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REDUCING HOUSEHOLD ENERGY CONSUMPTION: A QUALITATIVE AND QUANTITATIVE FIELD STUDY

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Abstract

One hundred and twenty households in Bath, U.K., had their energy consumption monitored over a 9-month period and compared (weather-corrected) to the previous year's consumption. Participants (with the exception of the control group) received feedback in various forms, i.e. consumption compared to previous consumption or to similar others; energy saving tips in leaflets or on a computer; or feedback relating to financial or environmental costs. Respondents were interviewed after the start of the study to establish their income, socio-demographic status, environmental attitudes and the extent to which they already engaged in conserving activities. Participants also took part in focus groups after the final meter readings were taken. Overall the results indicated that income and demographic features predicted historic energy consumption but not changes in consumption during the field study, where environmental attitudes and feedback were influential. Of all the feedback groups, the installation of computers helped reduce consumption most markedly. Furthermore, people with positive environmental attitudes, but who had not previously been engaged in many conservation actions, were more likely to change their consumption subsequent to the feedback period. Recommendations are made both for energy conservation policy and future research.

Introduction

Domestic energy consumption represents one area where the links between global environmental problems and individual behaviour are clearly identifiable, even if consumers do not immediately recognize the connection. This means that energy conservation has become one of the first sustainability issues to be addressed through a combination of national and local government policies, specifically Local Agenda 21. However, the promoters of energy conservation face a major problem: how to increase the visibility of domestic fuel consumption in homes and increase peoples' awareness of the links between their behaviour and problems such as global warming. To most consumers in developed countries, the fuel used within homes has become, to a large extent, an *invisible* resource, yet in the U.K. it accounts for 30 per cent of the CO_2 (D.O.E., 1995) produced. The only commonly visible record of consumption comes in the form of quarterly bills or monthly statements, by which time the links between specific activities and the energy consumed are severely dislocated, a situation described elsewhere as akin to a supermarket not displaying any individual product prices but merely providing the shopper with a total non-itemised bill at the checkout (Stern & Aronson, 1984). This policy context coupled with a need to overcome the problem of fuel invisibility formed the starting point for the research reported here. Previous research (albeit mostly dealing with the U.S. oil crisis of the 1970s) has raised some interesting questions about the effectiveness of using feedback on consumption as a means of encouraging energy conservation (Farhar & Fitzpatrick, 1989).

Despite the continuing debate about the merits of feedback on behaviour generally (Kluger & DeNisi, 1996), the literature specifically concerned with energy consumption feedback presents a more consensual view on the positive role feedback can have (Farhar & Fitzpatrick, 1989), although it fails to pinpoint which *types* of feedback are most effective. A repeated question in previous work has been

whether feedback containing an element of comparison, either in terms of comparing one household to another or by comparing the same person's consumption with their previous consumption, works. Another common theme has concerned the issue of personal values; specifically whether economic motives or environmental motives influence behaviour and therefore whether feedback appealing to one or other of these values would be more successful than less value-oriented information. There has also been considerable exploration of the influence of a household's social-economic circumstances upon their energy consumption and take up of energy efficiency measures. However, rarely, if ever, have these various factors been considered together.

The work of Stern and Aronson (1984) and Pallak *et al.* (1989) has attested that self-monitoring works, and comparing one household with an area average is effective also. Comparative feedback was also found to be very effective by Arvola (1993), who examined how people changed their consumption if given the opportunity to compare their present consumption with a previous similar period. Other research has looked at whether feedback which emphasizes the financial costs of energy consumption, but more frequently than the typical quarterly bill, has any impact (Winett & Kagel, 1984; Ester, 1985). In their review of feedback experiments, Farhar and Fitzpatrick (1989) concluded that cost-based energy feedback consistently resulted in reductions, and that people liked to receive breakdowns of their consumption in this way, although Hutton *et al.* (1986) found that feedback emphasizing financial values did not have positive results across all their samples.

A similar lack of agreement about the positive impact of feedback has arisen from research on the role of environmental attitudes and energy conservation; many commentators have suggested that the link between pro-environmental attitudes and concern about energy-related environmental issues and conservation behaviour is a weak one (Cook & Berenberg, 1981; Ritchie *et al.*, 1981; Axelrod & Lehman, 1993; Uutela, 1994). However, Seligman and Kriss (1979) have found that 50 per cent of variance in energy use could be explained by attitudes towards energy conservation, and Belk *et al.* (1981), Verhallen and van Raaij (1981) and Uusitalo (1989) have all argued that people's perceptions of their own contribution to energy problems is predictive of household energy conservation and that information designed to promote energy consciousness should emphasize such values.

