 1999; Clarke, 2001; Dewick & Miozzo, 2004).

The Market

Historically, conservatism amongst house-purchasers has very much influenced the types of housing developed and restricted innovation (Holdsworth, 2003). EP has been a minor consideration for house-purchasers (Dixon *et al*., 2005), particularly first-time buyers (Waters, 2007). Affordability, design, location, access to transport, security and safety are far more important in purchasing decisions. Affordability is particularly crucial. As a result, developers are sceptical about size of the market for more costly high EP housing (Townshend, 2005).

Although there has been very little market research into demand for high EP housing (HEPH), there is some evidence to suggest growth in demand (Townshend, 2005). Developers have emerged who specialise in 'high-end' sustainable properties (e.g. Southwest Ecohomes), in rural (e.g. Living Villages) and urban locations (e.g. Urban Splash and RGEN). A property agent dealing solely with ecohomes has also recently become established (Green Moves). However, in practice demand still appears to be limited to a niche market (Carter, 2006).

There appears to be more interest in energy-efficient homes driven by increasing energy costs (Jones & Leach, 2000; Waters, 2007). Recent surveys showed that 84% of home buyers would be prepared to pay up to 2% more for an 'ecohome' (as rated by the EHR) or an extra £3400 for an energy efficient home (WWF, 2003). Therefore, 84% of the market would be prepared to pay for 3-star accommodation.[9] However, other research suggests that some purchasers (particularly less affluent first-time buyers) are unwilling to pay the additional costs (Waters, 2007). Certainly a greater understanding of the demand for higher EP standards is needed.

Providing more information about the EP of stock could also help to raise awareness amongst potential purchasers, generate demand and increase market value (Eyre, 1997; Waters, 2007). Indeed, labelling has successfully increased demand for energy-efficient appliances (Boardmann, 1998; Sammer & Wustenhagen, 2005). EP information for housing has been very limited to date. The introduction of the Home Information Pack (HIP) and Energy Performance Certificates will begin to address this and incentivise improvements in the energy efficiency of stock (Waters, 2007). However, this provides a very limited measure of EP and will not help to generate demand for other environmental features. The Code assessment could provide purchasers with more comprehensive performance information for new-build and generate demand for other environmental features. However, even with improved labelling, consumers are unlikely to change mainstream product markets in the absence of institutional, economic and technological change (DEFRA, 2006).

Cost

A major barrier to improving the EP of housing appears to be increased build cost. Building units to a higher environmental specification can increase the time period for a successful application to be made and for planning permission to be granted. This increases costs and the risk of investment to the developer and other investors. New delivery and supply structures will inevitability be required, which will also be costly and time-consuming to set up (Barlow & Bhatti, 1997; Barlow, 1999). Improving EP will also require the use of a more skilled labour force and more expensive materials, both eating into profit margins (Barlow, 1999). However, research suggests that additional costs are small (Table 6) and could be further reduced by building on a larger scale (Minton, 2002).

Additional costs could be passed on to the resident whose increase in mortgage repayments would be compensated for by lower utility bills (James & Desai, 2003). However, there is some concern currently that improved EP could increase property values and thus council tax payments (highlighted by the DTI and Commons Committee, 2007). Thus, additional incentives may be needed to encourage the public to buy high-performance housing, including stamp duty relief, tax relief for sustainable home mortgages and council tax reductions (ERM, 2002). The Government has already proposed stamp duty exemption and cheaper green mortgages for zero-carbon homes (DCLG, 2006d).

Additional costs of increasing the EP of homes could also be offset. If a developer's land acquisition team has foreseen impending EP requirements, additional costs could be accounted for within the residual land value and initial costing of the site (Carter, 2006). Thus additional costs could be offset. Those developers who have the expertise and delivery mechanisms in place could also gain market advantage. Developers acting now to put in place the supply chains and

Table 6. Additional build costs for greater environmental performance

Environmental performance	**Cost per unit £ (average)**	**Percentage of build costs (average)**	**Information source**
EHR 'Very Good' standard or 3-star units (compared to unit built to Building Regulations 2002)	2000	2	E2S (2002) James & Desai (2003)
EHR Excellent standard (compared to unit built to Building Regulations 2002)	2350	2.35	E2S (2002)
EHR Excellent standard for improvements in water and energy performance only (compared to unit built to Building Regulations 2002)	160	0.16	Environment Agency (2005)
'Z-squared' (compared to unit built to Building Regulations 2002)	10 000	10	James & Desai (2003)
4-star units (compared to unit built to Building Regulations 2002)	4000 – 7000	4 – 7	DCLG (2006c)

Sources: Compiled using James & Desai (2003); Environment Agency (2005); E2S (2002); DCLG (2006c).

develop the expertise needed to construct ecologically-sound units will be more competitive in future markets (Carter, 2006).

Business Benefits

Capturing the business benefits of improved EP could provide further incentive to developers, for example by making more sites available or reducing construction costs (WWF, 2005). Some traditional and industrial landowners (including local authorities and English Partnership) stipulate that units built on their land should achieve higher EP standards. Thus adopting higher standards may increase access to sites for development. Adopting waste management strategies on site, off-site construction, or increasing building densities can also reduce construction costs. At a corporate level there has been some evidence of an increasing interest amongst housing developers in non-financial risks and opportunities (WWF, 2005). Companies are beginning to demonstrate a better understanding of the relevance of sustainability issues to their business (WWF, 2005). They are beginning to understand the relationship between the housing industry and the environment (WWF, 2005), particularly in terms of climate change. Taking environmental responsibility for developments is becoming increasingly important to the house-builders, who aim to reduce the risk of damaged reputation, lost revenues and lawsuits associated with poor EP (WWF, 2005). Improving the environmental credentials of a developer could increase access to land and investment capital (Carter, 2006). It could also help to improve developers' relationships with landowners, local communities and authorities (Carter, 2006).

