SUSTAINABILITY AND THE DEVELOPMENT OF AN ENERGY EFFICIENT HOUSING STOCK: A REVIEW OF SOME THEORETICAL ISSUES

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SUSTAINABILITY AND THE DEVELOPMENT OF AN ENERGY EFFICIENT HOUSING STOCK: A REVIEW OF SOME THEORETICAL ISSUES

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ABSTRACT

Global stabilisation of carbon emissions may require emission reductions of 60 percent in the first half of the next century and governments are placing increasing importance on energy efficiency in carbon abatement policies. However a large gap exists between what is possible and what has been achieved to date. This paper seeks to discuss the fundamental issues which should be addressed in the definition and application of energy efficiency policy designed to close the gap. It also addresses the likely impact of take-back effects (the Brookes-Khazzom postulate). The paper argues that despite the considerable work on the problem, the mechanisms which determine the propensity of individuals and organisations to invest in efficiency improvements are not well understood and that greater attention should be paid to motivational factors if a more complete understanding is to emerge.
Keywords: climate, energy, housing, sociotechnical change, motivation

1. INTRODUCTION

The stabilisation of global concentrations of atmospheric carbon is one of the most important challenges of sustainability faced by the world community. There is widespread agreement within the scientific community that failure to achieve this objective could result in major changes to the earth's climate as global temperatures rise (the so called greenhouse effect). If no action is taken to reduce carbon emissions (mainly resulting from the burning of fossil fuels) global temperature rises of 1 - 3.5 K can be expected in the next century, producing, even at the lower end of the range, a rate of change not seen since the evolution of the humans (Houghton 1996). Work by Lowe (1997) based on IPCC carbon trajectories (See Houghton 1996) and previous work by Krauser et. al. (1990), estimates that emission reductions of about 60 percent may be required by 2050 if carbon concentrations are to be stabilised by 2100 and significant interference with climate systems avoided.

Political consensus on the need to tackle this issue resulted in the adoption of the Kyoto protocol in December 1997. Under this protocol a target of a 5.5 percent reduction in global emissions of greenhouse gases[1] (the "basket of six") by 2008 - 2012 was agreed. Following discussions within the European Union, the UK agreed to

[1] A "basket" of 6 gasses is included in the Kyoto protocol - carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6). Although the least potent of the six gases, CO_2 is emitted in much larger quantities than the other five and is estimated to contribute about 80 percent to global warming (DETR 1998).

a reduction target of 12.5 percent. The UK government also aims to reduce CO_2 by 20 percent by 2010. Although the levels agreed at Kyoto do not approach the scale of reductions indicated above, they represent an important step in the development of the necessary political momentum. Achieving the sort of reductions, which the estimates by Lowe (1997) suggest, will require action across a wide range of activity. Energy efficiency is at the centre of international and national emission reduction programmes because it offers the prospect of reduced emissions with a reasonable standard of living for all. This paper focuses its attention on the contribution to climate sustainability which can be made through the development of an energy efficient housing stock.

2. EFFICIENCY POTENTIAL IN THE HOUSING SECTOR

In 1996 the domestic sector accounted for 28 percent of CO_2 emissions in the UK, this compares with transport at 25 percent and industrial sector emissions at 27 percent (DETR 1998). Clearly, savings in the domestic sector could have a significant impact on national emissions. The technical potential for energy efficiency improvements in housing have been well demonstrated by a great many housing schemes across the world. Figure 1 compares the energy consumption, per m^2 of floor area, for a range of schemes against the average for Great Britain. The York scheme (Bell and Lowe 1997a and 1997b) demonstrates the application of cost effective improvements in existing housing (both those achieved and an estimate of the remaining potential, assuming no major structural alterations), the Longwood (Lowe and Curwell 1996) and Kranichstein (Feist 1994) schemes are traditional new build schemes built in the early 1990s. Other new build schemes have been constructed which demonstrate not only the very large potential which exists but also that the potential can be realised using a range of construction techniques which are within the scope of traditional construction methods and styles (see Olivier and Willoughby 1996a and 1996b). A review of building codes (Lowe and Bell 1998) suggests that space heating consumption in new UK dwellings could be reduced by 50 to 85 percent by adopting codes applied elsewhere in Europe.