In terms of socio-demographic factors, Kasulis *et al.* (1981) have argued that if a household is on a low income, they are already very likely to be using low amounts of energy and thus would not have the ability to respond to requests for greater conservation activity. Similarly, people living in rented accommodation might not have the right, as tenants, or the incentive to invest in energy saving for their homes (Joerges & Muller, 1983). Home ownership, on the other hand, makes it possible to gain the personal benefits of investment, either in comfort, energy savings, property values, or whatever; renters are not likely to invest their money to improve the energy efficiency of their landlord's property (Black *et al.* 1985).

Despite the general consensus on the importance of energy consumption feedback reached by earlier research, the relative merits of different forms of feedback for particular audiences is still unclear. Previous work has also been marked by a lack of research within a U.K. context, and typically has involved field experiments of a very short duration with small samples (Farhar & Fitzpatrick, 1989). In addition, while it is largely agreed that favourable and unfavourable predispositions, structural, situational, and income and demographic variables are all likely to have an influence on changes in energy, they have been inadequately studied in field feedback experiments.

The present study sought to narrow these gaps in the literature by conducting the largest household energy field feedback experiment ever undertaken in the U.K. (120 households), simultaneously comparing seven feedback conditions, and including the influence of income constraints, behavioural/structural aspects, environmental attitudes and socio-demographics in the analysis.

Methods

The participants

One hundred and twenty households, living in houses first built in the 18th century (see Figure 1), in the City of Bath took part. While the housing stock was kept constant, no control was kept over the demographic and socio-economic characteristics of participants, so consequently the sample constituted a rich and varied one comprising large families and people living on their own, people in

