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An economic appraisal of local energy conservation schemes

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This paper presents an economic appraisal of some work carried out in the homes of low-income families by local energy conservation schemes under the auspices of Neighbourhood Energy Action. Low-income families with their proportionately high expenditure on fuel and relatively low energy efficient homes are hard hit by energy pricing policies and unable to respond to government measures which seek to encourage energy conservation. Local energy conservation schemes may be seen as attempting to fill this gap left by general government policy. This paper concentrates on the economic appraisal from the perspective of the client households of the schemes and a model is developed of the benefits of energy conservation work. In connection with the latter, it is argued that it is crucially important to distinguish carefully between delivered energy and energy service.

Keywords: Domestic energy use: UK; Energy efficiency.

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Since the first energy crisis of 1973–74 UK government policy has sought to encourage the more efficient use of energy. Towards this end, successive governments have not only pursued rigorous pricing policies, but have also supported the installation of energy conservation measures in both the home and the place of work. Almost 30% of energy consumption takes place in the home and although there is evidence to suggest that government policy has had a sizeable impact, these policies have been least successful in addressing the problems of poor consumers. Indeed, it can be argued that energy conservation policies are likely to have a distributionally inequitable consequence. The poor and elderly spend a relatively large proportion of their income on fuel and are more likely to be living in low energy efficient homes. They are consequently hard hit by pricing policies and cannot afford to respond to the incentives to install energy conservation measures.

Neighbourhood Energy Action (NEA) is a National Council of Voluntary Organisations service and assists local communities to run projects which help to install energy conservation measures in low-income households. It serves, then, to help to bridge the gap in government policy with respect to poor consumers. The NEA local energy conservation schemes are associated in a loose federation and draw money from a variety of sources: the homes insulation programme to pay for materials; the Manpower Services Commission to pay for staff; the Department of Energy for seed corn grants to get the schemes established; the Department of Health and Social Security where households are eligible for single payments. Some also receive funds from local authorities and charities.

The aim of this paper is to provide an economic appraisal of the work undertaken by local energy conservation schemes under the auspices of NEA. The paper forms part of a larger study which seeks to evaluate the work undertaken by the NEA schemes.[1] The empirical findings refer to the answers given by some 310 client households of five of the local energy conservation schemes. The five schemes selected for the detailed analysis of client household reactions were selected following an initial survey of all the schemes known to NEA in summer 1982. The five schemes varied in their geographical distribution, type of sponsor, range and amount of conservation work undertaken, sources of funding and type of area (urban/rural) in which they operated.[2]

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Economic appraisal, domestic energy conservation and energy policy

Economics is about choice and economic appraisal is concerned with the evaluation of choice.[3] Thus the objective here is to evaluate the act of choice which resulted in economic resources being used in local energy conservation schemes. At the outset of an economic appraisal it is important that the objective of the act of choice that is being evaluated is clearly defined and here the objective of the NEA projects is taken to be energy conservation where the latter is defined as the more economically efficient use of delivered energy. This objective is taken in preference to the narrower one of achieving a reduction in the use of delivered energy and the reason for this is justified later when it is shown that a conservation measure can be economically efficient even if it leads to no reduction (or indeed even if it leads to an increase) in fuel expenditure. The NEA schemes may see themselves as having other objectives such as the temporary creation of jobs, the alleviation of fuel poverty and improving the housing stock, but these further objectives and the extent to which they reinforce or conflict with the objective of energy conservation are not discussed in this paper.

Also of central importance in an economic appraisal is an explicit statement concerning whose interests are to be taken into account. If the interests of all individuals in society are to be considered, then the economic appraisal can be referred to as a social cost–benefit analysis. But whose interests are to be included is not dictated by the technique of economic appraisal; instead the issue is best viewed as one aspect of the need to specify clearly the objective of the act of choice. In terms of the work undertaken by the local energy conservation schemes there are several groups whose interests might be considered. These include the clients of the schemes, the employees of the schemes, owners of property, various political groupings interested in achieving (or maintaining) power and society as a whole. In this paper the concentration is on the interests of the clients and broader social issues are not investigated.[4]

At the centre of the current Conservative government's policy on energy conservation is fuel pricing and the policy on fuel pricing is supported by information and advice and backed up by various financial incentives. That a pricing policy alone is unlikely to lead to an efficient pattern of energy use can readily be seen if a distinction is made between:

1. primary energy (fuel resources), for example, coal, crude oil, hydroelectric power;
2. delivered energy, for example coal, electricity, gas;
3. useful energy, for example, heat, power, light;
4. energy service, for example, increase in room temperature, or more generally changes in comfort levels.