Technology

Technological deficiencies and lack of appropriate expertise amongst built environment professionals and developers has also limited improvement in the EP of housing (WWF, 2005). Unreliable, expensive and inefficient technologies in combination with supply constraints and inadequate expertise amongst planners, developers and service providers limits the adoption of new technologies (Painuly, 2000; DTI, 2006). Technologies to improve energy and water efficiency are relatively well developed and reasonably cost-effective, whilst microgeneration technologies are still in the early stages of development. Further problems are created by the inadequacies of the wider supply infrastructure needed to support these innovations (Chappells & Shove, 2003). If zero-carbon housing is to be feasible this technology gap will need to be bridged.

Tackling Supply and Demand

Regulatory, economic and educational instruments could be used to improve the EP of housing and increase demand amongst house purchasers. Regulation is likely to be the most effective instrument for increasing EP (Asibong & Barlow, 1997; Gann *et al.*, 1998; Dewick & Miozzo, 2004; DEFRA, 2006). Voluntary industry initiatives (e.g. voluntary compliance with the Code) are important, but rarely play a leadership role and lead to ad hoc implementation (DEFRA, 2006). Early announcements of regulation drives technological improvements, stimulates demand and develops more secure supply chains for new technologies (DEFRA, 2006).

Economic instruments could be used to increase demand for improved EP in housing amongst purchasers. Economic instruments will only work if they close the price gap between high and standard performance housing (e.g. stamp duty relief for zero-carbon homes), reduce daily household expenditure (e.g. reduce council tax for households) or create significant tax rebates (e.g. tax relief for zero-carbon home mortgages) for homeowners (DEFRA, 2006). Labelling schemes could help to increase demand, but the effectiveness of this approach is restricted by the limited importance purchasers place on EP (Dixon *et al.*, 2005; Waters, 2007). Although labelling and economic instruments could produce environmental improvements in privately funded developments, the results are likely to be more ad hoc than if regulatory controls are enforced.

The potential for niche-derived change (i.e. the adoption of higher EP standards by the mainstream developers) is contested in the literature (Smith, 2006). Niche projects will have to offer considerable positive feedbacks, in terms of scope for profitable application, before mainstream actors become enrolled (Smith, 2003). However, valuable lessons can be learnt from the niche projects, which will ultimately help to facilitate adoption if there is sufficient institutional, market and technological support for higher EP standards in the future.

Long-term EP of Housing

Household behaviour can also have a significant impact on the EP of housing (Schipper *et al.*, 1994; Noorman & Uiterkamp, 1998; Svane, 2002). Households must effectively utilise the technology provided in order for it to operate to its full potential. Various factors result in the under-performance of technologies:

- Lack of user understanding of the potential savings (particularly financial) that can be made by utilising technologies effectively (Schipper *et al.*, 1994);
- Time needed to train users to operate the technology effectively reduces their willingness to learn (Schipper *et al.*, 1994);
- Poor maintenance (Elmberg *et al.*, 1996; Svane, 2002);
- Conflicts between household expectations for comfort, convenience and cleanliness and the effective use of technologies (Svane, 2002; Shove, 2003).

The appropriate use of technologies in the home is influenced by householder intentions (influenced by outcomes, roles, norms, self-concept and emotions) and habits. Change in household habits can have a major impact on resources use (according to Svane, 2002, between 10–30% reduction in resource consumption). Raising awareness amongst user groups of the resource and financial savings that can be made through the effective operation of the technologies provided has proved successful in tackling both intentions and habits. In units where resource use is monitored and households pay the real cost of resource consumption, technologies are utilised more effectively (Svane, 2002). There is also evidence to suggest that consumer preference for these technologies could be increased through positive interaction (Lovell, 2005).

These savings can be further increased using training programmes, particularly when implemented at neighbourhood level (GAP, 2002). Training households provides them with a clearer understanding of how to utilise technologies effectively and highlights the economic and environmental advantages of doing so. Monitoring changes enables households to see the resulting benefits. The involvement of the wider community in training programmes reinforces this by establishing a social context in which this behaviour is expected. The Ecoteams scheme (GAP, 2002) uses these methods and has achieved significant changes in long-term household behaviour, resulting in a reduction in resource consumption and waste (Table 7).

The time commitment of participating in training programmes can act as a disincentive for households to be involved (Schipper *et al.*, 1994). Less time-consuming approaches to training are also needed (e.g. household training manuals). Alternatively, the use of passive technologies could offer a solution by removing the need for effective user interaction. However, passive technologies would still have to be maintained in order to remain effective. Maintenance measures can increase energy efficiency between 10–20% (Elmberg *et al.*, 1996) and water efficiency by 10% (Svane, 2002). Maintenance companies could be employed to limit household involvement. This 'passive approach' will not actively tackle household behaviour but could improve EP and provide a more acceptable approach for hard-to-reach groups (e.g. the 'time-poor').

Household expectations in terms of comfort, convenience and cleanliness can also conflict with improving the EP of housing (Shove, 2003). These expectations have evolved and increased with technological improvements (Cooper, 1998) and have resulted in an increase in water and energy consumption. These expectations will need to be tackled if technologies are to be effective. The willingness of households to utilise technologies effectively varies greatly. This may be dependent on whether households prioritise the environment. It may also be dependent on different interpretations and values concerning comfort, cleanliness and convenience. These have been shown to vary across cultures (Chappells & Shove, 2003). This suggests different approaches may be needed to tackle a range of expectations appropriately.

Table 7. Reductions in resource consumption monitored amongst GAP Ecoteams in the Netherlands

	Consumption prior to ETP	**Consumption shortly after participation**	**Consumption 2 years after participation**	N^a
Waste (Kg/person/day)	0.216 (0.15)	0.153 (0.12) = −29%	0.145 (0.12) = −32%	37
Natural Gas cubic metres/person/week)	0.299 (0.21)	0.237 (0.18) = −21%	0.248 (0.18) = −17%	77
Electricity (KWH/ person/week)	27.2 (15.4)	25.9 (15.6) = −5% ns[b]	25.1 (14.3) = −8%	83
Water (cubic metres/ person/week	0.854 (0.38)	0.830 (0.38) = −3% ns	0.796 (0.33) = −7%	75

Notes: [a]N = number of households participating in survey.
[b]ns = non-significant.
Source: Global Action Plan Website (2002).

