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Potential for improvement in UK housing stock

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Energy costs for housing in the UK amount to over £11bn each year. Although most people immediately think of space heating in this context, in fact space heating costs constitute less than 40 per cent of the total. Electrical appliances, hot water, cooking and lighting are the other so called 'end uses' in housing, while standing charges also make up well over 10 per cent of the bill. Savings are possible for each of these end uses, but to differing degrees, and dependent on circumstances. In this article, Dr Hunter Danskin of the EEO takes a very broad view of the savings potential in the existing stock, in some cases for quite hypothetical situations. The figures in no way represent targets, or forecasts of what might happen by any particular date in the future – not least because some of today's stock will have disappeared, and new buildings will have been added. Nevertheless, the figures do illustrate the scale of inefficiency which currently exists in our housing.

Breakdown by End Use Figure 1 illustrates this for 1988, both by Delivered Energy (ie measured at the house meter, domestic oil storage tank or coal bunker) and by cost (at today's prices), with standing charges for electricity and gas included separately in the total. An important point to note is that, although space heating does dominate the consumption, when it comes to costs the much higher price of electricity (over 5.9p/kWh) compared to that of the dominant heating fuel, gas (around 1.3p/kWh) brings household electricity appliances into a more important position.

Potential for improvement

Introduction Energy efficiency improvements can manifest themselves as reductions in consumption for the same level of service (eg constant temperature), or as improvements in service for the same consumption, or as a mixture of the two. The value to the occupant of the higher temperatures can be estimated from the costs of additional fuel which would have been required to achieve the same temperature rise at the original level of insulation. In the improvements discussed in this article, their values are estimated on the assumption that the levels of service remain constant.

Definitions Before going any further, it is important to understand what we mean by 'potential'. In essence, it represents what is left to be done, or saved, at any particular instant of time; for example, the savings available if all the remaining unfilled cavity walls were filled. It is immediately obvious that this is quite different from any *forecast* of savings by a given date in the future, which would have to take account of the number of new, unfilled cavity-walled houses to be built by then, the number of old unfilled ones demolished, the rate of retrofilling, as well as changes in heating consumption arising for other reasons.

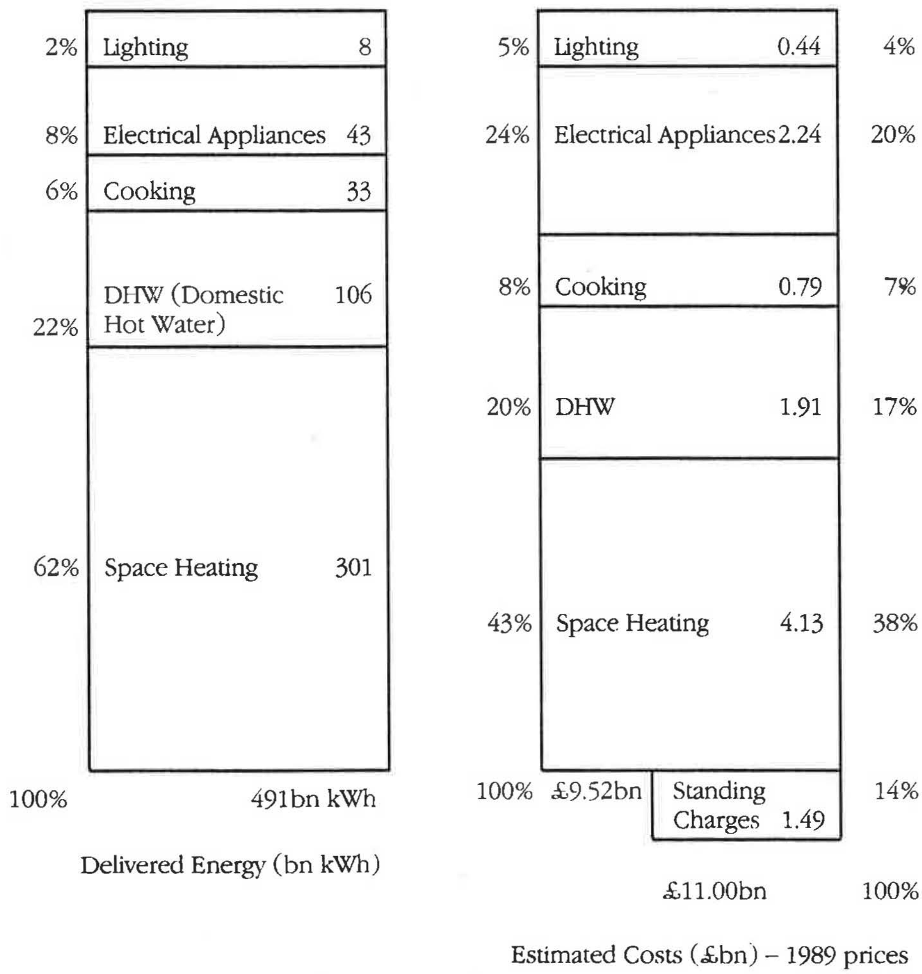
The value of estimates of potential is in setting a scale against which other achievements or targets can be measured. To give the reader full value for money, this article looks at five different definitions of potential, in order to illustrate how the scope for savings in the housing stock increases first with the simple addition of energy efficiency measures, then with more complete refurbishment, and finally with complete renewal of the stock.

