Building fabric and housing stock

This chapter considers the state of the existing UK housing stock and the options for improving the energy efficiency of dwellings to provide appropriate levels of comfort whilst minimising energy consumption. The role of the building fabric in achieving the 60% target is discussed, along with a consideration of the levels of refurbishment, construction and demolition that are required, whilst ensuring social and political acceptability. Policy options forming part of a market transformation strategy for the housing stock are introduced.

Results from the UKDCM show that the 60% reduction target can only be met if there is a step-change in the quality of the fabric of the housing stock. Demolition and construction rates both need to rise; the average energy consumption of the existing stock needs to be brought up to a SAP (Standard Assessment Procedure) rating of 80, and all new homes need to achieve close to zero space heating demand from 2020 at the latest.

5.1 Context

There were 25 million homes in the UK in 2003, making up one of the oldest and least efficient housing stocks in Europe. The poor quality of the building fabric across the whole stock means that space heating accounts for roughly 60% of total delivered residential energy demand (Shorrock and Utley 2003). Some 2 million homes in England are rated with a SAP score of below 30 (ODPM 2003a), representing a very low efficiency standard. In contrast, a handful of pioneering housing developments have been designed and built to achieve zero space heating demand.

Improvements through a range of cost-effective energy efficiency measures are currently promoted in a variety of Government programmes, and heat loss standards for new homes have become progressively tighter in the regular cycle of revisions to the Building Regulations. The net effect on the UK housing stock has been a 1% annual drop in fabric heat loss from UK homes between 1970 and 2001 (Figure 1.2).

However, current policies are inadequate to the scale and urgency of the task. Existing grants and advice programmes promoting cost-effective energy efficiency measures are planned to achieve 2020 targets (DEFRA 2004a) but the same set of measures cannot deliver enough additional savings beyond 2020. The Building Regulations set standards for new construction which, though they get tighter with each five-yearly revision, fall a long way short of the low or zero space heating energy demand of the best current practice using existing technology. There is a poor record of compliance with the design standards and a dearth of data on real-life performance of new homes.

5.2 Heat losses and gains in buildings

Heat is lost from buildings through the fabric of the building itself (roof, walls, floor, windows and doors) and through infiltration of cold air via any holes and gaps. Fabric heat loss can be slowed down with insulation materials, the performance of which is a function of the material used, its thickness and a number of other factors to do with how well the insulation is installed: gaps in insulation quickly compromise performance, for example. Ventilation heat loss can only be reduced by minimising infiltration of cold air: construction needs to be airtight, with controlled ventilation supplying adequate fresh air, possibly with a heat recovery system to reduce the heat loss even further. Airtight construction requires good design and close attention to detail during construction. As insulation standards have improved in the UK for new construction, the issue of ventilation heat loss has become relatively more significant (ODPM 2004h).

Buildings also gain heat – from sunshine coming through windows, from body warmth, from hot water in pipes and storage tanks, and from the heat given off by lights and appliances. In a building where the total heat loss is kept to a minimum, these incidental gains contribute more of the heating.

15% of solid walls will be insulated by 2050

5.3 Current picture

The main challenge in working towards a 60% reduction in carbon emissions from the residential sector is the poor state of the existing housing stock.

5.3.1 Stock profile

National statistics on energy in housing use the Standard Assessment Procedure (SAP), which gives a score of up to 120 – the higher the number, the better the rating (recalibration under SAP 2005 will give a top score of 100). SAP is based on the thermal performance of a building, its heating appliances and the energy prices for different heating fuels used. SAP 2005 will take more account of carbon emissions.

The average SAP rating in England in 2001 was 51 (Figure 5.1). Almost 2 million homes have a SAP rating below 30 (ODPM 2003a). A transformation of the housing stock to a target SAP rating of 70 would reduce CO_2 emissions by 34.5% (DETR 2000). Such a transformation of the stock would be an enormous challenge but would still not provide enough savings in space heating demand to make the overall 60% carbon reduction achievable.