The consumer is interested in (and gets wellbeing from) energy service, but this can only be bought indirectly by the purchase of delivered energy. Pricing policy on the other hand is concerned with primary and delivered energy and getting the price of these 'right' will only lead to an optimal price and hence optimal consumption of energy service if there are no economically efficient investments that can be made in the link between delivered energy and energy service. It is here that energy conservation measures come in.[5]

[1]The findings of the wider evaluation are summarized in S. Hutton *et al*, *Energy Efficiency in Low Income Households: An Evaluation of Local Insulation Projects*, Energy Efficiency Series 4, HMSO, London, 1985. More detailed results are reported in A. Corden *et al*, *Local Energy Conservation Schemes in the UK*, Working Paper DHSS 139/4.83. AC/RP/JB, Social Policy Research Unit, University of York, York, UK, 1983; R. R. Barnett, *Local Energy Conservation Schemes: An Economic Appraisal*, Working Paper DHSS 188/5.84.RB, Social Policy Research Unit, University of York, York, UK, 1983; S. Hutton *et al*, *The Impact of Local Energy Conservation Schemes in the UK*, Working Paper DHSS 185/4.84 SH/RP/JB/GG, Social Policy Research Unit, University of York, York, UK and Department of Social Psychology, London School of Economics, London, 1984.

[2]For further details of the schemes and methods of investigation see *ibid*, Hutton *et al*, 1985, chapter 2.

[3]For a detailed exposition of the methods of economic appraisal see, for example, R. Sugden and A. H. Williams, *The Principles of Practical Cost-Benefit Analysis*, Oxford University Press, Oxford, UK, 1978. Excellent contextual material for an economic appraisal in this area is provided by G. Leach *et al*, *A Low Energy Strategy for the United Kingdom*, International Institute for Environment and Development, London, 1979.

[4]The nature of these broader social issues, such as the benefits and shadow costs of the job creation aspects of the local energy conservation schemes, are briefly discussed in R. R. Barnett, *op cit*, Ref 1, Section 6.

[5]Similar conditions have to apply in the link between primary and delivered energy, but since our interest here is with domestic energy conservation measures, rather than energy supply, these are not discussed.

If the government had complete control over every decision it could authorize conservation measures whenever the social benefits exceeded the social costs. Such investments would be socially optimal. But instead of one decision-making body, decisions with respect to energy conservation measures are taken by literally millions of different individuals. These individuals will carry out a conservation measure if the perceived private benefits exceed the perceived private costs and thus it is unlikely that the socially optimal amount of conservation work will be undertaken. Individuals may misperceive the private benefits and costs of conservation work and the true private and social values may differ. The decentralized nature of the decision making coupled with any problems of perception and valuation make government policy in this area much more difficult than in the complementary area of energy supply where decision making is much more centralized. But an optimal energy policy requires the right balance of investments to be undertaken in both of these areas. A world in which economically efficient conservation projects are left undone is second best and thus it is no longer necessarily the case that efficiency principles (for example, setting price equal to marginal costs) should govern energy supply.[6]

To achieve social efficiency in energy conservation is likely to require: (a) the provision of information regarding the true private benefits and costs of various conservation measures and (b) financial inducement to bring social and private valuations into line. It is likely that any financial inducements will have to be geared to the requirements of particular client groups and of particular relevance here are the likely special features of any inducements aimed at the elderly and low-income households. Other things being equal, the elderly can be expected to have relatively short time horizons and thus not find it worthwhile to invest in conservation measures which have fairly long payback periods. The poor will face a capital constraint and thus a high implied discount rate which again will militate against investment in conservation projects. In both of these cases socially efficient conservation projects will be left undone and local energy schemes can be viewed as one approach to dealing with this problem.

A model of the benefits of domestic energy conservation measures

By making technical improvements in the link between delivered energy and energy service, domestic energy conservation measures reduce the implicit price of energy service. The benefits of such measures can be measured by the change in consumer surplus as indicated by the area under the demand curve for energy service. But although it is energy service that contributes to an individual's wellbeing, it cannot be directly purchased. Instead there is an indirect or derived demand for delivered energy: delivered energy does not itself contribute to consumer wellbeing but must be purchased if energy service is to be achieved.[7] Since market data refer to delivered energy but consumer wellbeing is gained from energy service the two need to be linked and this is done in Figure 1.