In the case of electrical appliances and lighting, estimates of savings which are technically and economic feasible could result in electricity savings of 33 percent by the year 2010 when measured against a “Business as Usual” reference case scenario. These estimates are based on proven technology and on economic viability measured in terms of revenue savings over the appliance life and additional purchase price. The theoretical potential for savings is, however, much greater than this (Boardman et. al. 1997). The gap between the most efficient appliances available and those in wide circulation can be very large, particularly in the case of refrigerators and freezers. In their summary of the potential for increased efficiency in refrigerators, Weizsäcker et. al. (1997) point out that the best mass-produced models on the US market in 1990 (using 1.32 kWh/year/litre) were already surpassed by a Danish model available in 1988 with a performance of only 0.45 kWh/y/l; some 66 percent more efficient. They also indicate that improvements in insulation techniques (principally vacuum insulation panels) and compressor design could reduce consumption to below 0.2 kWh/y/l, a reduction on 1990 levels of over 85 percent. Work by Nørgård (1989) over ten years ago demonstrated the potential for appliance electricity consumption reductions of 74 percent with technology available over ten years ago in 1988.

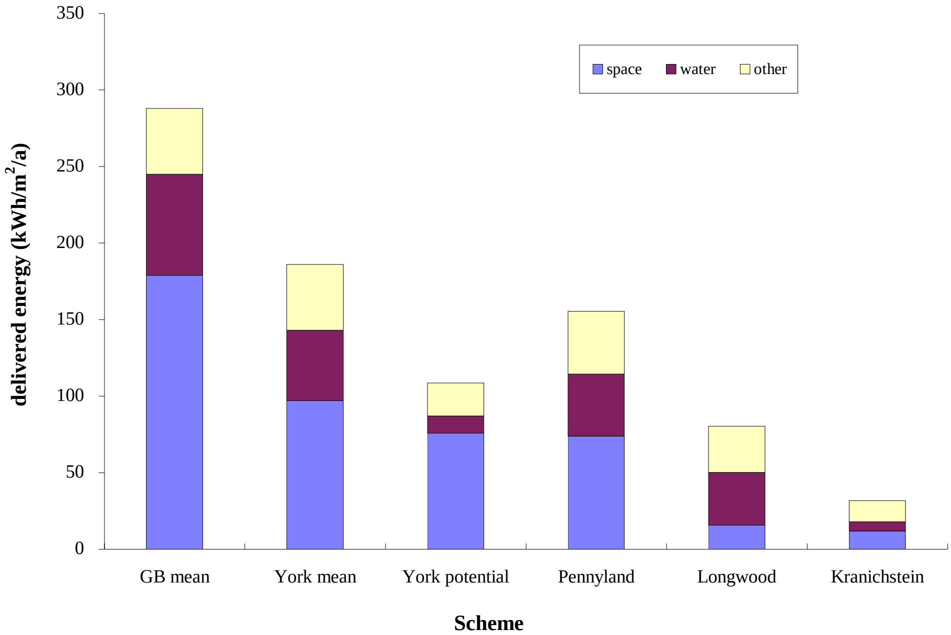

Figure 1 Comparison of energy efficiency in housing schemes
Source: Bell and Lowe 1997b