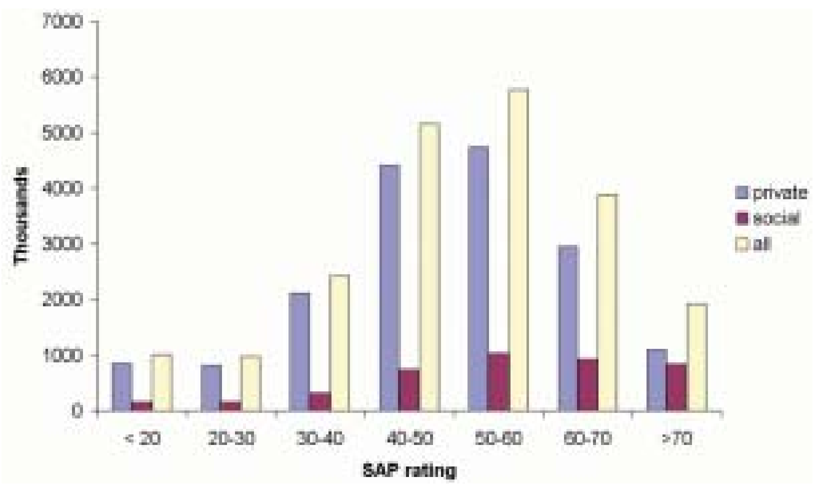

Figure 5.1: English housing tenure by SAP rating, 2001

Source: ODPM (2003a)

5.3.2 Refurbishment opportunities

The distinction between old and new housing is crucial to the overall performance of the stock, as there are practical limits to what can be done to improve a building. Energy efficiency is much easier to achieve when it is incorporated at the design stage in new build, rather than as a refurbishment. However, since many of the existing dwellings will still be standing in 2050, refurbishment will be a necessary part of improving the energy efficiency of the stock.

Options for refurbishment range from easy, cost-effective measures to more expensive and disruptive solutions. Although a certain number of measures have already been installed in the existing stock, there is still substantial opportunity for further improvement.

In 2003 there were an estimated 17 million homes with cavity walls, of which 11 million were uninsulated (DEFRA 2004a). Cavity wall insulation is one of several cost-effective measures supported by the Energy Efficiency Commitment (EEC) and Warm Front grant schemes. Another 7 million dwellings have solid walls, almost all of which are uninsulated, as solid wall insulation is a costly, disruptive measure resulting in slightly reduced room sizes (if the wall is insulated on the inside) or a changed façade (if the insulation is clad on the outside). A future technical breakthrough may lead to the development of a new insulation product without these drawbacks, but has not been assumed here.

Most homes with a loft have some loft insulation, although the commonest thickness of 100mm is well below the current recommended level, and performance may frequently be compromised through compaction due to the storage of heavy items directly on top of the insulation material. Loft insulation is a cost-effective measure, causing minimal disruption, and is also supported by grants under EEC and Warm Front.

Solid ground floors can be insulated during construction, with the insulation under a slab of poured concrete. In refurbishment, the floor would need to be excavated and re-laid to achieve comparable performance. Suspended timber floors can be insulated more easily as a refurbishment measure, typically to the depth of the floor joists, although deeper insulation can be installed on hangers fixed to the joists where there is sufficient space below the floor. There are no data on floor insulation or the proportion of solid versus suspended timber floors in published housing statistics, and so the potential for uptake in older dwellings is unknown.

The performance of glazing has increased considerably in recent years with multiple panes (double-, triple- and quadruple-glazing), low emissivity coatings, inert gas fills between the panes, and improved seals and frame designs. Whole window replacements are regulated by the Building Regulations, although compliance is reported to be low (EAC 2005). Replacement glazing is a home improvement that improves security and sound-proofing, as well as energy efficiency, and the market is already mature.

5.3.3 Demolition and construction rates

Current levels of construction are relatively low, with around 167,000 housing starts in the UK in 2002-3. Demolition rates are also low – between 1996-2004, a total of nearly 160,000 dwellings were demolished, approaching 20,000 a year. Continuing at these rates means that the average house will last for over 1000 years – clearly an unrealistic scenario.

Historically, the highest level of demolition occurred between 1961-75, when the annual rate was just over 81,000 pa in GB, the majority being defined as unfit. Only 20% of those demolished between 1996-2004 were considered to be unfit (EHCS 2001), indicating a shift in the criteria used to decide which properties are removed from the stock.

5.3.4 Decent homes

A third of dwellings in England are acknowledged to be 'non-decent' – unhealthy, in disrepair, in need of modernisation or providing insufficient thermal comfort, with 80% of these failing the comfort criterion (ODPM, 2003a). Current policy on decent homes sets a basic standard and a timetable for implementation. Homes should be free from serious disrepair, structurally stable, free from damp, have adequate light, heat and ventilation. All social housing should be up to standard by 2010; for vulnerable private-sector households, 65% are to reach the standard by 2006 and 70% by 2010.