In quadrant 3, point a indicates the initial and observable price and quantity purchased combination for delivered energy for a given household: given the ruling price of p_1^d quantity q_1^d is purchased and thus the household's expenditure on fuel is represented by the area $Oq_1^d\ ap_1^d$.

[6]The seminal reference on second best is R. G. Lipsey and K. Lancaster, 'The general theory of second best', *Review of Economic Studies*, Vol 24, pp 11–32. For a discussion of its implications see, for example, Y-K Ng, *Welfare Economics*, (revised edition), Macmillan, London, 1983.

[7]In a similar way, there is an indirect or desired demand for energy-using appliances.

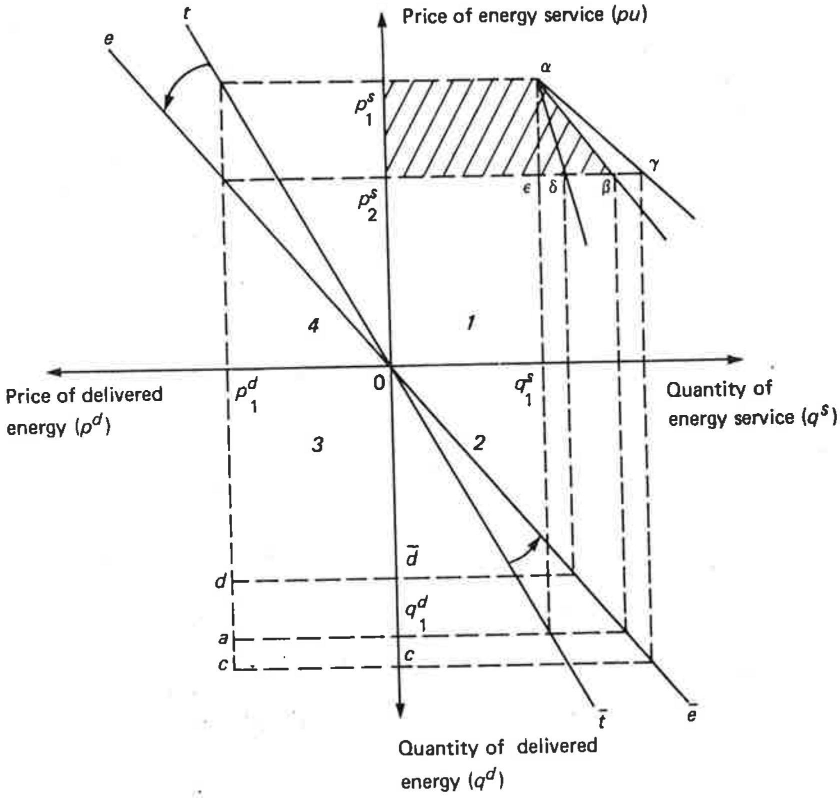

Figure 1. Delivered energy and consumer wellbeing.

The line $t0\bar{t}$ in quadrants 2 and 4 shows the technical and behavioural relationship between delivered energy and energy service; for example, for a given household's living style, its ownership of energy-using appliances and the physical characteristics of its house, the line might indicate how many units of electricity (delivered energy) are required to provide sufficient heat (useful energy) to increase room temperature (energy service) by 1°C for one hour. For ease of exposition a simple linear relationship is assumed although this is not essential for the analysis and the empirical results in no way depend upon it.

Given the technical and behavioural relationship between delivered and useful energy, it can be seen that the q^d_1 units of delivered energy produce q^s_1 units of energy service. Similarly the price of delivered energy of p^d_1 gives an implicit price for energy service of p^s_1 and thus point a in quadrant 3 implies that the household is consuming at point α in quadrant 1. Point α represents one point on the household's demand curve for energy service and it is what happens in quadrant 1 that matters for the household's wellbeing and hence for the economic appraisal also.

A technically efficient energy conservation measure will mean that each unit of delivered energy will produce more energy service and such a measure can be represented in Figure 1 by an anti-clockwise pivot of line $t0\bar{t}$ around the origin.[8] Consequent upon the introduction of a conservation measure the new technical and behavioural relationship between delivered energy and energy service will be represented by a line such as $e0\bar{e}$. Each unit of delivered energy will produce more units of energy service and thus a given price for delivered energy will result as a lower implicit price of energy service. It is this latter consequence

[8]A change in the household's lifestyle would also cause $t0\bar{t}$ to pivot. Such a change could result, for example, from educating young children not to leave 'every door in the house open'. Local energy conservation schemes which offer advice on what might be termed the effective use of a given heating system provide a potential benefit by causing $t0\bar{t}$ to pivot in this way.

that is of primary importance here: a technically efficient domestic energy conservation measure reduces the implicit price of energy service.