3. THE POTENTIALITY GAP

The scope for technical efficiency improvements in housing is matched in other sectors. Weizsäcker et. al. (1997) present 30 examples of the potential for very large reductions in resource and energy consumption in a variety of spheres with no reduction (and often improvements) in the level of service provided. It is however too easy to conclude from this that the solution, at least in principle, is simple; that all we need to do is to implement the cost effective measures and watch energy consumption and carbon emissions fall in line with the technological improvements. It is, of course, not that simple. Many of the measures available have been known about for decades and their cost effectiveness well established, yet they are not applied in significant volume and although improvements have taken place, the pace of change is slow. The complexity of technological, economic and social systems is great and there is no simple link between efficiency and consumption. In fact the growth in consumption since the beginning of the industrial revolution has often gone hand-in-hand with greater energy efficiency as populations increased their demand for energy services made cheaper, at least in part, by improved efficiency. What exists is a large gap between the potential and the achievement and it is this gap which energy and environmental policy in all sectors should address.

The existence of a large gap between what is technically and economically feasible is clearly illustrated by the uptake of cavity wall insulation in the UK. Despite the fact that the technology has been available for over two decades and pay-back times short (less than two years in many cases) uptake is extremely low. By 1996 only 24 percent of cavity walls had been filled with the rate of uptake slowing down rather than accelerating. During the 1980s the proportion of the potential stock with insulation grew by 1.21 percent per annum but in the first seven years of the 1990s (a decade when a great deal of new dwellings would have had cavity wall insulation because of building regulation changes in 1990) the growth rate was only 0.31 percent per annum (Shorrock and Walters 1998). It would appear that increased government activity on domestic energy efficiency through advertising campaigns and the establishment of local energy advice centres in the 1990s, seems to have had little effect on the uptake of this measure.

The availability of efficient electrical appliances reveals a similar picture with the average new refrigerator on the UK market in 1996 consuming 270 kWh/y compared with a technical and economic potential of 40 kWh/y, a reduction of 85 percent (Boardman et. al. 1997)[2]. A brief visit to a branch of a national electrical appliance retailing chain suggested that, at least in the case of refrigerators, very little change has taken place in the energy efficiency of goods on sale from the 1996 figure quoted by Boardman et. al. In terms of the European Union energy label (see Refrigeration Label Directive 84/2/EC) only one "A" rated appliance was available with a quoted energy consumption of 0.78 kWh/l/y the majority were in the B to D categories with consumption figures ranging from 2.23 kWh/l/y to 1.46 kWh/l/y. A comparison of these figures with those discussed by Nørgård (1989) would suggest that when measured against the best available in 1988 (0.45 kWh/y/l) even the "A" rated refrigerator falls some way short of what is possible. Data given in Weizsäcker et. al. (1997) on United States appliance standards for refrigerators would suggest that only EU "B" rated appliances would meet United States 1990 standards (1.52 kWh/l/y) and only "A" rated appliances would satisfy standards introduced in 1993[3].

4. REALISING THE POTENTIAL

Reducing carbon emissions to the levels needed to avoid major climate change will depend, at least in part, on reducing the gap between what is achieved in practice and what is technically feasible. It is, of course, to be expected that some form of gap will always exist as technology continues to change and the its implementation lags behind. The problem for policy making, however, is to keep the gap as small as possible. As indicated above, the gap in the domestic sector is very large despite the availability of technology which is over 20 years old in many cases. The framing of policy in this area must address a number of major issues as discussed below.

4.1 Market imperfections and barriers

The gap between what is technologically feasible and cost effective and what is done in practice is often explained by the existence of market imperfections and other non-

[2] The potentiality gap in cold goods is perhaps the largest of all appliances, for washing machines the potential is about 28 percent and for ovens it is around 52 percent (Boardman et. al. 1997).
[3] It must be remembered, however, that refrigerators in the USA are much larger and consume more energy overall than typical European models.

technical barriers. If households acted in a rational manner (at least from an economic point of view) one would expect cost effective improvements to be carried out. The fact that the uptake of improvements is slow and that they are often sub-optimal suggests that the market is not operating in a perfect way. One of the most common themes in the literature, is the lack of information about what is possible and the various costs involved. A review of the literature by Bell et. al. (1996) suggests that the lack of information goes even further than this in that the very notion of efficiency is not well understood and that for many consumers reducing energy consumption is seen, primarily, as an exercise in deprivation, leading to a net cost rather than a net benefit. Imperfections in information can exist at all levels from policy makers and regulators who are not aware of the potential (or are confused by conflicting information) through intermediaries such as designers, sales personnel and capital providers to consumers themselves. This sort of analysis has lead to the adoption of advice programmes for householders and best practice programmes for construction and housing professionals in an attempt to fill in the missing ingredients.