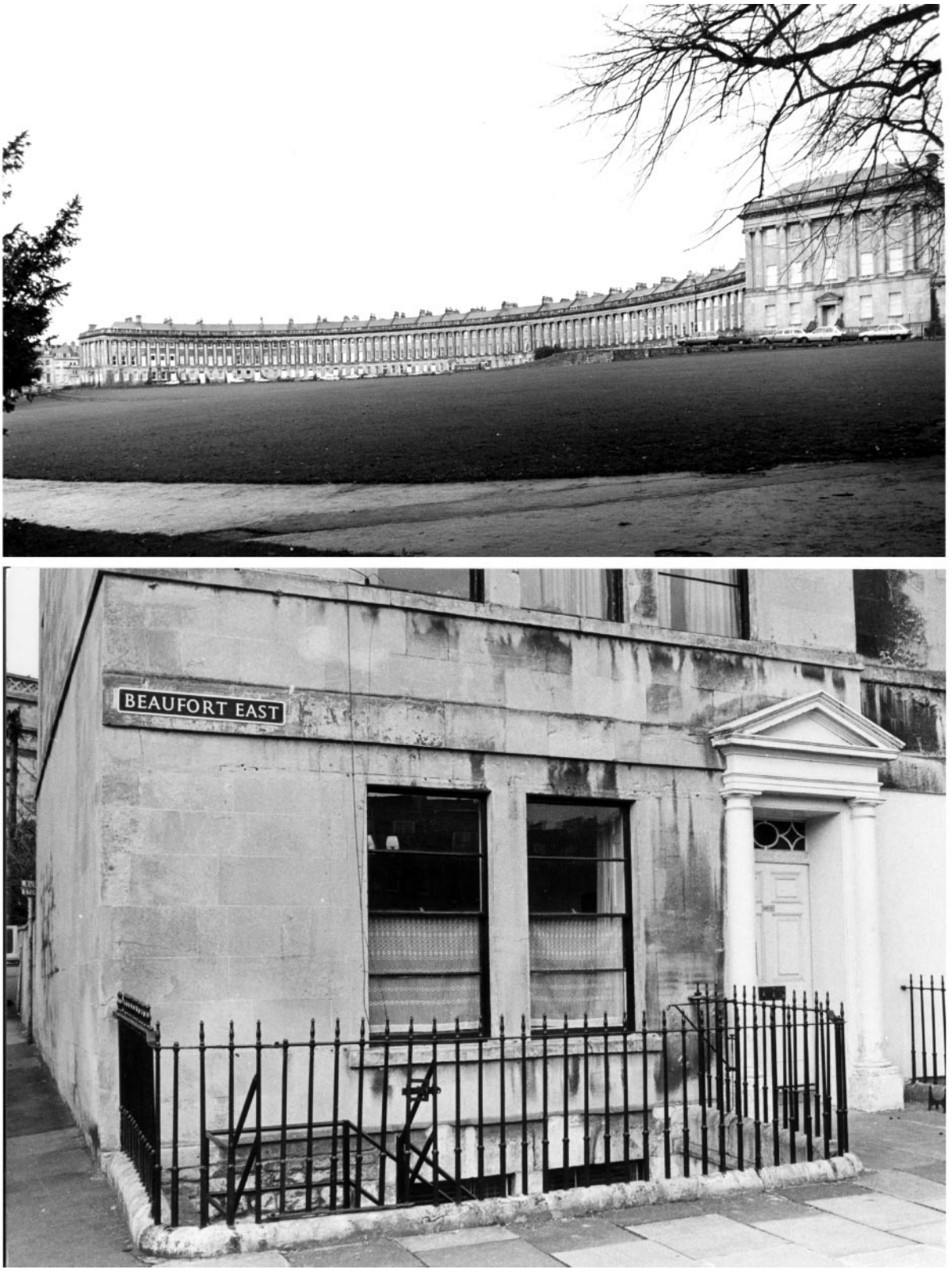

FIGURE 1. The grand and the not so grand houses of Bath.

TABLE 1
Demographic features of respondents and households (rounded percentages)

Sex (of respondent)		Tenure*					Age (of respondent)			Full Time Occupants			Income (household)			Social Class† (by occupation of main earner/ main previous occupation)		
M	F	HA	LA	M	OO	PR	⟨41	41–60	60⟩	1	2	3	⟨20k	20–40k	40k⟩	I + II	III	IV + V
45	55	4	16	29	30	21	32	38	30	47	39	14	57	30	13	65	23	12

* HA = Housing Association; LA = local authority; M = mortgaged; OO = owner-occupied; PR = privately rented.
† I + II = professional and higher managerial; III = junior managerial and clerical; IV + V = skilled and unskilled manual workers.

manual occupations and in the professions, those who owned their properties and those renting either privately or from Bath City Council, the wealthy and the poor: these features are summarized in Table 1.

Design and materials

This was a longitudinal study of household energy consumption, where consumption during the trial period was compared with the previous year's consumption for the same household. Households were placed in one of six feedback groups namely self vs others comparison (group 1); self vs self (group 2); financial values (group 3); environmental values (group 4); leaflet presentation (group 5); and computer presentation (group 6). A seventh group (group 7), constituting the control, received no feedback.

Printed information was designed and forwarded through the mail which variously informed households of their energy consumption for the month compared with: an average figure based on all the properties in the project with a similar size and occupancy profile (group 1); a weather-corrected comparison of consumption to the previous year for the same household (group 2); energy consumption in both kWh and equivalent monetary value (group 3); energy consumption in relation to environmental problems such as acid rain and global warming (group 4) and a full literature pack (some of which was already available to consumers, but not previously mailed directly) providing advice on energy savings matters (group 5). In group 6 computer software was designed so that households could input individual household data on a P.C. provided by the project. The P.C. contained three different programs, the first of which presented current consumption and the previous year's consumption for the same household on a graph; the second contained a questionnaire on general aspects of energy saving, while the third was a directory of energy saving information and advice. Group 7, the control, received no feedback.

Households were assigned randomly to the groups, with the exception of the housing tenure of the household where an effort was made to balance evenly the number of privately owned and rented houses in each condition. [Housing tenure has been found to be the most influential demographic feature on household energy consumption in previous studies (Joerges & Muller, 1983)].

A questionnaire was also designed, comprising 40 questions (completed early in the study), which asked about existing attitudes towards the environment and energy consumption and conservation, made a record of conservation activities, heating systems and energy efficiency measures currently in place, and indicated the potential to reduce consumption as well as the composition and sociodemographic features of the household.