Supplying Green Homes

Greenwich Millennium Village was built as a showcase for innovations in EP. The £250 million development of nearly 1400 homes was built to the EHR 'excellent' standard. The development features water and energy saving devices, a CHP plant, low embodied energy materials, divided recycling bins, bike storage facilities and an eco-park. The development also has access to a range of public transport services. New techniques to reduce construction waste were adopted by the developer.

English Partnerships required that new housing on the site be built to EHR 'excellent' standard. In return the developer benefited from significant government investment in local infrastructure and site remediation, which reduced overall build costs. Thus a combination of obligatory targets and financial incentives ensured that high EP standards were achieved. The Greenwich peninsula is a high-value site because of its excellent links with Docklands, the City and West End of London. This attracted mid-high income groups, particularly in the first phase of development. The development team highlighted five key factors that influenced their decision to build units to higher EP standards on the Greenwich site: the market, cost, technology, business benefits and performance standards.

The Market

Scale of market demand for HEPH cannot be determined by examining the GMV development. However, a survey of residents showed that 40% believed EP influenced their purchase decision, although it was not as high a priority as location, other aspects of design and economic value (Simpson, 2003). The combination of location, well-proportioned units and reasonable price had attracted most residents to the development, whilst the more innovative EP features further added to the cache. However, for some residents the EP features had been crucial in their purchase decision. Thus inclusion of EP features created a new market for the developer's product amongst 'green consumers'. The development team recognised that including EP features had helped them to tap into a new market and had broadened the appeal of their product. However, at the time the research was completed the team still felt that this was a niche market.

Both findings suggest EP could be used as a marketing tool by housing developers for mid-high income groups and 'green consumers'. However, the development team believed that the demand for HEPH amongst lower-income groups, particularly first-time buyers, would be limited. For this group affordability was the key factor influencing their purchase decision. Thus some form of financial incentive would be needed to encourage them to buy more expensive HEPH.

A more detailed assessment of the EP features that added to the value of housing was completed. It showed that efficiency measures (for energy and water), transport provision (public transport and bike storage facilities), recycling facilities and services, water features and the eco-park all added value to the units (FRESH, 2003; Simpson, 2003). The value placed on each of these features varied considerably between individual residents.

There was no evidence to demonstrate that energy efficiency measures were valued more highly than other features. This may be for a number of reasons. First, the initial problems encountered with the operation and management of the CHP system, reduced energy savings and residents confidence in the technology. Second, most of the energy efficiency measures were not visible to residents, unlike the water features, public transport services and eco-park. Third, at the time when the research was conducted energy prices were still relatively low.

When the research was conducted it was too early to determine whether EP increased re-sale value for units in GMV. If EP was shown to have a market value then developers would be more willing to build to higher standards in all new developments as the cost could be passed on to the purchaser. Thus, more detailed research into the market value of EP and households' willingness-to-pay increased costs is needed.

Cost

Higher EP standards did increase the cost of building units around 2–5%. This cost was passed on to the purchaser. Other infrastructure and site remediation costs were borne by English Partnerships. Thus the cost and risk of building to higher EP standards to the developer was minimised. However, throughout the growth region developers will be building on low-value, brown-field sites, where demands for decontamination, infrastructure and affordable housing provision will compete with raising EP standards. On low-value sites (incorporating a high percentage of starter homes or requiring considerable site improvements), opportunities for passing on costs to purchasers is limited. For these sites some financial subsidy will be needed to reduce the build cost to ensure they are not left redundant.

The development team highlighted that some practices for improving EP actually reduced build costs. Techniques used for reducing construction waste in the GMV project made significant financial savings and were to be applied to all future developments. The development team were also willing to incorporate features that demonstrated a market value as these could be passed on to purchasers particularly in mid-high income groups. However, more research was needed to determine which of these features were attractive to the market and how much purchasers were willing to pay for them.

Technology

The case study indicated various technological issues that were likely to influence the EP standards reached in new housing including:

- Difficulties sourcing suitable technologies.
- Difficulties establishing sustainable supply chains.
- Finding utilities, management and maintenance companies willing to support new technologies.
- The inefficiencies and cost-effectiveness of the technologies themselves.
- Site problems.
- Lack of appropriate expertise in-house to advise on the most suitable and effective technologies for a development.

The development team had encountered difficulties in sourcing a sustained supply of triple-glazed windows from the UK. Eventually they had sourced the windows from outside the UK and the supply had proved unreliable, which had created problems in construction. This had slowed the pace of development and increased build costs. Sustainable supply chains are needed if new technologies are to be cost-effective. A database of suppliers might provide a useful tool for developers to help them identify suitable supply chains.

Originally the developer had hoped to generate energy for the development on site using a renewable resource. Wind and solar sources were considered but discarded because of site conditions, cost and efficiency of the technologies available at the time. Wood burning was then considered but was not viable due to transport, storage and potential emissions.

Therefore, a gas-powered CHP system was eventually installed. Even the adoption of a gas-powered CHP system was difficult because of the weak specialist supply base in the UK and instability within utility companies. It took time to find a utilities company prepared to support the CHP system. This is a common problem for decentralised energy generation. Difficulties were also encountered in the management of the system, which reduced efficiency and resident confidence in it.