The difficulty with attempting to tackle market imperfections which arise from a lack of information is that its provision in a meaningful way is fraught with difficulties. Information needs are often very complex and it is almost impossible to clearly demonstrate, empirically, the energy savings which result from any attempt to provide information. It has even been argued (Inhaber 1997) that the provision of information may actually increase energy consumption if it reveals that energy is cheaper than consumers had previously thought! In the analogous area of the provision of energy advice to households, evidence of the positive impact of information and feed-back on energy consumption is very inconclusive with one of the most recent studies showing no change in consumption despite a well designed information package (Walker and Oseland 1997).

A large range of other barriers to closing the gap have been identified such as the landlord - tenant divide in which capital expenditure by the landlord brings savings to the tenant with no return on capital (Bell et. al. 1996) or the resistance of a traditional construction industry to well proven technological improvements in the construction of new housing (Lowe and Bell 1998). As with the provision of information, overcoming the various barriers requires a wide range of solutions which will almost certainly display considerable interdependence. Various analysts have attempted to do this. Weizsäcker et. al. (1997) identify a broad range of possibilities, most of which are based on some form of market intervention in an attempt to redress what are perceived as market failures. Similarly, Boardman et. al. (1997) argue for a “market transformation” policy for domestic electrical appliances which would use a mixture of information (energy labels), regulation, and tax incentives or rebates in an attempt to improve the efficiency distribution of appliances on the market. All have their problems not least of which is the willingness of governments, utilities and the private sector to agree on which ones are acceptable.

4.2 Sociotechnical change

The difficulty with an approach which seeks the rectification of market imperfections and the surmounting of non-technical barriers is that it is apt to focus on specific problems without addressing the wider picture. It has been argued (Shove 1998) that this “conventional package” which depicts a high level of technological potential hindered by an imperfect market and non technical barriers, does not reflect the complexity of change process and is unhelpful in the development of policy. The core of Shove’s argument is that the technical and social are inextricably linked and that the analysis of the problem and development of solutions cannot split the two. The discussion emphasises the importance of the social context in which decisions about energy efficiency are taken and that context, is as powerful for organisations as for individuals.

A comparison of the uptake of two important efficiency measures in the housing stock will help to illustrate some of the issues at the level of the individual. As we have already observed, the uptake of cavity all insulation remains low and, if anything, the rate is slowing down. This contrasts sharply with the uptake rates for double glazing. Despite the fact that from a technical point of view double glazing is much less cost effective than cavity wall insulation, its uptake is greater by a factor of two with just under 50 percent for dwellings having 60 percent or more of windows double glazed (Shorrock and Walters 1998). Looked at overall, this is not irrational behaviour but an attempt to satisfy a wide range of non energy requirements such as repair, improved comfort, reduced noise and aesthetic enhancement. Energy efficiency is likely to be only a small factor in the decision and may not be considered at all in many cases. The contrast in uptake may also be coupled with a positive image of double glazing contrasting sharply with some of the rather negative perceptions which have dogged the cavity wall insulation industry over the last twenty years. The social context and the influences of socially transmitted concerns about the merits of cavity wall insulation provide a backdrop to decision making which seems to overturn (or at lest mitigate) purely technical issues.