The dependant measure in the study comprised energy consumption compared with the consumption in the previous year for each household averaged for each (feedback, control) condition. Consumption figures for gas, peak and off-peak electricity and standard tariff electricity for the previous 2 years for each property were provided by British Gas and the South West Electricity Board. All consumption was measured in kWh in order that the dependent variable, the percentage change in total consumption, would be comparable for all households regardless of the fuels they used. The comparative figures were weather-corrected using data from the Meteorological Office[1]. The total percentage difference (TOTPD) measure was therefore calculated as follows:

$$\text{TOTPD} = \frac{\text{field study consumption} - \text{historic consumption}}{\text{historic consumption}} \times 100$$

Qualitative information was provided by three focus groups representing both the households who had increased consumption and those who had reduced their consumption during the feedback period. All the feedback conditions, as well as the control group, were represented at the focus sessions. Three main questions formed the basis of the focus group discussions: (1) were people aware of the feedback they received? (2) did taking part in the study make them think more about household energy consumption? (3) which ways did they believe would be most effective in encouraging people to reduce their household energy consumption?

Procedure

In November 1994, 1000 residents of Georgian properties in Bath were sent letters requesting their participation in the project and were told that it was concerned with the energy performance of Georgian buildings. Using local census data, participants were selected from areas of mixed housing types and tenure, and so included family homes, some occupying full buildings, to smaller single occupancy dwellings on one floor, all within typical five-storey Georgian buildings. There was a

response rate of approximately 20 per cent, of which 140 households were finally deemed suitable after an initial interview and structural survey. A further 20 households were removed from the original sample of 140 due to either moving away or because of problems accessing their historical or meter data.

A representative from each selected household was then interviewed with the use of a questionnaire consisting of 13 statements, measured on a Likert scale, designed to establish participants' environmental attitudes, attitudes to energy conservation specifically and generally, and perceptions about their efficacy in addressing energy-related problems. A further 16 questions, a mixture of closed and open-ended questions, were asked to elicit information about participants' energy knowledge, their current energy use and conservation activities as well as details about their motivations and intentions with regard to energy use and conservation. The remaining questions referred to social, economic and demographic characteristics. A structural survey of the dwelling was carried out during the visit recording details about the types and positions of all heating and lighting systems, appliances used, presence of any energy conservation measures and the volume and layout of the dwelling. Households were then assigned to one of the seven conditions described in the design.

All the gas and electricity meters of the participants were initially read during July 1995 to provide baseline consumption figures, and then subsequently every month until March 1996 when the readings were incorporated into the feedback information. A standardization process was used to even out periods between meter readings if the number of days covered, as a result of delays or access problems, varied. Participants received a total of eight postal feedback communications. A ninth closing meter reading was taken in April 1996.

Three focus groups of 10–12 participants each were conducted in June 1996. The discussions were led by the two authors, tape recorded and transcribed.

Results and Discussion

Two sections follow: the first assesses the relative influence of the factors identified in Figure 2 (with the exception of feedback) on historical energy consumption; and the second assesses the influence of the independent variables (including feedback) on energy consumption during the trial period. A series of multiple regressions (using the SPSSX 'Enter' procedure) were undertaken; the best fitting models are reported on below.

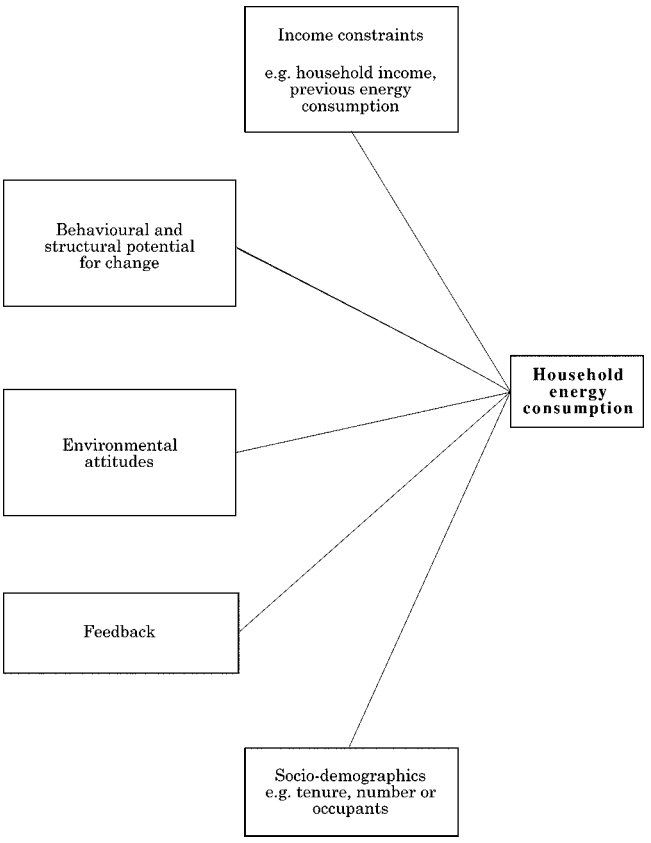

FIGURE 2. An illustrative model of hypothesized factors influencing household energy consumption.