If, after the implementation of the energy conservation measure, the household is observed to continue to purchase the same amount of delivered energy (point *a* in quadrant 3) then, in terms of quadrant 1, consumption is taking place at point β. The line αβ maps out a segment of the household's demand curve for energy service and the gain in consumer surplus consequent upon the introduction of the energy conservation measure, and thus the reduction in the implicit price of energy service, is represented by the shaded area p_1^s αβ p_2^s. But the household would in fact only continue to buy the same amount of delivered energy and hence leave expenditure on fuel unchanged if the price elasticity of demand for energy service is unity. Line αβ then represents a segment of the demand curve over which there is unitary price elasticity. If the household's demand for energy service is price elastic, expenditure on it will increase as its price falls; in this case the installation of the energy conservation measure will result in the household moving to a point such as *c* in quadrant 3 giving demand curve αγ in quadrant 1. In this case the gain in consumer surplus is represented by the area p_1^s αγ p_2^s. By analogous reasoning if demand for energy service is price inelastic there will be a reduction in expenditure on fuel and a move to a point such as *d* in quadrant 3 giving demand curve in quadrant 1 and a gain in consumer surplus of p_1^sα δ p_2^s.

The above examples show that the greater the price elasticity of demand for energy service, the greater will be the gain in household wellbeing following the introduction of an energy conservation measure. The intuition here is quite straightforward. Reference to quadrant 1 of Figure 1 shows that the increase in consumer surplus comes from two sources: (a) being able to purchase the quantity of energy service previously purchased at a lower price (represented by the rectangular area p_2^s p_1^s αε); (b) the consumer surplus element on the additional units of energy service bought (represented by the various triangular areas such as αεδ and αεβ). For any given energy conservation measure the former can be thought of as a constant while the latter will be larger the greater is the price elasticity of demand for energy service.

It is also now quite straightforward to see why it is inappropriate to discuss the benefits to households of energy conservation measures in terms of reduced expenditure on delivered energy.[9] When price elasticity of demand for energy service is unity, expenditure on delivered energy does not change, yet there is nevertheless an increase in the household's wellbeing (as illustrated by area p_2^s p_1^s αβ in Figure 1). Moreover, when the demand for energy service is price elastic, expenditure on delivered energy actually increases, yet there is still an increase in household wellbeing (as illustrated by area p_2^s p_1^s αγ in Figure 1). Not only does the use of changed expenditure on delivered energy as an indicator of change in wellbeing lead to an error in quantifying the size of the change in wellbeing, but it also gets the rank ordering of the change in wellbeing for different demand conditions wrong. Such a measure suggests negative benefits when the demand for energy service is price elastic, zero benefits when price elasticity is unity; positive benefits when demand is price inelastic. It has been shown above that when the correct measure of change in wellbeing, that is, change in consumer surplus, is used, the actual ranking is the reverse of this.

[9] Such an objective is formulated by D. W. Pearce, 'Balancing investment in energy conservation and energy supply', in *Fifth Report from the Select Committee on Energy, Session 1981–2, Energy Conservation in Buildings*, Vol II, Appendixes, HC 401–II, HMSO, London, pp 193–198. Pearce does seem to realize the limitations of his approach when he writes towards the end of his evidence: 'more strictly, we should replace (the reduced expenditure on fuel terms) with expressions which have measures of consumers' net gains in terms of welfare' (p 198). But he leaves the matter there and does not seem to be aware that this admission renders his earlier detailed formulation wholly inappropriate.