The social context in which the organisation operates can also act to foster or inhibit the application of efficient technology. In a paper on CO_2 abatement policy and technology Grubb (1997) stresses the importance of understanding the processes of technological change in the framing of climate change policy. Among other things, Grubb (1997) identifies the inhibiting effects of clustering and the tendency to lock-in and lock-out certain players and technologies. This is the observation that industries (or, perhaps large companies) who have made a considerable R&D investment in developing and modifying their products will seek to preserve their position and try to “lock-out” others who could disturb the status quo. Interdependencies between players both within and between industries will lock individual players into existing approaches and technologies and drive them down parallel interdependent paths. An interesting example of this in house building, can be seen in the attempts by steel lintel manufactures to maintain their position in the cavity lintel market despite the intrinsic thermal bridging involved in many of their products, even to the extent of inserting insulation into their various steel box sections in an attempt avoid the problem. From a technical point of view, such an attempt is futile because it seeks to set aside the laws of physics. But; and here’s the rub, in the interdependent social domain of supplier and contractor, who cares about the laws of physics? The components are widely used in the belief that they are achieving the required performance. In a similar vein, the use of timber “I” beams in roof construction, providing considerable insulation opportunities with minimal thermal bridging, will face stiff opposition by trussed rafter manufactures as they attempt to protect their investment over the last 20 or 30 years.

The insight provided by Shove (1998), is that a shift in the definition of the problem from one which is technical first and social second alters the landscape of the discussion and the search for solutions. Instead of developing the technology first and then seeking to identify barriers and ways round them, a sociotechnical approach would consider the problem in a more holistic way and it may be that solutions would emerge which avoid the use of energy consuming technology altogether. Although this alters the landscape of the discussion, it still leaves unanswered the question of how we are able to realise the sociotechnical potential for reducing energy consumption in dwellings. Before we return to that problem there is another aspect of the realisation of energy efficiency potential which must be considered.

4.3 Does energy efficiency reduce energy consumption?

The common sense answer to this question would appear to be "yes" and this seems to be the conventional wisdom behind the energy policy of most governments. However, for the last 20 years a debate has been raging between economists and between economists and conservationists about the wisdom of this view (for a wide ranging review of this debate see Herring 1998). The apparently counter intuitive view that energy efficiency may lead to an increase in energy consumption has been referred to as the Khazzoom-Brookes postulate (Sanders 1992) in recognition of the contribution of Brookes (1990) in the UK and Khazzoom (1980) in the USA. The basis of the argument rests on the fact that an increase in the efficiency with which energy is used reduces the effective cost of energy services such as heat, light and clothes washing. This intrinsic reduction in energy price can have two effects; in the first place it can stimulate increased demand for energy (the "take-back" effect) and in the second place, energy efficiency can improve overall productivity in an economy which will feed back into economic growth, which in turn will feed into higher incomes and enable consumers to afford more energy services. It is possible for these two effects to counter the initial reduction in consumption resulting from increased efficiency. The theoretical limit of the first effect would be to bring consumption back to the level prior to the efficiency improvement but the second effect has the potential to increase consumption further, such that an improvement in efficiency could actually increase energy consumption.

While it is possible to see the "take-back" effect in operation particularly, in such things as increased warmth in low income households, the extent of this and the more general feed-back into the macro economy is the prime area of debate. Howarth (1997) points out (after work by Greening and Sanstad 1995) that the take-back effect may be much smaller than has been suggested because of the saturation of energy services (if comfort conditions have been reached no more heat is required) and the fact that energy costs are often only a small fraction of the total cost of owning and operating equipment which produces energy services. Howarth's exploration of the neoclassical growth model used by Sanders (1992) takes up this last point. He concludes that if the model were adjusted to reflect the part energy consumption plays in the provision of energy services, the prediction of Sanders' model would only hold good if energy expenditure played a large part in the provision of energy services and that expenditure on energy services constituted a large part of economic activity. Howarth also comments that: “Since casual observations suggest that neither of these requirements is satisfied in real-world economies ……… the macroeconomic feedbacks of energy efficiency may be less substantial than Sanders’ initial study suggests….” (Howarth 1997 p. 3)