There are useful policies and programmes to address fuel poverty and market transformation, such as the Energy Efficiency Commitment, Warm Front and Decent Homes, but these are inadequate, not linked to each other and their effect is limited in relation to the scale and urgency of the challenge.

The policies needed to achieve 60% reductions in residential carbon emissions can also deliver decent homes to the most vulnerable in society.

5.4 40% House scenario

By 2050, 31.8 million dwellings will be needed to meet the growth in population (Chapter 3). This represents a net increase of 7.9 million homes (33%) from 1996. The stock increased by 1.1 million between 1996 and 2004, leaving 6.8 million to build between 2005 and 2050. Under the 40% House scenario this has been achieved through the construction of 10 million new homes and demolition of 3.2 million existing homes (Table 5.1). In other words, over two-thirds of the 2050 housing stock has already been built, highlighting the importance of refurbishment of these dwellings. The total space heating energy

Table 5.1: Housing stock assumptions, 40% House scenario, 1996 and 2050

	Base year 1996	*40% House scenario 2050*
Total number of dwellings	23,900,000	31,800,000
New build 1996 – 2004		1,280,000
Demolition 1996 – 2004		160,000
Homes already built and remaining in 2050		21,800,000
Homes demolished 2005 to 2050		3,200,000
New homes built from 2005 to 2050		10,000,000
Heat demand for space heating per dwelling built pre-1996 (kWh delivered energy)	14,600	9,000
Heat demand for space heating per dwelling built post-1996 (kWh delivered energy)		2,000
Total space heating demand (TWh delivered energy)	348	216
Energy saving from fabric measures (TWh delivered energy)		148
Average heat demand for hot water per dwelling (kWh delivered energy)	5,000	3,400*
Total water heating demand (TWh delivered energy)	120	108*
Total space and water heating demand (TWh delivered energy)	468	324*
Energy saving from all space and water measures (TWh delivered energy)		144*

Source: UKCDM
* net of solar hot water

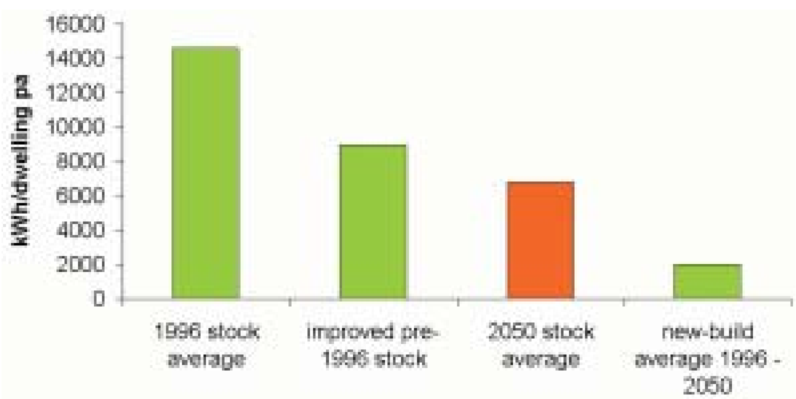

Figure 5.2: Net space heating energy demand, existing stock and new-build to 2050

Source: UKDCM

demand in 2050 is reduced by 38% compared to 1996 levels, despite a 33% increase in the number of households.

The demolition rate is assumed to rise from current levels until it reaches 80,000 per annum in 2016, after which time it remains constant. This represents an increase from 0.1% of the stock now to 0.25% of the housing stock in 2050. Continuing at this rate means that it will take 400 years to replace the 2050 stock of houses. The average annual construction rate is assumed to be 220,000 completions per annum between 2005 and 2050.

5.4.1 Space heating demand

The energy efficiency of the fabric of the housing stock in 2050 is a function of the energy efficiency improvements made to existing homes, the number of existing homes demolished and the quality of the new homes built. In the 40% House scenario, the average net space heating demand across the whole stock in 2050 is 6,800 kWh/year. For homes built before 1996, the average net space heat demand in 2050 is 9,000 kWh/year (after energy efficiency improvements and incidental heat gains) – a 38% reduction compared to 1996 levels. For homes built after 1996, the average net space heating demand is 2,000 kWh pa (Figure 5.2).

5.4.2 Refurbishment of existing stock

To achieve a 38% reduction in the average space heating demand of the existing stock, a high level of refurbishment has been assumed. This was considered a preferable option (even where expensive and disruptive) compared to higher levels of demolition (potentially more expensive and disruptive) in order to realise the necessary levels of energy efficiency.