Applying the model

The consumer surplus measure derived in the previous section represents the benefit from an energy conservation measure over a specific period of time, say one year. What matters to a household contemplating installing a conservation measure is the present value of the net benefits of the project over its useful life, and this is given by:

$$NPV_O = -C_O + \sum_{i=O}^{T} B_i (1 + r)^{-i}$$

where NPV_O is the net present value of the energy conservation measure in the current period (period O); C_O is the cost *to the household* of installing the conservation measure; B_i is the increase in consumer surplus on energy service which is brought about by the conservation measure, r is the discount rate; T is the useful life of the conservation measure. In the above formula it is assumed that the only cost associated with the conservation measure is the installation cost and in particular that there are no recurrent maintenance costs; also T measures either the life of the conservation measure or the expected time in the current dwelling of the household, whichever is the shorter.[10] Since conservation projects are initially being evaluated from the perspective of the household, rather than, say, of society as a whole, the terms in the above formula refer to the household's perception of the costs, benefits and useful life of the project. As noted above, the elderly might be expected to have relatively short time horizons and the poor to face a capital constraint and thus a high implied discount rate. Without information there may also be misconceptions about the nature of the benefits of particular energy conservation measures. The results reported here refer to households' perceptions of the net present value of various energy conservation measures following the nature of the advice and size of the subsidy given by the local energy conservation schemes.

Client households were initally asked if they thought that the work was good value for money, an affirmative answer indicating that the households' experience of the conservation measure over the period between its installation and the interview has led them to expect NPV_O to be positive. Any answer to this question is based on subjective views about the various terms entering the above formula[11] and the questionnaire sought to isolate general characteristics (of households, type of conservation measures, types of building, etc) which influence the number of people believing conservation measures to be good value. An attempt was also made to quantify the NPV_O by asking how much more the household would have been prepared to pay to have the conservation work undertaken. In the limit a household should be willing to pay an amount equal to the perceived NPV_O of the conservation measure. Again the questionnaire sought to isolate general characteristics which determine how much a household is willing to pay.

Although numerous variables might be expected to influence a household's evaluation of a conservation measure, by reference to the model developed above and the NPV_O formula these can be divided into four main areas. First, these are variables which influence by how much the price of energy service is reduced. Such influences determine the extent to which line *t0t* in Figure 1 pivots, that is, they determine by how much the relationship between a unit of delivered energy and a unit

[10]The clients might also, rightly or wrongly, perceive the conservation measure to have associated with it recurrent maintenance costs. If this is the case the NPV_O formula becomes:

$$NPV_O = \sum_{i=O}^{T} (B_i - C_i)(1 + r)^{-i}$$

That individuals do have misconceptions about the private costs and benefits of such measures is shown by the fact that conservation work tends not to be capitalized into house prices; on this see Economists Advisory Group, *Domestic Energy Conservation and the UK Economy*, London, 1981. But this accepted position is not fully supported by the perceptions of the clients of the local energy conservation schemes: of the 86 homes owners giving a definite answer, 52 believed the conservation measure to have increased in value of their property.

[11]Client households are not, of course, expected to know the NPV_O formula and the research methodology does not require this.

of energy service is changed by the conservation measure. Included here are, *inter alia*: type of conservation measure; physical characteristics of the dwelling. Second, there are variables which determine by how much a household will gain from a given reduction in the price of useful energy. The model developed in the previous section suggests that two factors will positively influence the size of this gain: (a) how far the demand curve for useful energy is to the right (cf the rectangular area $p_2^s p_1^s \alpha\varepsilon$ in Figure 1); (b) the price elasticity of demand for useful energy (cf the triangular areas in Figure 1, for example, area $\alpha\varepsilon\beta$). Influences considered here are the usual ones affecting the position of a demand curve: household income, reflecting ability to pay; length of use of heated room(s), reflecting need for energy service. Third, there are variables which influence the time horizon and discount rate; as has been suggested these relate in the main to the age and income of the household. Thus income has two complementary influences on the size of NPV_O; *ceteris paribus*, higher-income households have a higher demand and a lower implicit discount rate. Both of these influences mean that energy conservation measures are, other things equal, more likely to be worthwhile for higher income households. The final influence on the size of NPV_O is the cost to the household of having the energy conservation measure installed; the higher the cost the less likely it is that a household is going to view a given energy conservation measure as worthwhile.

Although it is readily observable, the relationship between quantity and price of delivered energy is not of direct relevance to the economic appraisal. Households do not gain wellbeing from delivered energy and the demand for it is a derived one. Thus changes in expenditure on delivered energy are only indicative of what is happening elsewhere, or in terms of Figure 1, what happens in quadrant 3 is the result of various changes in the other three (relevant) quadrants.

Results

Two types of energy conservation measures are considered: loft insulation and draught-proofing. Thus client households are divided into three groups according to the type of work undertaken for them by a local energy conservation scheme as follows:[12]

1. households which had a loft insulated but no draught-proofing work done (group L);
2. households which had some draught-proofing work done but did not have a loft insulated (group D);
3. households which had both loft insulation and draught-proofing work carried out (group LD).