The empirical literature on energy consumption and CO_2 emissions demonstrates the restraining effect of improved energy efficiency and changes in the carbon content of the electricity primary fuel mix. Work by Schipper et. al. (1997), which analysed energy consumption and CO_2 emissions in ten industrialised countries over the last twenty to thirty years, and Golve and Schipper (1997) concentrating on the USA, conclude that rises in GDP have exerted an upward pressure on emissions but that this has been largely offset by a decline in the energy intensity of end uses (as a result of improved energy efficiency) and a decline in the carbon content of energy. A review of the available evidence by Greening and Green (1998 - reported in Herring 1998) leads to the view that the rebound effect is not large enough to nullify the effect of energy efficiency improvements but that it would be unwise to rely on energy efficiency alone in ensuring the large reductions in carbon emissions likely to be required. They also point out the importance of such things as fuel taxes and other economic mechanisms designed to discourage significant take-back on efficiency improvements.

Whatever view is taken about the magnitude of the rebound effect, there can be little doubt about its sign. The problem for policy makers is not about achieving the potential efficiency improvements per se but about achieving them in such a way as to avoid an all consuming rise in demand. In other words; how can we have our cake and eat it?

5. A MATTER OF MOTIVATION?

At this point in the discussion it seems that we are beset with difficulties. It is very likely that large reductions in carbon emissions will be necessary from housing (as from all sectors), and that there is a large potential for efficiency improvements which could deliver lower emissions with no reduction in life style but realising the potential is fraught with difficulty and even if we did manage to pull it off, the potential savings could be squandered in ever higher demand. It has been argued (Weizsäcker et. al. 1997) that a way out of the problem will not emerge from conventional economics but from a re-evaluation of what constitutes a sustainable lifestyle in which wellbeing is not aligned with Gross Domestic Product.

In reviewing the above literature it is evident that there is very little discussion of what people actually do and why they do it. It is argued here that this leaves something of a hole in the analysis (perhaps not the only one) and that a more complete understanding of the problem could be gained from insight into motivational factors. Whatever the macro economists may say, the behaviour of societies is made up of the behaviour of millions of individuals who are motivated to do certain things rather than others. The provision of information and advice, proposals for environmental taxes or rebates are all based on the notion that they will encourage (motivate people towards) lower consumption, whether that be through investment in energy efficient capital or direct conserving behaviour. In its widest sense, motivation is at the heart of the whole issue, for it relates not only to why people (and organisations of people) invest or do not invest in energy efficiency but why they may respond with increased consumption as efficiency gains reduce the price of energy. To capture a particular price elasticity may enable the running of a macroeconomic model but it does not say anything about why the number is as it is or what would happen if circumstances changed. Observations about the large gap between attitudes to energy efficiency (generally very positive) and action to improve efficiency in the domestic sector suggest that motivating people to be more efficient through attitudinal change without addressing other aspects of motivation are likely to fail as are many price incentives (Bell et. al. 1996). Doggart and Grant (1997) report an energy management programme in commercial buildings which identified cost savings to building operators of between 10 and 30 percent at little or no cost but almost none of the organisations involved made the necessary changes and often displayed a defensive attitude when the potential was pointed out. This seems irrational behaviour until it is realised that motivational influences are much wider than was presumed by the energy management programme. What appears to be lacking is a model of motivation which can capture the essential characteristics of the human dimension in energy efficiency.

Psychology has grappled with the problem of motivation in human activity for most of this century and various models have been developed and applied in fields such as education and management but no attempt seems to have been made to relate them to the problem of energy consumption behaviour. One of the most all embracing theories is motivational systems theory (MST - Ford 1992). This theory seeks, first of all to place motivation in the context of effective functioning and then to model the constituents of motivation itself. For effective action to take place motivation must be supported by the necessary skills and biological capabilities together with a responsive environment which is able to provide the materials, information and skills needed for the attainment of some goal. All aspects are important but the motivational characteristics of an individual are of particular importance and interest. Of course motivation is not the same as action but it a psychological state which is a necessary precursor to action. According to MST, motivation is a function of Goals, Emotions and Personal Agency Beliefs.