Under the 40% House scenario, energy efficiency improvements to the existing stock are modelled, with average uptake rates and insulation levels for each decade. Values for 1996 and 2050 are given in Table 5.2. It is assumed that there is a considerable market in replacement double-glazing, so that all windows in 2050 have

Table 5.2: Refurbishment measures, 40% House scenario, 1996 and 2050

Efficiency measure	*U value 1996 W/m²K*	*U value 2050 W/m²K*	*Uptake by 2050*
Cavity wall insulation	0.4	0.25	100%
Solid wall insulation	0.5	0.25	15%
Loft insulation	0.6	0.15	100%
Floor insulation	Varies with dwelling age	Varies with dwelling age	0%
Glazing	3.3	0.8	100%
Doors	3.5	2.0	100%
	Air changes per hour, 1996	Air changes per hour, 2050	
Ventilation	3.5	0.6	

Source: UKDCM

a U value of 0.8 W/m²K. Solid wall insulation is assumed to reach 15% uptake by 2050, with a U value of 0.25 W/m²K for work done between 2030 and 2050. From 2030 onwards, many cavity-walled dwellings will have external cladding in addition to filled cavities, so that 35% of this dwelling type has a wall U value of 0.25 W/m²K by 2050. All lofts are assumed to be insulated by 2050 with a U value in 2050 of 0.15 W/m²K, equivalent to about 300 mm of insulation (dwellings with no roof above or a flat roof are not insulated). Although technically feasible, no retro-fit floor insulation is modelled, erring on the side of extreme caution in the absence of reliable data. The U value for floors varies with the age of the dwelling.

The 40% House scenario assumes no loss of architectural heritage in conservation areas (1.2 million dwellings) or listed buildings (300,000 dwellings). Internal measures that do not alter the appearance of valuable interiors are permitted (eg loft insulation), but solid walls, doors and windows are assumed to remain untouched by energy efficiency improvements in these dwellings.

5.4.3 Performance of new homes

All new homes built to 2050 are assumed to be of a high efficiency standard, based on demonstrated design and technology already in existence (Table 5.3). The average net space heating demand of 2,000 kWh pa across all new homes built since 1996 incorporates a range of efficiencies, gradually improving to 2020 when the standard for space heating energy demand in new housing is assumed to be close to zero, depending on the availability of solar gains. Site conditions (eg shading of sunlight) may mean that zero is not always achieved but demand for space heating will still be low.

Table 5.3: Performance standard of new housing, 40% House scenario

	Rate of heat loss (U value, W/m²K)					
Source of fabric heat loss	*1997-2004*	*2005-2009*	*2010-2019*	*2020-2029*	*2030-2039*	*2040-2050*
walls	0.35	0.3	0.2	0.1	0.1	0.1
roof	0.24	0.15	0.1	0.1	0.1	0.1
floor	0.35	0.2	0.15	0.1	0.1	0.1
glazing	2.2	2.0	1.5	0.8	0.8	0.8
doors	2.5	2.0	2.0	2.0	2.0	2.0
Ventilation heat loss (air changes per hour)	2.0	1.5	0.6	0.6	0.6	0.6

Source: UKDCM

5.5 Housing renewal

Aside from improving the efficiency of the housing stock, the building of 10 million houses and demolition of 3.2 million by 2050 raises a number of other issues around design, location and the amount of energy and waste involved in this level of housing renewal.

5.5.1 Energy in construction and demolition processes

Construction and demolition processes all use energy, but the amount is relatively small compared to the energy consumption in the use of buildings. When an old, inefficient building is replaced with a new, efficient one, the embodied energy in the construction process will be offset within a few years by the lower energy consumption of the more efficient building in occupation: thereafter, the more efficient building will represent savings throughout its lifetime (Matsumoto 1999, XCO2 2002).

While the priority is clearly to reduce energy in use, there are significant secondary concerns to do with the carbon balance of building materials and processes. When local plant-derived materials are used, they may act as net carbon sinks, helping to offset carbon emissions (Reid et al 2004).

5.5.2 Waste minimisation

The construction and demolition industry produces some 70 million tonnes of waste, of which 13 million tonnes (19%) are materials that are ordered but never used (EAC 2005). An accelerated programme of housing stock replacement would exacerbate the problem unless waste management is also improved. Where practically possible, old buildings need to be dismantled brick by brick and re-used, rather than demolished into rubble. The re-use of building materials needs to be considered at the design stage of new construction, so that a maximum quantity of materials can be

Demolition at current rates means the average house will last over 1,000 years. Demolition will have to increase to turn over an inefficient housing stock by 2050 dismantled intact, rather than being ‘down-cycled’ at the end of the building’s useful life (OECD 2003). However, it is beyond the scope of this report to analyse waste issues in detail.