The developer also intended to include a grey-water recycling system on site. However, cost, lack of UK standards, maintenance and level of contamination on the peninsula prevented this. The development team explained the cost of providing a grey-water recycling system varied depending on whether it was provided for individual households or for the community as a whole. Maintenance was also an issue, particularly finding service providers willing to maintain smaller systems. Larger facilities operated by water-treatment companies provided the most viable option, however, it would still significantly increase the cost of a unit. Land contamination was also a problem for installing grey-water recycling systems on the GMV site and could be a problem encountered on many brown-field sites in the growth region. The cost of bringing land to the standard required in order that water supplies were not contaminated in this instance rendered grey-water recycling unviable.

The development team said that lack of in-house technological expertise (particularly awareness of the optimal technologies for the development and where to source them) had proved a major barrier to implementation. Finding service companies with the expertise required to manage and maintain the technologies used in the project was also highlighted as a further problem. The team also questioned the current viability of some technologies in terms of efficiency and pay-back period (particularly for microgeneration and grey-water recycling) and suggested that there might be a technology gap that needed to be addressed before more ambitious EP targets could be met.

Overall improved access to a sustained supply of cost-effective and efficient technologies was needed. This would need to be supported by utilities services and the wider utilities infrastructure. In addition, management and maintenance companies with appropriate expertise would also be required to ensure effective operation long-term. Building technological, service and infrastructural capacity is crucial for achieving the highest levels of EP.

Business Benefits

The case study demonstrated a range of business benefits of building to higher EP standards. It confirmed that there was a market for EP features amongst mid-high income groups. It showed that the inclusion of EP features could broaden markets for mainstream developers by attracting the 'green consumers'. New practices for reducing construction waste also reduced build costs. The inclusion of EP features increased the developer's competitiveness when bidding for developments on publicly owned sites. The publicity given to the project also enhanced the developer's profile and competitiveness.

The project provided the developer with an opportunity to test the principles of ecological construction, design and new technologies, to determine the feasibility of replicating the product and process in other locations, with relatively low risk. The developer learnt a great deal from the process particularly concerning the factors influencing the implementation of new technologies. It highlighted the technologies that were viable without major changes to current systems (i.e. some efficiency measures, eco-park, bike storage and recycling facilities). It also demonstrated the various constraints, beyond the control of the developer (e.g. problems connecting to the grid; lack of utilities, maintenance and management companies willing to service technologies; problematic supply chains; lack of effective technologies; site conditions) that restricted the adoption of technologies particularly for water treatment and microgeneration. These constraints would need to be addressed if technologies were to be adopted in mainstream housing.

Performance Standards

English Partnerships set a performance standard for the development—'excellent' ecohomes rating. The standard was obligatory and clear. The development team said they preferred this approach as it provided a clear framework to operate in. It gave a clear understanding of what was required by the client and reduced risk when applying for planning permission. Without these obligatory standards the team believed few developers would build to this higher specification.

The team felt that the ad hoc enforcement of standards or voluntary compliance would be counter-productive. In the short-term it would result in competition between developers for sites without restrictions and could leave those sites where standards were enforced redundant. Thus, the team favoured a more comprehensive approach to the enforcement of EP standards for all new development. This could be achieved by increasing the performance standards required by the building regulations.

This is likely to have resource implications, particularly in terms of enforcement. The development team did suggest that EP standards should be set at a level that was achievable in current conditions. They alluded to the problems they had encountered in implementing some technologies (see subsection above). Certainly the evidence from the research suggests some technological improvements and capacity building would be needed before higher-end performance standards could be achieved. Equally the enforcement of higher EP standards might help to build capacity, but could slow development in the short-term.

Planning controls should also be used to provide a suitable context for the HEPH. Planning already influences site design (orientation and density of buildings, provision of green space, parking spaces, communal recycling and bike storage facilities), the mixture of uses in an area and provision of transport infrastructure, all of which impact on the overall EP of housing and the households living in them. Planning is also beginning to play a greater role in the delivery of microgeneration systems. Closer links between building control and planning are needed to ensure that both approaches are complementary and not in conflict. In addition, political support for planning policy approaches will be needed if new standards are to be implemented. Certainly there appears to be increasing political support for achieving greater EP in new developments in order to achieve the Government targets set for 2016.

Summary

The case study confirmed many of the findings in the wider literature (Table 8) and raised new possibilities. It demonstrated that there was some demand for higher EP standards in housing amongst mid-high income groups. Some features appeared to have greater market value although more research is needed to establish this definitively. The literature showed that additional cost of building to higher EP standards is often the main barrier. However, the research suggests that for high-value sites and mid-high income groups the additional cost is not an issue for the developer as it can be recouped from the purchaser. For low-value sites and first-time buyers (of which there are likely to be many in the growth region) some financial subsidies will be needed to ensure sites are developed and starter homes are affordable.

The research showed that the key barrier to achieving high EP standards in mainstream housing projects is insufficient technological, infrastructural capacity and expertise. Building capacity in these areas is essential and could be achieved through investment in: technological development, educational programmes (training service providers and developers), adapting existing utilities infrastructure to enable a more decentralised approach and establishing sustainable supply chains for new technologies. The research suggested that in addition to investment a more comprehensive and integrated regulatory framework (a combination of building regulations, planning policy and controls) could also help to build capacity and achieve higher EP in housing. Further consideration of the level at which to set EP targets is needed.