The vast array of goals and the way they are ordered governs what we wish to strive for. The pattern of goals changes as our perception of their relative importance changes, creating a sort of dynamic goal fabric which is influenced by attitudes, social relationships, cultural norms and the like. If individuals do not perceive energy efficiency as a goal worth striving for, motivation will be non existent unless the perception is changed and/or it can be shown that it creates a pathway to some other valued goal. The influence of emotions is primarily in the way they provide evaluative information about interactions with the environment and by supporting and facilitating actions towards some desired goal. It tends to serve a regulatory function which helps in the initiation or abandonment of action, with efforts to cope with problems, and with social behaviours such as conformity, bonding as a team or being part of a group. Personal Agency Beliefs relate to an individuals perceptions of their personal ability to achieve a goal and of the responsiveness of the environment. It is, of course, a matter of perception not of absolute reality.

The use of a theory such as this may seem strange to technologists used to hard scientific notions which carry a set of underlying, often mechanistic, assumptions about how people respond to technological change (Shove 1998). However, the theory raises a number of important questions in the context of climate change and housing energy policy which have not been addressed in any fundamental way. What are the goals of households and how do concerns about energy efficiency filter through into goal sets which are salient enough to influence their motivation to take action? What happens when perceptions about energy efficiency conflict with other salient goals such as comfort (note that there does not have to be any actual conflict, the perception is enough to hinder motivation). The potential conflict between energy efficiency and health or comfort goals is illustrated by the work of Salvage (1992) which highlights a concern among elderly respondents for fresh air leading to windows being opened for considerable periods in winter. It is quite likely that beliefs about the impact of energy efficiency measures on comfort and health override any desire to reduce energy consumption (Williams and Crawshaw 1987).

What part does emotional arousal play in the motivation to invest? Perhaps the aesthetic and amenity value in having replacement double glazing has a much stronger emotional component (as well as satisfying a wider range of goals) than cavity wall insulation (see section 4.2 above). Emotions involved in social cohesion may have a part to play in decision making. For example Stern and Aronson (1984) identify social contacts as a powerful force in energy investment decisions and the framing of beliefs about the benefits of energy efficiency.

Assuming that strong positive attitudes to energy efficiency lead to appropriate goals and have a strong emotional component, how do Personal Agency Beliefs influence the motivation to conserve energy? Beliefs about the effectiveness of personal action or the existence of a supportive environment are of clear importance. The 1996/97 survey of public attitudes to the environment (DETR 1998) show that only 31 percent of respondents considered energy conservation to be the responsibility of individuals (as opposed to governments or other organisations). The corresponding figure for global warming was only 16 percent. Much of this result may well stem from the misconception that there is very little that individuals can do (especially if the term "global warming" is used in the interview). Again, however, it is the perception of ones ability to do anything to improve the situation that counts. Beliefs about a supportive environment such as the availability of cavity wall insulation installers capable of doing a good job may well influence an individual’s motivation to embark on insulation improvements.

6. CONCLUDING REMARKS

This paper was constructed to raise more questions than it can answer. That a large potential for energy efficiency in the domestic sector exists (at least in a purely technical sense) is not in doubt. However realising the potential and the reductions in carbon emissions which could result remains a very difficult problem to solve. Central to the debate is the way in which people operate, for they are more than a source of heat gain, they do not act on economic criteria alone, they have goals and perceptions about the world which influence actions and in the process they consume energy and emit carbon into the atmosphere. Our understanding of the processes at work is far from complete. It is clear that more research is needed and a broad range of theoretical constructs will be required and applied if the complexity of the problem is to be adequately reflected in policy.

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