The five cases are defined by the measures undertaken, and are broadly as follows:

- Case 1 – generally acceptable to householders (ie with a payback on energy savings alone of no more than 3-4 years);
- Case 2 – generally regarded as economic when the wider benefits are also included (eg reduced repair and maintenance, extended lifetime of the building);
- Case 3 – entire stock rebuilt to best Demonstration Project standards, and fitted with the most cost-effective high efficiency appliances;
- Case 4 – entire stock rebuilt to best technical standard available today, and similarly equipped;
- Case 5 – as for Case 4, but to standards expected to be available by 2000.

Each case is discussed more fully below. For each end use, a broad estimate is given for the potential savings, based on more detailed calculations for individual measures and then rounded to the nearest 5 per cent. Although such details

Figure 1: UK consumption and estimated costs by end use, 1988



are not quoted here, where possible, a simplified order of magnitude estimate is provided to give the reader a 'feel' for the figures.

Case 1 – Acceptable to householders

TABLE 1: Percentage savings for each end use

Space heating (1) *%*	30
Hot water %	5
Cooking %	—
Electrical appliances %	—
Lighting %	15
Total energy (2) *%*	20
Total energy costs (3) *%*	15

Footnotes: (1) Savings as per centage of total space heating consumption; and similarly for other end uses.
(2) Total energy savings as per centage of original total energy.
(3) Total cost savings as per centage of original total costs excluding standing charges.

Space heating Space heating savings arise in two ways, the larger contribution (25 per cent) from reduced heat losses and the smaller (5 per cent) from improved efficiency and control of the supply.

The heat necessary to maintain indoor comfort (and which is ultimately lost through the fabric and by ventilation) is supplied both by fuel used in heating systems and by 'incidental gains' from cooking, electrical appliances and lights, occupants and some solar gain. BRE estimate that, for the stock as a whole at the present time a 1 per cent heat loss reduction leads to a 1.5 per cent saving in fuel.

In a typical uninsulated home, cavity wall and loft insulation, together with draughtproofing, can reduce heating energy consumption by around 50 per cent. Most homes now have some loft insulation, about 40 per cent have some draughtproofing, but only 2.5 million out of 14.5 million have their cavity walls insulated – of the remaining 12 million, perhaps 2 million are unsuitable for cavity insulation. Therefore, a 50 per cent saving in 50 per cent of the (total) stock of 21 million dwellings is not unreasonable, especially if suspended ground floors with easy access (assumed to be 25 per cent of all ground floors) are also insulated.

Older central heating boilers (ie older than 10 years) will generally have efficiencies just above 60 per cent, often be part of systems with poor controls (thereby reducing the system efficiency by another 10-15 per cent), and be nearing the end of their useful lifetimes. New, well controlled systems with condensing gas boilers achieve annual efficiencies of 85 per cent and over. Householders would find it cost-effective to replace the estimated 2 million 15-year-old (and older) boilers with condensing boilers, and this would raise the national average heating system efficiency from around 60 per cent to 63 per cent, resulting in an energy saving of almost 5 per cent. Replacement of other old equipment would raise the overall saving figure to over 6 per cent.

Domestic hot water: The improvement is assumed to be similar to that for central heating appliances, ie 5 per cent.

Cooking: There is no evidence to suggest that householders will install more efficient appliances on energy grounds alone.

Electrical appliances: As for cooking.

