THE CHALLENGE OF EXISTING UK HOUSES

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The UK has a legacy of old, inefficient dwellings and by 2050 at least 87% of these are probably still occupied. Whatever the standard of new buildings, this quantity of existing construction represents a major challenge to the objective of sustainable cities.

There are four interlocking issues that require debate to both reduce demand and supply it with low carbon technologies, within the curtilage of the building, or nearby. None of the solution is deemed to come from major changes in centralised electricity supply in the following debate, as the aim is to examine how much could be achieved in the buildings themselves:

- Number of new homes needed;
- Amount of demolition;
- Energy efficiency standard of the remaining homes;
- Quantity of micro-generation installed.

Number of new homes

The population of the UK continues to grow and by 2050 will have increased from 59 million in 2002 to about 66.8 million (+13%). There is some degree of confidence in this number, as so many of the people are already alive. The two main causes of uncertainty are the extent to which greater longevity will occur and immigration numbers. The compounding factor is that people in the UK are choosing to live in ever-smaller units. Household size was 2.6 people in 1985, is now 2.3 people and is expected to drop further. In *40% house* (Boardman et al 2005), a figure of 2.1 people per household was used, although this is still higher than the present level in Sweden. The combined effect of more people and smaller households results in a 24% increase in household numbers between 2002 and 2050: from 25.6 to 31.8m. This is a 33% increase over the 1996 level of 23.9m used as the base year in *40% house.*

These 6.2m homes are all new. None of them existed in 2002. This is the minimum number of new homes required. Additional construction will be required to replace any homes that are demolished, so total levels of new build will be somewhat higher.

One of the implications of this large number of new homes comes from the impact on land use. There are in essence two options in relation to the present boundaries of the built-up areas: extend the geographical footprint, or stay within the present area and make the housing more dense. The former results in the loss of green belts and agricultural land. The latter implies the demolition of existing homes to make way for these denser developments.

Amount of demolition

The present rate of demolition in the UK is extremely low at around 20,000 dwellings pa, ie less than 0.1%. At this rate, the stock turns over once in nearly 1,300 years. This is unlikely to be a sound housing or energy strategy. In *40% house* the rate of demolition is increased by a factor of four, to

80,000 pa. This is the same annual rate as was achieved in 1975, whereas it was as high as 120,000 pa during 1968-1970.

The buildings to be demolished would probably be the least energy efficient, with a Standard Assessment Procedure (SAP) rating of less than 30. Many of these buildings are pre-1919, terraced homes that are providing poor living conditions that result in fuel poverty. They may even fail the new Housing, Health and Safety Rating System assessment. Because these are old buildings, they are, by definition, in urban centres, meaning that their replacement with more, energy-efficient dwellings would provide a useful step towards sustainability.

A demolition rate of 80,000 pa is achieved gradually, so that in total by 2050, 3.2m dwellings have been demolished out of the stock of 25m in 2005. Hence, 87% of today's homes are still standing in 2050.

Energy consumption in existing homes by 2050

The embodied energy and carbon in a new building is offset after about 13 years, if the construction is to a high standard of energy efficiency and low level of energy consumption. This is true, even where the comparison is with a substantial improvement to the existing building. Approximately, the background figures are:

- the space heating needs of average existing dwelling 14,600 kWh pa
- the space heating needs of improved existing dwelling 9,000 kWh pa
- the space heating needs of new dwelling 2,000 kWh pa
- stock average in 2050 6,800 kWh pa
- the embodied energy in the new building is taken to be 90,000 kWh.

Hence, the expenditure of 90,000 kWh embodied energy is offset by the 7,000 kWh saved by replacing an improved building (@ 9,000 kWh) with a new building (@ 2,000 kWh) over a period of 13 years.

The level of 9,000 kWh in the average existing building is achieved as a result of nearly maximum insulation levels (Table 1). The one exception is with solid walled homes, as this is both expensive and often unsightly (if on the outside) or inconvenient (if on the inside). Hence, it is virtually impossible to envisage reducing the standard of the average existing building to much below 9,000 kWh for space heating pa with existing technology, or even with what might be developed (eg smart coatings for walls).

	U value 1996 W/m²K	**U value 2050** W/m²K	**Uptake by 2050**
Cavity walls	0.4	0.25	100%
Solid Walls	0.5	0.25	15%
Loft insulation	0.6	0.15	100%
Glazing	3.3	0.8	100%
Air changes (ach)	1.5	0.6	

Note: The U value in 2050 is what is being installed in that year, not the standard of all homes in 2050.