The current government plan to initially set low targets and improve them over time seems fraught as it is unlikely to drive the required increase in technological, infrastructural, service and knowledge capacity. However, setting targets too high at a stage when there is insufficient capacity could dramatically slow completions. This then creates a tension between achieving EP and providing sufficient accommodation for the growth in demand. Perhaps the solution is to set high targets and then invest substantially in building capacity in the required areas. Certainly lessons can be learnt from niche projects like GMV and where considerable positive feedbacks are identified these will be adopted by mainstream developers. However, compatibility with wider technological, institutional, economic and cultural frameworks is

Table 8. Case study findings

	Existing knowledge (literature review)	Findings confirmed by case study	New findings from case study
Market (Demand)	Limited market for HEPH	Not confirmed—inadequate data—from the case study there appears to be demand for HEPH amongst mid/high-income groups	• Taps into new markets for mainstream developers • Demand for EP was demonstrated amongst mid/high-income groups • Energy and water efficiency measures, transport services, water features, eco-park, recycling and bike storage facilities all add value to properties • Value placed on each feature varies between individuals
	EP minor consideration in purchase decision	Not confirmed	
	Energy efficiency is the key EP feature adding value to a development	Not confirmed	
	Increased re-sale value for HEPH	Not confirmed, but value attached to EP features indicated by current residents	
	Demand amongst lower income groups (e.g. first-time buyers) limited	Confirmed	
Cost	Increased build cost for HEPH	Confirmed, 2–5% increase in build costs	• Subsidies needed for low value sites, particularly a problem on brown-field sites, on sites providing high percentage of starter homes/affordable accommodation
	Cost can be borne by residents or landowners	Confirmed, for this particular development	

(*continued*)

Table 8. (*Continued*)

	Existing knowledge (literature review)	Findings confirmed by case study	New findings from case study
Business benefits	Increase availability of sites to those willing to build HEPH	Confirmed, particularly true for sites in public ownership	
	Utilising some aspects of EP can reduce construction costs (e.g. better waste management, increased densities)	Partially confirmed, savings made in terms of construction waste not outweighed by other additional build costs	
	EP can be used as a marketing tool	Partially confirmed, EP can be used as a marketing tool particularly amongst mid/high-income groups	
	Landowners can reduce site cost for developers willing to build HEPH	Confirmed, true for this site	
	Building to higher environmental standards improves relationship with LAs, landowners and communities	Confirmed, true for this site	
Technology	Expensive technologies and long pay-back periods	Confirmed, e.g. grey-water recycling system.	• Some technologies incompatible with site conditions, particularly a problem on brown-field sites • Finding management and maintenance companies with suitable expertise to manage and maintain HEPH is a major problem
	Inefficient technologies	Confirmed, e.g. CHP system, micor-generation technologies	
	Lack of expertise amongst developers, service providers and planners	Confirmed	
	Lack of reliable supply chains	Confirmed, e.g. triple-glazed windows	
	Lack of suitable supporting infrastructure (particularly connecting with existing utilities infrastructure)	Confirmed, supply chains and utilities infrastructure	

(*continued*)

Table 8. (*Continued*)

	Existing knowledge (literature review)	Findings confirmed by case study	New findings from case study
Performance targets	Performance targets are important and can drive innovation	Confirmed	• Level at which to set targets and how to enforce them needs further consideration • Play-off between EP and supply
Instruments to encourage supply of HEPH	Enforced targets EP more effective than voluntary agreements	Confirmed	• A consistent regulatory framework needed to minimise risk for developer and reduce competitive strategies • Requirements placed on developers by regulatory framework need to be deliverable, i.e. suitable, technologies must be available • Investment needed to establish reliable supply chains and training programmes for developers and service companies
	Economic instruments need to close price gap between standard and HEPH, reduce daily household expenditure, or create tax rebates	Not confirmed – mid/high-income groups seem prepared to pay additional cost. Subsidies may be needed on low-value sites and for lower income groups	
	Educational, labelling schemes	Not confirmed	
Moving from niche to mainstream	Considerable positive feedbacks needed, profitable application	Confirmed	Capacity building (knowledge, technology services and infrastructure) and a comprehensive regulatory framework will help to move HEPH from niche projects into the mainstream
	Valuable lessons can be learnt from niche projects	Confirmed	
	Compatibility with the wider technological, institutional, economic and cultural frameworks is necessary	Confirmed	

necessary. To secure this capacity needs to be built in areas identified and supportive regulatory frameworks established.

Long-term Environmental Performance

The long-term EP of housing also depends on how new technologies are utilised and maintained by residents. When compared to similar properties constructed to Building Regulation standards (Great Britain, 2002[10]), units in GMV performed well (Table 9). However most of the targets set by English Partnerships were not achieved (with the exception of construction waste). This could in part be tackled through encouraging more effective use of the technologies provided.

Prioritisation, Awareness and Time Constraints

The survey conducted by the developer showed that 40% of residents valued the EP of their units and had factored it into their purchase decision (Simpson, 2003). It was difficult to determine in practice whether this translated into individuals prioritising EP once living in the development. The anecdotal evidence was conflicting. Examples were given by the development team of some residents who had actually removed environmental technologies from their units (particularly in kitchens and bathrooms) and replaced them with less efficient technologies for aesthetic reasons. In contrast the residents association highlighted examples where joint collaborations between the developer and the sustainability sub-group had brought about improvements in the CHP system, cycle storage facilities, transport and waste recycling services. Certainly the sub-group prioritised EP.

The residents association said they were keen to reinforce pro-environmental lifestyles amongst households and the appropriate use of the technologies provided in the community through their sustainability sub-group. However, few residents were active within the group and thus the ability of the sub-group to alter priorities and change behaviour was limited.

The development team explained that all residents received a handbook providing instructions on how to use the environmental technologies in their units effectively. This was supplemented with information on the community website. Meters

Table 9. Environmental performance of units in Phase 1 of Greenwich Millenium Village

	Savings made in GMV Units[a]	Target savings set by English Partnerships[b]
Primary energy consumption	65	80
Embodied energy consumption	25	50
Water consumption	22	30
Construction waste	59	50

Notes: [a]Percentage savings in GMV units compared to units built to building regulations standards 2002 (Great Britain, 2002).
[b]English Partnerships target for percentage savings in GMV units compared to units built to building regulations standards 2002 (Great Britain, 2002).
Source: Countryside Homes (2003).

provided in individual units enabled residents to monitor their consumption levels and provided a means by which they could assess the impact of their activities on resource use and daily expenditure. Thus, in theory residents were provided with adequate information to encourage effective use of technologies.