5.5.3 Modern Methods of Construction

There is renewed interest in making modular, prefabricated building elements as a solution to the dual problems of a housing shortage and a persistent low level of quality in construction. Modern Methods of Construction (a new term for high-quality prefabrication) has inherent advantages: quality control is easier in a factory environment than on a building site and fewer days are lost due to inclement weather. However, pre-fabrication using mainly lightweight building materials may lead to an increase in summer over-heating and an energy penalty from residential air-conditioning demand. Pre-fabricated panels may also be harder to re-use than conventional building materials, adding to future waste problems.

5.5.4 The built environment in a changing climate

Building design and planning policy in the twenty-first century need to take account of the likely impacts of climate change, including greater extremes of summer heat and increased flood risks. One estimate is that over 2 million properties in the UK already are at risk of flooding (OST 2004). Avoiding flood-risk areas in future is a planning issue, and will put additional development pressure on other areas.

As highlighted in Chapter 4, the take-up of air-conditioning in UK homes is at negligible levels now, but a warming climate may well increase demand, potentially adding significantly to electricity consumption and carbon emissions. Optimising the adaptive potential of buildings and minimising demand for air-conditioning will be increasingly important across the whole housing sector. New and existing homes can be fitted with shutters or other shading devices to help prevent over-heating in summer. A key design strategy for new buildings is to make use of materials with high thermal mass, which moderate extreme temperature changes and provide comfort without mechanical cooling.

5.5.5 Spatial development

In the 40% House scenario, the housing stock increases by a net 7.9 million homes from 1996 to 2050, risking increased pressure on green-field sites.

Raising the demolition rate not only creates the opportunity to remove some of the worst housing from the stock, but it also creates new development sites in urban areas. Local planning authorities will need to ensure that replacement housing increases in density, as well as energy efficiency, across the local area, particularly since increased density is also well suited to carbon-efficient heating and cooling systems (Chapter 7).

5.6 Policies

A market transformation approach to the housing stock requires an overall coherent strategy if it is to be effective. Improvement of the energy efficiency of the housing stock is a vital part of this strategy and there are a number of measures that need to be put in place in order to achieve this and meet the 60% target.

5.6.1 Information

Clear, reliable information about the energy performance of a dwelling is a crucial first step in market transformation. By 2006, all EU member states are required to have a methodology in place for providing information on the energy performance of all buildings when they are built, sold or rented, as set out in the Energy Performance of Buildings Directive (EPBD). The current revisions to SAP are intended to fulfil the requirement for a building rating methodology under this Directive. The SAP rating of a dwelling, together with other information about energy use and potential for efficiency improvements, will be included in the proposed Home Information Pack (HIP), which puts the onus on the vendor of a property to gather all relevant information about the property prior to sale. Both SAP and HIP cover space and water heating only. An equivalent information service is needed for the rented sector.

5.6.2 Regulation at point of sale or rental

Sales and rentals of residential properties totalled 1.3 million transactions in 2002, far exceeding the number of newly built homes (ODPM 2003e). The point of sale or rental is therefore of critical importance to the transformation of the housing stock. Tenants in rented housing move, on average, every five years, while owner occupiers move less often – about once every fifteen years (Robinson et al 2004). By 2050, each rented dwelling therefore needs to be transformed through the process of nine property transactions. Owner-occupied homes need to achieve the same transformation in only three transactions.

Energy consumption is typically not a deciding factor in the purchase of somewhere to live, especially when there is a shortage of choice in the sought-after areas. Therefore, information on energy efficiency – necessary though it is – is unlikely to be enough on its own to transform the housing stock. A system of rebates on stamp duty is proposed as a means of motivating energy efficiency improvements in the time just following a property sale, when major works are often undertaken or considered. In the rental sector, where the efficiency cost savings and comfort improvement are enjoyed by the tenant rather than the landlord, there is far less scope for incentivising improvement. Regulation of the rented sector could provide an obligation to improve the property to a minimum standard before a new rental contract can be agreed.