Table 1. Insulation levels assumed in existing UK homes, 2050

The *40% house* target for the whole stock of 6,800 kWh for space heating alone, has been arrived at through a process of iteration, with the 60% carbon reduction by 2050 the main objective. There are four components to the equation involved in this iteration: the standards for new and existing buildings and the numbers of each. With the energy consumption standard for existing dwellings and the rate of demolition fixed, the 2,000 kWh is the result for all new homes built since 1996. As over 1m have been built between 1996-2005, the remaining construction has to achieve a zero heating demand by 2020 at the latest.

Beyond space heating, energy is used for two main categories of energy service which are common to both existing and new buildings: hot water and lights and appliances. The demand for hot water is increasing, so the energy to provide this is assumed to offset improvements in the efficiency of the standard boiler. As a result, delivered energy use is taken to be 5,000kWh in both 2005 and 2050.

The use of lights and appliances (including cooking) result in an electricity consumption of about 3,000 kWh in 2005 and, with considerable policy direction, is assumed to be reduced to 1,680 kWh pa by 2050. The main reductions are in the electricity used in lighting, refrigeration and consumer electronics, below what would have happened otherwise. This is about the lowest possible conceivable level and also requires constraint on the part of householders, for instance there is a decline in the purchase of additional, inessential or inefficient equipment, such as patio heaters and plasma TVs. This constraint has been encouraged through the introduction of personal carbon allowances.

As a result, total energy demand in an existing UK home is reduced by 2050 to 70% of the 2005 level: barely on the way to sustainability. Any remaining carbon reduction has to come from the way that the energy is supplied and the next section looks at the potential for building-integrated or community-based micro-generation.

Quantity of micro-generation installed

Across the whole housing stock, both existing and new build, there are major opportunities for the installation of micro-generation. In this context, micro-generation is taken to include all the technologies listed in Table 2. Some combined heat and power is based on community schemes, but most is individual units, within the home.

	Heating only	Heating & Electricity	Electricity only
Low-carbon	Heat pumps	Combined heat & power (CHP)	-
Zero-carbon	Solar thermal, biomass boiler/stove	CHP using energy from waste or biomass	Solar PV, micro-wind, micro-hydro

Table 2. Potential micro-generation technologies

The quantity of micro-generation installed is based on the following influences:

- all these technologies are already known and, where they are not yet commercial, will become so in the next decade or so;
- demand for micro-generation is increased partly through the requirements in the Building Regulations and partly as a result of conditions attached to planning permission by local authorities;
- as a result, there is a reduction in costs and an increase in experience within the construction industry;

- cost-effectiveness is not the sole criterion for householders, many of whom are also motivated by concern for the environment and a desire for a degree of independence from the national electricity and gas networks. This is enhanced by personal carbon allowances;
- there may be financial incentives to install combined heat and power, as this contributes usefully to reducing peak electricity demand and contributes to national electricity security;
- micro-wind is not installed on many homes until the technology is better suited to the prevailing wind characteristics found in urban areas;
- some properties have both solar thermal and photovoltaics, but these installations are limited to roofs facing an appropriate direction.

As a result of the reduction in the use of electricity in lights and appliances and the installation of micro-generation, it is perfectly feasible to envisage the residential sector becoming a net exporter of electricity, over the year. This would occur if 10% of homes have photovoltaics, 35% of homes have individual chp (either sterling engine or fuel cell) and 15% of homes have community chp.

Another implication of this scenario is that peak electricity demand has been reduced by 25GW, which is the equivalent to the amount of nuclear and coal-fired power generation expected to be phased out by 2025.

The majority of space heating comes from the chp, which is initially gas-fired and then hydrogen-powered fuel cells. Where gas is not available, electric ground-sourced heat pumps are installed. Over 12% of homes have solar water heaters, which provide up to 50% of their hot water needs.

This is a substantial quantity of micro-generation, but the technology is available and could easily be incorporated into the housing stock. Whether it could result in a 10% housing stock will depend upon policy decisions that also include the quantity of new build and the shape of the rest of the electricity generation system.

Reference

Boardman, B et al (2005), *40 percent house*, Environmental Change Institute, University of Oxford, Oxford. (www.40percent.org.uk).