Lighting: Low energy lamps come in several forms which affect their price and, to a small extent, their efficiency. The familiar fluorescent tubes, found in many kitchens, normally have a separate ballast and starting mechanism in the light fittings, and use around 25 per cent as much electricity as normal (GLS) tungsten lamps. Compact fluorescents, used as plug-in replacements for ordinary GLS bulbs, come with integral ballasts and cost around twice as much as those without. In addition, electronic ballasts – whether integral or detached – cost more than conventional ones, but cut electricity consumption even further, to 20 per cent of that of a normal (GLS) bulb of equivalent light output, instead of to 25 per cent. On the plus side, fluorescents have much longer lifetimes than conventional bulbs, typically 6-8,000 hours instead of 1,000 hours, ie around 4-6 years of normal use in a living room instead of 9 months. In such a situation a 20W compact fluorescent with integral electronic ballast could cost around £15.50 and have a payback period of under 2 years. The less efficient 25W fluorescent with integral conventional ballast costs around £10.50 and has a shorter payback, but saves less energy.

In absolute terms, the largest energy savings are from space heating (90.2bn kWh), while those from hot water (5.3bn kWh) and lighting (1.1bn kWh) are relatively insignificant. The position is similar on cost savings, though less pronounced, and the overall percentage cost savings are lower than for energy because the price of gas, the dominant heating fuel, is a factor of 3 or more lower than the price of electricity.

Case 2 – Economic on broader criteria (non-energy benefits included)

TABLE 2: Percentage savings for Case 2

Space heating %	40
Hot water %	10
Cooking %	—
Electrical appliances %	
Lighting %	60
Total energy %	28
Total energy costs %	22

Space heating: The fabric heat losses can be reduced further, principally because solid wall insulation may be justified in many of the remaining 8 million or so dwellings without wall insulation on the basis of wider economic benefits, eg reduced maintenance, extended lifetime of the building. Many of these buildings are more than 50 years old, or consist of 1960s tower blocks, and in both cases often require some remedial action, thus providing an ideal opportunity for upgrading insulation standards in walls, floors and roofs. Such improvements could contribute 30-35 per cent savings relative to the initial space heating consumption.

More efficient heating systems can contribute additional savings of around 10 per cent. It is probably cost-effective to replace all central heating boilers over 10 years old (estimated at around 3 million) by gas condensing boilers and the improved controls on these older systems will provide the additional 5 per cent improvement on top of the original 5 per cent in Case 1.

Hot water: Improved Appliance Efficiency, as above, now gives 10 per cent.

Cooking and Electrical appliances: No change from Case 1.

Lighting: Assuming (1) that 10 per cent of existing lighting consumption is by fluorescent tubes (in kitchens) and (2) that a further 10 per cent is not yet suitable for compact fluorescents, eg unacceptable colour, 60-65 per cent overall savings can be cost-effectively achieved by compact fluorescents for the remaining load.

Case 3 – Best economic standards for new build

TABLE 3: Percentage savings for Case 3

Space heating %	75
Hot water %	15
Cooking %	15
Electrical appliances %	20
Lighting %	65
Total energy %	53
Total energy costs %	45

Space heating: BRECSU's Demonstration projects in new housing have produced savings of 60-70 per cent relative to the 1982 Building Regulations average consumption, ie about 70-80 per cent savings relative to the mean value for the present UK stock. Savings from reduced heat losses alone are around 70 per cent, and from more efficient heating systems alone, about 15 per cent. The combined

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effect of these is an overall saving of 75 per cent – not 85 per cent as one might first think. This is because the 15 per cent heating system savings apply to a very much smaller heating load, only 30 per cent of the original once the extra insulation is in place. Since 15 per cent of the remaining 30 per cent is only 4.5 per cent of the original, the total saving is 70 per cent + 4.5 per cent of the original, ie almost 75 per cent.

The boilers are usually the most efficient conventional ones in these highly insulated houses, since at present prices, condensing boilers are not yet cost-effective. In fact, central heating is necessary only in the largest dwellings, which means that the overall capital cost of these low energy dwellings is only marginally above that of the corresponding standard houses (see references 1-3 for more details).

Hot water: Improved system efficiency, as explained above, gives 15 per cent.

Cooking: Since the whole stock would be equipped with the latest 'standard' models – not necessarily the most efficient – an educated guess of 15 per cent savings does not seem unreasonable.

Electrical appliances: As for cooking, currently available appliances popular with consumers are at least 20 per cent more efficient than the stock average.

Lighting: Starting from scratch, it is cost-effective to install the electronic version of compact fluorescents (80 per cent saving) for the same 80 per cent load as in Case 2, giving 65 per cent savings overall.