The analysis of the results is structured as follows. Factors which are hypothesized to influence the extent to which the price of energy service is reduced are considered first. Factors which are hypothesized to influence how a household will respond to a given price reduction are then introduced. Influences on the discount rate and time horizon are considered concurrently with these and cost factors are introduced at the end of the section.[13]

In answer to the initial question about whether or not the conservation work was good value for money, while 92% of the client households answered in the affirmative, there was a significant difference at the

[12]The results are based on detailed investigation of a sample of 310 clients of the five local energy conservation schemes. Comparison interviews were obtained from 167 households who did not have conservation work undertaken but who in other respects could be matched with 167 households in the sample of clients. For details of the sampling technique see S. Hutton *et al*, *Energy Efficiency in Low Income Households: An Evaluation of Local Insulation Projects,* Energy Efficiency Series 4, HMSO, London, 1985, chapter 2.
[13]The statistical tables are not presented here, but may be found in Barnett, *op cit*, Ref 1.

95% confidence level in the answers according to the type of work undertaken. Significantly more client households in group D believed the work not to be good value than those in L and LD. But even for group D, 88% of client households believed the work to be good value for money. Those client households which believed the work to be good value for money were asked how much extra they would have been willing to pay to have had the work undertaken. Again the differences in responses for the three groups were statistically significant at 95% confidence level. Significantly a larger part of the D group were willing to pay up to £10 more, while a significantly greater proportion of those in group LD were willing to pay at least £15 more and up to £20 more.[14] When just groups LD and L were compared, no statistically significant result emerged concerning the additional willingness to pay. Thus the initial conclusion to emerge was that significantly more client households who had some loft insulation work done, that is group L and LD, believed the work to be good value than did those who just had draught-proofing work undertaken. Also of those who did believe the work to be good value, those in group D were willing to increase their payments by a smaller amount than those in the other groups. It should perhaps be noted that when asked about changed comfort levels, draught-proofing was believed to have made the greatest contribution. This does not conflict with the findings reported above. In terms of the economic appraisal, changed comfort levels represent part of the flow of benefits; good value and additional willingness to pay are concerned with the flow of the whole of the benefits relative to costs.

Architects and building surveyors reports suggest that the type and age of the dwelling and the way in which it is heated are likely to influence the extent to which energy conservation measures are beneficial. Considered first is the possible effect of type of dwellings on whether or not energy conservation measures are believed to be good value. A threefold classification was used for type of dwelling: semi-detached or end terraced; mid-terrace; flat or rooms.[15] No statistically significant association was found between these types of property and whether or not energy conservation work was believed to be good value. The building regulations have been periodically upgraded and thus any inherent heat loss should be less from newer dwellings; because of data limitations it was only possible to divide property into pre- and post-1940 categories. Again no statistically significant association between age of property and perception of good value was found. Although there was no statistically significant association between age of property and perception of good value, it was believed that there might have been such an association between age of property and additional willingness to pay. The hypothesis to be tested was that those client households which believe the work to be of good value might value it more highly if they lived in an older and thus less intrinsically energy-efficient property. However, no statistically significant association was found at the 95% confidence level.

Whether or not a property has central heating and if so, what type of central heating (classified as gas or other) both showed no statistically significant association with perception of good value. Additional willingness to pay also showed no statistical association with these central heating characteristics of a property.

The factors discussed so far relate to the technical characteristics of the energy conservation measure and/or of the property. Behavioural

[14]The average cost of materials for loft insulation work was £78 and the average contribution made by client households for such work (after the receipt of home insulation grants, etc) was £15. The average cost to client households for draught-proofing was £13 and the average cost of the materials was £19.