However, the success of this approach was limited according to both the development team and residents association. The development team suggested that for most households the time needed to read and understand the information provided by the handbook was off-putting. The residents association thought the handbook could be more user-friendly, perhaps in terms of presenting information in a more accessible format, by reducing technical jargon and providing information about the financial savings that could be made by utilising technologies effectively. They also suggested that the handbook could provide more information about outlets where suitable replacement fittings could be sourced.

Alternatively, the resident association proposed that an interactive training programme might be more effective than a handbook, particularly if it also offered residents the opportunity to socialise with their neighbours. However, the development team was sceptical about the level of resident attendance at such an event and certainly low levels of participation in the sustainability sub-group and apparent under-utilisation of the existing information provided supported that concern.

The characteristics of the households living in GMV are likely to influence the extent to which they prioritise EP, the financial savings made through the effective use of technologies and whether these benefits outweigh the time cost. The majority of those living in the development are affluent and in employment.[11] Thus they are 'time-poor' and 'materially-rich'. As a result the financial savings made by operating technologies effectively are less important to the group than convenience. Overall, it seems in GMV effective use of technologies is not hampered by lack of awareness amongst residents, but by their lack of prioritisation of EP. Put simply, households value their time and the aesthetic quality of their accommodation more than its EP and financial savings.

For this group new approaches will be needed to change behaviour and encourage effective use of the technologies provided. Passive technologies and external service providers employed to manage and maintain these technologies on behalf of the residents may be most effective (i.e. where time-cost to residents is minimised). A variety of aesthetically pleasing environmental technologies and designs will also be needed. This might be achieved by introducing more stringent product legislation. It could be reinforced by the introduction of voluntary agreements that ensure residents preserve appropriate technologies in private units. Further research to determine the most appropriate approaches for this group is necessary.

Maintenance

The development team confirmed that poor maintenance reduced the performance of the technologies provided. Both the resident association and development team highlighted problems in maintaining and replacing the technologies provided in the development. Identifying sustainable supply chains for technologies used in the development and lack of service providers with adequate expertise to maintain and manage the technologies had created considerable difficulties in maintaining EP in the long-term. Neither the service providers nor technologies were easily accessible. The residents association was also concerned about the efficiencies and diversity of technologies available to households. They were particularly concerned about the efficiency of the CHP system, but also complained about the limited range of suitable technologies available for the bathrooms and kitchens.

The relatively high proportion of rental units in GMV (21% of those living in GMV rent their units, Simpson, 2003) further complicated the situation. According to the residents association some property owners wanted to minimise their costs and were reticent about paying for technologies to be maintained or replaced, whilst those renting units did not see it as their responsibility. This could result in poor maintenance and lower EP in rental units. The residents association also said that renters tended to participate less in community activities, thus community training programmes might be unsuitable for the group. Again, this problem could be tackled through the use of passive technologies, maintenance companies and voluntary agreements.

The introduction of product legislation and labelling systems[12] could ensure all technologies available on the market achieve higher EP requirements. Thus mainstream outlets would automatically stock these technologies, increasing access for residents and maintenance companies. It could also drive an increase in the diversity of high performance products available to the market. Raising awareness of the potential business benefits of offering environmental services amongst management and maintenance companies is also needed. Schemes offering training opportunities to increase expertise amongst key service providers would help to build the capacity needed for the successful long-term operation.

User Experience

Positive outcomes from the use of environmental technologies should increase residents' willingness to utilise them effectively. The residents association highlighted three examples where the failure of technologies, features or associated services had led to a loss of confidence amongst residents and a reduction in their willingness to utilise the technologies provided.

Some problems encountered with the CHP system had reduced residents' trust in the reliability of the environmental technologies provided in the development. Approximately 30% of residents were not satisfied with the CHP system. A number of reasons were given including: the time it took for the system to warm-up; ability to control warmth in different rooms; running costs and the overall performance of the system (Simpson, 2003). This negative interaction with the technology had in some instances reduced residents' confidence in other environmental technologies provided in the development. However, in most instances residents' negative perception was confined to the CHP system itself.

In all units residents were provided with separated bins and storage facilities for recycled waste. However, the local authority had been very slow to provide collection services to the site. This meant services were non-existent in the early phases of the development. As a result some residents reported that they had given up trying to recycle their rubbish (FRESH, 2003). The under-provision of secure bike storage facilities was also highlighted as an issue by 26% of the residents living in GMV (Simpson, 2003). Again, this discouraged cycling amongst residents living in the community. These teething problems could affect the long-term EP of a project and need to be addressed as soon as they arise if technologies are to be used effectively and sustainable lifestyles are to be adopted. Further investigation of the long-term impact of positive/negative interactions with environmental technologies, design features and associated services is needed.

Summary

The profile of the user-group in GMV limits the more general conclusions that can be drawn from the case study. It shows that for more affluent and 'time-poor' households convenience is prioritised above EP. Thus for this group passive technologies and maintenance programmes carried out by external service providers are probably the most effective solutions for ensuring that technologies are maintained and used effectively.

The research does support some of the more general points highlighted in the literature (Table 10). First, that prioritisation of EP and household expectations influence the manner in which technologies are utilised and maintained. Second, that the maintenance of technologies is important if optimal EP is to be achieved. Third, the research reinforced the importance of the positive experience of using technologies on the effective engagement of residents.

The research also contradicts the literature by suggesting that raising residents awareness of how to utilise technologies effectively will not necessarily result in optimal use. Nor will it be easy to raise awareness amongst residents who are 'time-poor' and affluent because their motivation to be involved in training programmes and their interest in reducing resource consumption is limited. However, for less affluent and 'time-rich' households training programmes and monitoring suggested in the literature may be more effective.

Further conclusions from the research were not identified by the literature. The case study showed that the supply of service companies with the expertise needed to manage and maintain developments of this type are currently insufficient. If all future developments are required to incorporate these new technologies then demand for service companies is likely to increase, which suggests there will be significant business benefits for those companies specialising in this field. Service companies need to be made aware of this and should be assisted in building the capacity required to offer suitable services.