Case 4 – Best current technical standards for new build

TABLE 4: Percentage savings for Case 4

Space heating %	85
Hot water %	30
Cooking %	20
Electrical appliances %	40
Lighting %	65
Total energy %	65
Total energy costs %	57

Space heating: In principle heat losses can be reduced almost to zero, but at least 80 per cent risk-free savings should currently be possible. The widespread use of condensing boilers (at 85 per cent annual efficiency) would save some 30 per cent relative to the current mean efficiency of around 60 per cent. [Note that the percentage increase in efficiency –

$$\frac{85-60}{60} \times 100 \text{ per cent} = 41.7 \text{ per cent}$$

– is not the same as the corresponding percentage reduction in energy consumed, which is actually –

$$\frac{85-60}{85} \times 100 \text{ per cent} = 29.4 \text{ per cent}$$

If this seems odd, think of the corresponding figures when the efficiency improves from 50 per cent to 100 per cent: here, the efficiency improvement is 100 per cent (a doubling) of the original efficiency, while the savings are 50 per cent (a halving) of the original *consumption* – a 100 per cent saving means consumption disappears altogether.] After that digression the combined effect on the space heating is a reduction of 85 per cent on the original total.

Hot water: The space heating condensing boilers could also provide hot water at similar high efficiencies.

Cooking: 20 per cent is another 'guesstimate', but there seems only limited scope for improvement, possibly from increased use of microwave ovens.

Electrical appliances: Savings possible from the most efficient appliances currently available, though sometimes with reduced services or space, are 30-60 per cent relative to average new appliances, themselves 10-20 per cent better than the stock average. Improvements are lowest in washing machines, highest in freezers. An average of 40 per cent is assumed.

Lighting: The best available are all cost-effective, so the improvement is the same as for Case 3.

Case 5 – Best technical standards expected by 2000

TABLE 5: Percentage savings for Case 5

Space heating %	90
Hot water %	35
Cooking %	25
Electrical appliances %	50
Lighting %	70
Total energy %	70
Total energy costs %	63

Space heating: Continuing demonstrations of risk-free higher insulation levels, plus possibly slightly improved materials, might justify heat loss reductions of 85 per cent. Developments in condensing room heaters and boilers, and in heat delivery systems, might raise annual efficiencies to nearly 90 per cent, with savings of almost 35 per cent. The combined savings would then amount to 90 per cent.

Hot water: Either higher efficiency condensing boilers (as above) for combined space and water heating – but with attendant storage losses, or else higher efficiency point-of-use gas-fired water heaters, might give a small further improvement on Case 4, say to 35 per cent.

More radical changes, eg electric point-of-use heaters powered from CHP schemes, or the use of district heating water (via a calorifier) from CHP may not be widely available in the UK by 2000.

Cooking: 25 per cent is another guesstimate for marginal improvements, perhaps in gas burner design, and in use of microwaves.

Electrical appliances: Prototype appliances in the USA offer further improvements at present, and by 2000 may have recovered the amenity and convenience features currently sacrificed to higher efficiency. 50 per cent is an educated guess for an average over all household appliances.

Lighting: Further marginal improvements, eg in colour rendition, could make compact fluorescents acceptable everywhere, ie 80 per cent saving for 90 per cent of the existing load, or over 70 per cent overall reduction.

Conclusions

Space heating costs fall most dramatically, are less than those for Appliances and Hot Water by Case 3, to become the smallest – apart from Lighting – in Case 5. By then, Electrical Appliances constitutes the largest energy cost, although if service charges were to remain unchanged they would then become the largest single cost. In fact, this situation has already occurred in Giffard Park in Milton Keynes (ref 2).

Table 6 summarises the relative savings from all five cases, by expressing the savings in each end use in each case as a percentage of the original 1988 total costs, including Service Charges. It is clear that space heating always makes by far the largest contribution, each time greater than all the other savings put together. The reasons are that (like lighting) it offers most intrinsic scope for improvement, and also that (unlike lighting) it dominates current costs and consumption. This huge potential, of course, is the reason why most efforts in the housing sector have been devoted to reducing space heating. In the medium term, none of the other end uses stands out as an obvious priority on this analysis although environmental considerations would probably point to electricity end uses for consideration next.

References

(1) Low-energy local authority housing with reduced construction costs, Energy Efficiency Office, EPP 245, May 1989.
(2) An integrated design for energy efficient cooperative housing – A demonstration at Giffard Park, Milton
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