[15]The nature of the client group militated against further subdivision and the inclusion of other categories (for example, detached).

aspects of the household might also be expected to influence the relationship between delivered and energy service and thus whether or not a conservation measure is perceived to be good value. Draught-proofing measures were considered and client households were asked if they had done anything to prevent draughts before coming into contact with a local energy scheme. The hypothesis to be tested is that households which had already carried out some draught-proofing measures are, *ceteris paribus*, more energy conscious than those which have not done anything. But, in fact, no statistically significant association was found between good value and draught-proofing work undertaken before coming into contact with the scheme. Client households were also asked if any loft insulation work had been carried out on their dwelling before they came into contact with a local energy conservation scheme. Essentially the hypothesis to be tested is the same as the one just considered and here a significantly greater proportion of clients who already had some loft insulation found the work carried out by the scheme not to be good value. This can perhaps be explained in one or both of two ways. First, such client households are energy conscious and are already likely to be using their dwelling (given its characteristics) in an energy-efficient manner, thus any given conservation measure is likely to make less of an impact than in a house which is not already being used to some degree of 'energy efficiency'. Second, for households which already have some loft insulation, it is more likely that the work carried out by the scheme was draught-proofing and thus the result can be seen to support the earlier finding that draught-proofing seems not to have been such a good investment for client households as loft insulation work.

Turning now to consider the position of the demand curve for useful energy as an influence on good value or otherwise of energy conservation work, it will be recalled that, *ceteris paribus*, any given conservation measure is predicted to be of more value to a client household the further the demand curve is to the right and the more price elastic it is. In testing for the presence of an income effect on the position of the demand curve for useful energy, the concept of equivalent income per week is used.[16] But when this is tested against both perception of good value and additional willingness to pay, no statistically significant association is found. Although no income effect is found the nature of the client households with a concentration of equivalent income in the £25 to £50 per week range[17] perhaps militates against such an effect emerging.

Equivalent income is an objective measure of ability to pay but what may be of more relevance is a household's perceived poverty especially with respect to expenditure on energy. Client households were asked how easy it had been for them to find money to pay for fuel over the past year and the replies were grouped into three categories: those which found it very or fairly easy; those which found it rather difficult; those which found it very difficult or almost impossible. Testing this perceived poverty against additional willingness to pay shows no statistically significant association.

Although there was no statistically significant difference in the type of energy conservation measure undertaken for pensioner and non-pensioner households, a statistically significant association did show up between pensioner households or not and additional willingness to pay. Pensioner households are over-represented in the lower categories of

[16] In calculating equivalent income the first person in a household was given a weighting of 1 and all subsequent individuals a weighting of 0.6; for further details on this see S. Hutton *et al*, *op cit*, Ref 1.

[17] Of the 276 responses to the question on equivalent income 189 fell in the range of £25 to £50 per week; 32 were in the range £15 to £25 per week, 41 in the range £50 to £75 per week, and 14 in excess of £75 per week.

additional willingness to pay (less than £10). In interpreting this result it should be borne in mind that opposing forces are at work with respect to pension households: the time horizon might be expected to be shorter, this works to pull the value of NPV_O down; the need for energy service might be greater both because the place of residence is likely to be occupied for longer periods and because of the physical need of the elderly to keep warm, this works to push the value of NPV_O upwards; there may also be an income effect at work.

Turning to the influence of the cost of the energy conservation measure to the client and perception of good value a statistically significant association at the 95% level between these two factors was found. Client households which thought the work not to be good value for money were over-represented in the lowest and highest categories of payment. This finding reinforces the earlier one on the comparative return to clients from draught-proofing and loft insulation work. The lowest categories of payment are dominated by client households who had only draught-proofing work undertaken. The middle range of payments, in which the relative number of clients believing the conservation work to be good value for money was over-represented, was dominated by client households having loft insulation work undertaken.

Before drawing the various results of this section together, some comment is possible on the price elasticity of demand for energy service. It will be recalled that if the demand for energy service is price inelastic, expenditure on it will fall as its price is reduced, for unitary price elasticity expenditure remains the same and for some price elastic demand it increases. Client households were asked how the conservation work had changed this expenditure on fuel. Of those able to answer the question, 9% said that expenditure had increased (price elastic demand for useful energy), 21% said that they were spending less (inelastic demand) and 70% said that their expenditure on fuel has not changed (unitary price elasticity). In the case of unitary and price elastic demand for energy service, client households were clearly taking some of the benefits from the conservation measures in the form of increased comfort. These results tie in with the findings from the survey of delivered energy use where it was found that although client households on average reduced consumption of delivered energy by about 5% from what it would have otherwise have been, the reduction was not as great as that thought to be feasible for a constant comfort level.[18]

Finally, it might be noted how inappropriate it would have been to use reduced expenditure on delivered energy as a measure (or even an indicator) of the net benefits of an energy conservation measure. The use of such a measure would have indicated no net benefit for 79% of the client households who were able to answer the questions on changed fuel expenditure (the price inelastic and unitary price elasticity cases). A test of the statistical association between whether a client household was spending more, the same, or less on delivered energy and perception of good value showed no significance at the 95% confidence level: clearly the client households did not believe changed expenditure to be an adequate indicator of their changed level of wellbeing.