The research also highlights problems in accessing appropriate technologies. Product legislation could be used to increase the diversity and accessibility of appropriate environmental technologies available to the market, thus making them easier to replace. This could be reinforced by voluntary agreements made by landlords and owner-occupiers to use appropriate technologies in units. This would help to maintain EP in units and create demand for appropriate technologies. Alternatively, the individual carbon-rationing scheme already considered by government might bring about the required changes in household behaviour. Further research is needed to identify feasible and effective solutions.

Table 10. Case study findings: long-term operation

	Existing knowledge (literature review)	Findings confirmed by case study	New findings from case study
Awareness, prioritisation, time	Awareness of how to utilise technologies and the benefits (financial and resource savings) increases effective use of technologies	Not confirmed	• Residents' priorities have the greatest influence over the effective utilisation of technologies • Affluent, time-poor residents are not motivated to use technologies effectively by financial savings • Aesthetic and time-savings are prioritised by the time-poor and affluent • New approaches may be needed to tackle the time-poor and affluent, e.g. use of passive technologies, external maintenance service companies and voluntary agreements
	Time needed to train users to operate technologies effectively reduces willingness to learn	Confirmed	
	Technologies must be compatible with user expectations (convenience, comfort and cleanliness)	Confirmed – for convenience	
	Prioritisation of EP is an important factor influencing effective utilisation of technologies	Confirmed	
Maintenance	Poor maintenance reduces performance	Confirmed	• Need for maintenance companies with appropriate expertise, current supply insufficient • Technologies not easily accessible to residents • Diversity of appropriate technologies available too limited • Landlords and tenants less willing to maintain technologies

(*continued*)

Table 10. (*Continued*)

	Existing knowledge (literature review)	Findings confirmed by case study	New findings from case study
Resident interaction with technology	Positive interaction with technologies encourages optimal use	Not confirmed	• Negative interaction reduces residents' willingness to adopt technologies
Approaches to tackling behaviour	Monitoring encourages optimal use of resources	Not confirmed	• Product legislation to increase access and diversity of appropriate technologies is needed
	If user pays full cost of resource it will optimise their use of technologies	Not confirmed	• Training and programmes to raise awareness of potential business benefits for service providers is needed
	Training programmes for residents will optimise their use of technologies	Not confirmed	• Voluntary agreements made by all residents to maintain technologies or replace with appropriate technologies
			• Service providers and developers need to ensure that resident's experience of using technologies is positive (need to provide linking services and ensure technologies are operating efficiently)
			• Passive technologies – optimal resource savings
			• Maintenance carried out by external service provider ensures technology operates optimally

Green Houses for Growth Region?

The current government approach (Table 11) to improving the EP of housing in the growth region will almost certainly produce variable results. There is a real danger that privately funded housing will under-perform when compared with publicly-subsidised development. There is also a concern that even those units built to higher EP standards will under-achieve as a result of household activities (particularly the inefficient use and removal of environmental technologies).

The regulatory and assessment framework proposed by the government is not robust or comprehensive, but it is ad hoc and conflicting. The targets that have been set even for publicly-subsidised development are unchallenging. There is also a lack of adequate financial support from government to build the capacity required to support the changes suggested in this paper, particularly for training and development of new technologies. Finally, there are no measures in place to tackle the behaviour of those moving into HEPH to ensure that technologies are utilised optimally.

A more comprehensive and robust regulatory framework together with a demanding EP standard is needed. To enable implementation substantial investment in the development of technologies, training and raising of awareness are also required. A unified building code incorporating EP standards could help to drive technological innovation, markets and establish supply chains. The new EP standards set by the code should apply to all types of housing regardless of how projects are financed. The minimum rating should be subject to review to ensure the use of new technologies as they become available and adaptation as environmental priorities change. To sufficiently reduce the eco-footprint of those living in South East England and to achieve the government's carbon reduction targets rating of 6-stars[13] (as defined by the CSH) would be required, however, the technical feasibility of delivering this is currently in doubt. The EP assessment should also be mandatory for all new development as this will ensure quality control and provide valuable information for house purchasers.

Planning guidance has already been introduced which should help to ensure that the context in which the new homes are built is conducive to the successful operation of the technologies provided, as well as encourage more environmentally-friendly lifestyles amongst residents. It is important that the new-building code and planning system are complementary and supportive. These policies will require political support.

In order to deliver the new EP standards, greater investment in technological development will be required. Investment in the existing utilities infrastructure and services may also be needed to facilitate a more decentralised approach to energy generation and water treatment. Financial assistance from government would be needed for all low-value sites in conjunction with financial incentives for first-time buyers (including stamp duty relief, tax-relief for home mortgages and reduced rates of council tax for HEPH), to ensure that units are built and are affordable. Investment in educational programmes for developers and service providers would also be necessary to build capacity, increase expertise and raise awareness amongst those delivering the new communities.

Probably the most successful approach to ensure that households utilise technologies effectively would be to install passive technologies and employ external

Table 11. Comparing approaches

	Instruments	Government approach	Modifications to the government approach
Supply	Regulatory	• Planning system, building regulations and code sustainable homes (CSH) • For publicly funded developments obligatory target of 3-star CSH rating and code assessment • For privately funded developments building regulations obligatory no assessment required	• Planning system and one building code • Code and code assessment obligatory for all new development • Enforce higher targets for all new homes (i.e. 4–6 star rating) using the building code • Ensure code and planning controls are complementary and reinforcing
	Economic	• Subsidy for publicly funded developments: site remediation, infrastructure and affordable housing provision • For privately-funded developments no subsidy • Financial incentives for households to live in zero-carbon housing including stamp duty relief and green mortgages • Limited investment in researching new technologies particularly for micro-generation and energy efficiency	• Subsidy for all low-value sites • Financial incentives for first-time buyers • Greater investment in technological development • Fund educational programmes and resources for service providers and developers • Fund for adapting existing utilities infrastructure to enable a more decentralised approach
	Information/ training	• Energy certificates • CSH assessment obligatory for publicly funded development and voluntary for privately funded development • Limited information and training programmes for the construction industry	• Building code assessment obligatory for all new development • Educational programmes and resources for service providers and developers
Operation	Regulatory	• None available	• Product legislation for appropriate technologies • Voluntary agreements for residents to maintain or upgrade existing technologies
	Economic	• None available	• Fund research and development of passive technologies • Fund training programmes for service providers and residents
	Information/ training	• None available	• Awareness raising and training programmes for service providers • Training programmes for residents
	Design	• Active and passive technologies	• Passive technologies

service providers to maintain and manage them. To enable this, investment in the development of passive technologies and training service providers will be required. In addition, service providers will need to be made aware of the potential business benefits of becoming involved.