5.6.3 Regulation of refurbishment

Recent revisions to the Building Regulations have included controls on replacement heating boilers and replacement windows, extending the coverage of the legal standard to include refurbishment works, as well as new construction. For the 2005 revision, consideration is being given to a new requirement aimed at major renovations: for works costing over a threshold amount, an additional percentage of the total budget would have to be spent on cost-effective energy efficiency measures. By extending the scope of the Building Regulations to cover renovation in this way, energy efficiency will have to be considered at a time when major disruption and cost are already being contemplated.

The proposed extension of the Building Regulations to cover major refurbishments is a welcome first step, but its impact will be insufficient if it only covers those measures which are cost effective today. The 40% House scenario represents a massive level of improvement to the existing housing stock, as well as an accelerated programme of stock replacement. Increases in insulation and measures to reduce ventilation heat loss are all needed if the 60% target is to be met. As cost effective measures are taken up, the onus needs to shift towards new measures.

5.6.4 Ensuring compliance

Compliance with Building Regulations needs to be improved if claimed carbon savings from homes are to have any basis in fact. Very few studies are conducted on the performance of buildings in use, but these few suggest that standards are frequently not being met (eg Olivier 2001, EST 2004c). The current shortage of building control inspectors has led to trials of self-certification schemes, for example with replacement double-glazed windows. Widespread non-compliance has been reported (EAC 2005).

A policy which relies on un-policed standards or self-assessed compliance is unlikely to deliver all the expected benefits. The 2005 revision to the Building Regulations is likely to include a new requirement for pressure-testing a percentage of new dwellings as a proxy for overall quality in construction. It remains to be seen whether this will bring about improved performance.

For refurbishments, there will be a need for

All insulation measures, including costly and disruptive measures like underfloor insulation, need to be taken up at higher rates than at present

more qualified surveyors to carry out energy audits. The requirements of the EPBD allow EU member states until 2009 to put in place the systems for energy audits to take place.

5.7 Priorities for action

Translating these policy measures into practical steps identifies the following priorities for action:

- Initiate a system of incentives using rebates on stamp duty to encourage greater energy efficiency;
- Instigate a system of regulation for the rented sector to compel landlords to meet minimum energy efficiency standards;
- Extend the scope of the Building Regulations' coverage of major refurbishments;
- Broaden the coverage of the Building Regulations beyond 'cost effective' measures;
- Invest in research to create a database of real-life energy performance from a representative sample of UK homes;
- Develop a strategy to ensure compliance based on performance rather than design standards;
- Recruit and train enough surveyors to carry out clear and reliable residential energy audits.

5.8 Conclusions

Reducing space heating demand across the whole housing stock is made difficult by the poor standard of so many existing homes. A dual strategy of refurbishment and replacement is needed in order to make the necessary carbon savings, and compliance with design standards needs to be much better enforced.

Information on the energy performance of a dwelling at the point of sale or rental has the potential to increase the rate of improvement through refurbishment, but the impact of information alone is likely to be low. Regulation and financial incentives could help translate information on the quality of homes into lasting energy efficiency improvements, using a market transformation approach. Preparation for the implementation of the EPBD is already providing some of the groundwork for a market transformation system to be in place from 2009.

The quality of the audits will be key to the success of the EPBD. Financial incentives and, in time, the setting of minimum standards will also be needed.

The list of measures needs to be extended to include solid wall insulation, ground floor insulation (where feasible) and works to reduce ventilation heat loss from existing dwellings (eg blocking up chimneys, sealing skirting boards and service pipe penetrations). All measures – those that are currently promoted, as well as the more costly and disruptive ones – need to be taken up at higher rates than are currently achieved if the 60% carbon reduction target is to be met by 2050. Stamp duty rebates would be one way of increasing uptake in the private sector.

The major findings from the 40% House scenario for space and water heating are summarised below:

- The 21.8 million pre-1996 homes that are still standing in 2050 are much more energy efficient and only need 62% of the delivered energy for space heating.
- From 2020, all new homes have a space heat demand of near zero to achieve an acceptable stock average in 2050.
- The demand for hot water per home is assumed to stay at 1996 levels until 2050 though an increasing proportion is met by solar water heating.
- The quantity of energy for space heating, for the whole stock, has been reduced by 38% in 2050, despite the 33% increase in the number of homes and a nearly 2°C rise in internal temperatures.
- The rate of demolition in the UK rises to 80,000 per year by 2016, and stays at the same level to 2050: a total of 3.2 million demolitions from 2005-2050.
- The rate of new construction in the UK is an average of 220,000 dwellings per year for the next 45 years.