What conclusions can be drawn from these empirical findings? The first thing to be emphasized is that the lack of heterogeneity in some of the data militated against statistical testing in certain areas. But this problem was to be expected since the local energy schemes were geared

[18]For further details on this see S. Hutton *et al*, *op cit*, Ref 12, chapter 8. The finding of an average 5% reduction in delivered energy use is based on a comparison of meter readings in 182 client households with those in 167 matched households. Of course, some of the benefit from energy conservation measures will be taken in the form of increased comfort as long as the demand curve for energy service is downward sloping.

towards a specific group of people. Perhaps the most notable finding that should not be lost sight of is that 92% of the client households thought that the conservation work undertaken for them by the schemes had been good value for money. For client households which had some loft insulation work carried out this figure rose to 97% and although a significantly greater proportion of clients who had just draught-proofing work done thought the work not to be good value, 88% of clients in this category still believed their decision to invest in this area to have been a wise one.

The estimate of the size of the change in consumer surplus consequent upon the introduction of conservation measures further showed that this gain was significantly larger for projects involving some loft insulation. Thus, given the relative technical efficiencies[19] and the policy on subsidies, loft insulation was the better investment for clients. As has been noted, however, the best investment does not necessarily imply greatest increase in comfort level since the concept of investment involves the examination of both benefits and costs.

Although technical studies of the efficacy of various conservation measures point to the importance of the physical characteristics of the dwelling, clients' replies did not show factors such as type and age of property and type of heating to be significant in determining whether or not conservation measures were thought to be good value. The attempt to evaluate behavioural aspects of the household tended to support the earlier finding of a lower return to investment in draught-proofing. An income effect was not detected in that the level of equivalent income was not significantly associated with additional willingness to pay. The lack of variability in the data on equivalent income may, however, have worked against an income effect showing itself. Also perception of fuel poverty did not show up as a significant influence but there was a significant difference in the additional willingness to pay of pensioner and non-pensioner households. Finally, a unitary price elasticity of demand for energy service was found for the majority of client households.

Conclusion

The objective of this paper has been to present an economic appraisal of the work carried out in low-income households by local energy conservation schemes. The appraisal has been carried out from the perspective of the clients of the schemes and the data used came from the detailed study of five of the schemes and their clients.

The paper began with some general discussion of economic appraisal and emphasized the need to specify clearly the objective of any act of choice. To this end the meaning of energy conservation was discussed and a narrow definition in terms of saving delivered energy was rejected in favour of the broader one of improved economic efficiency of energy use. It was suggested that individuals can benefit from an energy conservation measure even if it does not lead to a reduction in their fuel expenditure and this was confirmed by the questionnaire responses which showed that 78% of clients who thought the conservation project to be a good investment had not reduced their expenditure on fuel. The alternative to taking the opportunity to cut fuel expenditure is to consume the increased welfare that a reduction in the implicit price of energy service brings about in the form of increased warmth and 85% of

[19]By technical efficiency is meant the ability of a given energy conservation measure to increase the amount of energy service attainable from a given input of delivered energy. Whether or not such a measure is also economically efficient is dependent both on its cost and the clients evaluation of the benefits.

clients said they felt warmer as a consequence of the conservation measure. Both the theoretical analysis and the clients' responses demonstrated that an appraisal in which the clients' objective was to achieve savings on fuel expenditure would be inappropriate.

It has also been suggested that a domestic energy conservation programme is likely to be a necessary part of an efficient energy policy in ensuring that socially efficient investments in the link between delivered and energy service are made. Throughout it has been emphasized that it is essential that a distinction is made between delivered energy and energy service: it is the latter which gives the consumer wellbeing and should, therefore, be central in any analysis.

The outstanding conclusion from the economic appraisal is that overall 92% of clients thought their decision to have conservation work carried out to have been a good one. Further, for those clients who had some loft insulation installed this figure rose to a staggering 97% and for draught-proofing it is 88%. The additional willingness to pay (representing the net change in consumer surplus) is also higher for loft insulation work than for draught-proofing. Other findings reported in the final section tend to support the conclusion that, as currently organized by the schemes and given the current subsidies available, loft insulation work has proved to be a better investment for clients than draught-proofing.