If residents wish to retain control over maintenance a different approach will be needed. Voluntary agreements to ensure that environmental technologies are maintained and replaced could be helpful. Technologies will also need to be diverse and easily accessible to residents. More comprehensive product legislation could ensure that appliances and materials available to the market meet more stringent EP standards and are easily accessible. Training programmes for residents will also help to build awareness and the capacity needed to maintain the technologies provided.

The current government approach is far less onerous in political and resource terms than the approach suggested above. However, the time-scale for development is short. Thus radical changes are needed both in terms of construction and household behaviour if the government's environmental targets are to be delivered by 2016.

Notes

1 The baseline scenario is based on a continuation of current targets taken from regional planning guidance together with additional dwellings associated with Sustainable Communities Plan (an average increase of around 162 000 units per annum).

2 Some facilitate the development of the infrastructure to service environmentally sustainable communities and encourage spatial patterns which reduce travel, increase facilities for waste recycling, enable the use of district heating systems and renewable energy sources (ODPM, 2004), waste (ODPM, 2005b) and transport, (ODPM, 2001). PPS3 (DCLG, 2006a) promotes more efficient use of land, energy and better access to local facilities and public transport in residential development. Residential design guidance (DTLR & CABE, 2001) supports greater energy and land efficiency in new residential development through the consideration of layout, building at higher densities and installing smart technology. More recently the government revised PPS1 (DCLG, 2006b) to tackle greenhouse gas emissions from development. It outlines how the location, siting and design of new development can contribute both to the reduction of emissions and delivery of zero carbon development, and to the shaping of sustainable communities that are resilient to climate change.

3 The Code sets sustainability standards that can be applied to all homes. There are six levels of the Code. At each level there are minimum energy efficiency/carbon emissions and water efficiency standards. The minimum energy/carbon standards for Code level 1 are higher than those found in the minimum mandatory standards set in Building Regulations (Great Britain, 2006). The Code also rewards other environmental considerations, such as sustainable construction materials, and the availability of recycling facilities, cycle spaces and home offices. These and other issues that contribute to a 'sustainable home' are awarded 'credits' to make up their Code rating. Therefore, the Code will contribute towards a number of environmental objectives, including waste and wider ecology issues.

4 A home meeting level 3 of the Code will have to be 25% more energy efficient than one built to the Building Regulations (Great Britain, 2006) standards; designed to use no more than about 105 litres of water per person per day; use surface water management, use materials with minimum green grade D, have a site waste management plan in place during the home's construction, and adequate space for waste storage during its use. To get to level 3 developers need a further 46.7 points, thus they must do other things to obtain the other points such as: providing drying space (so that tumble dryers need not be used); energy efficient lighting (both internally and externally); cycle storage; a home office; reducing the amount of water than runs off the site into the storm drains; using much more environmentally friendly materials; providing recycling capacity either inside or outside the home; enhancing the security of the home; enhancing the sound insulation used in the home.

5 The development team included staff involved in achieving EP standards, marketing, constructing, operating and maintaining the development.

6 The government definition of a zero carbon home is one with 'zero net emissions of Carbon Dioxide (CO^2) from all energy use in the home'. The definition encompasses all energy use in the home (including energy for cooking, TVs, computers and other appliances) rather than just those energy uses that are currently part of building regulations (space heating, hot water, ventilation and some lighting). It means that over a year there are no net carbon emissions resulting from the operation of the dwelling. This could be achieved either through steps taken at the individual dwelling level or through site wide strategies. So it will not be necessary for each dwelling to have its own microgeneration capacity where development level solutions would be more appropriate (DCLG, 2006d).

7 The ecological footprint is a measure of the area of biologically productive land that is required to meet the needs of a given product, person or population. It compares this area with the actual available area on Earth and informs us whether we are living within the Earth's regenerative capacity (James & Desai, 2003).

8 Based on ENTEC Scenario 1, which is a continuation of current targets taken from regional planning guidance together with additional dwellings associated with the communities plan (an average increase of around 162 000 dwellings per annum).

9 According to calculations made by the Housing Corporation it would cost approximately an extra 2% for a 3-star home.

10 Building Regulations (2002) were used as the benchmark by the developer against which to test the performance of units.

11 Approximately 63% of GMV residents living in phase one of the development are earning more than £50K and 15% more than £100K annually (FRESH, 2003). The development team also indicated that the majority of residents were employed in white-collar jobs although more specific data were confidential (interview with development team).

12 The European Union has already introduced some relevant legislation (e.g. Directive for Eco-design of energy using products—EuP Directive 2005/32/EC) and voluntary agreements to tackle the eco-efficiency of energy using products. It has also introduced labelling systems and minimum standards for a variety of household energy using products. However, more stringent and comprehensive legislation is needed at a national level in England and Wales. It also needs to be expanded to water efficient appliances and building materials. The government has established the Sustainable Design Forum and an advisory committee on consumer products and the environment to begin to research this further.

13 Refer back to the section which showed that achieving a 6-star (zero-carbon rating) would achieve a footprint of 3.405 global hectares per person, still significantly greater than 1.9 global hectares per person which is their fair share.

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