'Environmental attitudes' comprised two factors derived from a factor analysis (the SPSS default version, rotated) namely *environmental beliefs* (EB), which itself was composed of four Likert attitude statements ('The threat of environmental problems has been greatly exaggerated'/'Our present way of life is much too wasteful of resources'/'More and better science and technology are all that is needed to solve our energy problems'/'Energy problems must not stand in the way of economic growth'), and *predicted personal behaviour* (PPB) composed of another four Likert items ('I would make greater efforts to reduce my energy consumption if I knew my friends and neighbours did too'/'A 20 per cent rise in gas and electricity prices would cause me to reduce my consumption'/'I would do more to reduce my energy consumption if I knew it would save me money'/'I would do more to reduce my energy consumption if I knew it would help the environment'). The EB and PPB measures were

included in the multiple regression analyses which follow.

A multiple regression was first performed using previous (historic) consumption as the dependent variable to ascertain whether income and demographic variables, identified by earlier research as important, were indeed also influential in this case. The analysis for the independent variables 'household income', 'age of respondents' and 'the number in the household' all proved significant: multiple $R = 0{\cdot}587$, $r^2 = 0{\cdot}34$, $F = 19{\cdot}23$ (df. 3, 110), $p < 0{\cdot}0001$; 'income' produced a t value of 4·78, $p = 0{\cdot}0001$; 'age' a t value of 2·36, $p = 0{\cdot}0202$; and 'number of occupants' a t value of 3·89, $p = 0{\cdot}002$. 'Mature' households with higher incomes and more occupants consumed more. Tenure was included as a dummy variable in four forms: where rented Local Authority = 1, other = 0; mortgaged = 1, rest = 0; owner-occupied = 1, rest = 0; privately rented = 1, other = 0. These were entered independently with the previously identified significant income and demographic variables. The variance explained was increased when renters of Local Authority housing were included ($t = 1{\cdot}99$, $p = 0{\cdot}0492$) and owner-occupiers ($t = 2{\cdot}52$, $p = 0{\cdot}0133$), but in the latter case this was at the expense of the contribution of 'age', revealing that advancing years is correlated with owner-occupation. A one-way analysis of variance for all four tenure groups produced statistically significant differences between them ($F = 5{\cdot}96$, $p = 0{\cdot}0008$). As might be expected, those renting from the Local Authority, generally low income households, consumed the least (mean = 5904 kWh), followed by private renters (9765 kWh), mortgagees (15951 kWh), with owner-occupiers topping the poll (19172 kWh). No other variables, including environmental attitudes and behavioural or structural potential for change, had any (even marginal) influence on previous energy consumption.

These results are in marked contrast to those produced for the trial period employing the dependent variable as the total percentage difference between historic consumption and consumption during the field study (TOTPD). A series of multiple regressions showed that all the previously identified influential independent variables, namely income, age, number of occupants and tenure, were in this case insignificant. In fact the best fit included the variables *environmental beliefs* (EB), *predicted personal behaviour* (PPB), a dummy variable of feedback compared to the control (*Compdunc*), whether the household had previously been a high, medium or low energy user (*hlmuse*) and the number of occupants in the house (*f.t.occups*); although it should be noted that *PPB* and *f.t.occups* produced insignificant t values on their own (see Table 2). The amount of variance explained by this model was statistically greater than 0 (multiple $R = 0{\cdot}366$, $r^2 = 134$, $F = 3{\cdot}49$, df. = 5, 113, $p = 0{\cdot}0056$). This is the best performing model of all those employed incorporating demographics, income, conservation activity and attitudinal variables.

From this model it can be observed that the influence of environmental beliefs and attitudes was only marginally significant ($p = 0{\cdot}0794$), but there was no evidence of any kind that environmental attitudes were linked to previous consumption. The influence of feedback, taken as a whole, was also only marginally significant ($p = 0{\cdot}0993$); the major finding is the differential response from between high, low or medium users of energy ($p = 0{\cdot}0028$). A one-way ANOVA confirmed the finding, revealing a mean reduction of −3·69 per cent for high users, a mean reduction of −2·48 per cent for medium users and a +10·73 per cent increase for low users ($F = 5{\cdot}383$, $p = 0{\cdot}006$). Fifty per cent

TABLE 2
Multiple regression 'enter' solution for total percentage difference in energy consumption between historic and trail periods (dependent variable)

Independent variables	B	SEB	BETA	T	P
Environmental beliefs	4·87	2·57	0·158	1·77	0·794
Predicted personal behaviour	0·97	0·79	0·11	1·23	0·2223
Conditions (dummy) (feedback = 1, control = 0)	−8·07	4·86	−0·15	−1·66	0·0993
High, medium, low energy use	7·16	2·34	0·27	3·06	0·0028
Full time occupants	2·54	1·89	0·12	1·34	0·1817
Constant	−41·82	17·0		−2·46	0·0154

Multiple $R = 0{\cdot}366$; $r^2 = 0{\cdot}134$; $F = 3{\cdot}495$; $p = 0{\cdot}0056$.

of those in the highest declared household income bracket were high energy users, although a proxy for income is not straightforward.

It will be recalled that people in different types of tenure were allocated evenly across the seven conditions of the field experiment, and this has meant that the within-condition (within-group) variance was high, thus reducing the statistical significance of between group (conditions) differences. The analysis proceeded in two complimentary ways: the first involved nonparametric analysis concentrating on the direction of changes in consumption rather than the sizes of these changes; the second was focus group discussions with the households revealing the largest changes and the reasons behind them.

Nonparametric analysis

Table 3 portrays the number of households from each condition who reduced their consumption compared with those who did not. A binomial test revealed a significant difference only in the case of group 1, the computers condition, where the number reducing was significantly different ($z = 2{\cdot}09$, $p = 0{\cdot}0192$). This distribution was also different from the control ($\chi^2 = 4{\cdot}5$, df. $= 1$, $p < 0{\cdot}05$). As suggested by the multiple regression analysis, the influence of high/medium /low energy use is also statistically significant for the simple up/down measure of consumption, where medium and especially high energy users are more likely to reduce their consumption than low energy users where over two-thirds actually increased their consumption ($\chi^2 = 11{\cdot}65$, df. $= 2$, $p = 0{\cdot}00295$). This difference also holds for the feedback conditions where the control group is eliminated ($\chi^2 = 7{\cdot}08$, df. $= 2$, $p = 0{\cdot}029$).

Up to this point only total overall consumption has been considered. An alternative approach is to examine the households who reduce their consumption across all the fuel types used in their homes; the majority of the computer group behaved in this way compared to a third or less of members in the other conditions. Also, a significant chi-square was recorded for these households and the potential for change where those who had previously done little being more likely to reduce all types of household energy use measured ($\chi^2 = 10{\cdot}36$, df. $= 2$, $p < 0{\cdot}01$).

Focus groups

Generally people were aware that they had received feedback and were also able to describe its form. Those in the computer condition were pleased with the graphic displays but here, as elsewhere, there was disappointment about the lack of personalized information.

Participants' own accounts of their behaviour and what might encourage changes in household consumption provided the richest data from the focus groups. While people were sympathetic about environmental issues, there was no broad agreement that one should 'bring one's environmental attitudes home' when it comes to heating, lighting, cooking and washing, or indeed that stressing environmental issues was the best way to motivate people to conserve energy. The main issue appeared to be about the trade-off between comfort and expenditure with money commonly being identified as the main motivation for conservation among the focus groups—despite not being evident as a significant experimental manipulation.

Other points arising from the focus group discussions concern visibility and changes in household circumstances. The first of these is that visibility, in terms of making energy consumption visible as a prompt, may be the key to change. The installation of a computer certainly served as a very visible reminder of energy consumption, but may not be a feasible policy option to be applied generally. However, with the advent of improved metering technology there may be equally effective policy options

TABLE 3
Mean per cent increase / decrease (and standard deviation)

	Group						
	computers	self vs others	self vs self	leaflets	control	money	environment
Mean per cent increase/decrease	−4·31 (20·8)	−4·6 (18·6)	+1·5 (19·3)	−0·39 (12·1)	+7·78 (33·6)	−4·84 (13·5)	+4·46 (18·0)
Down	12*	09	08	11	10	07	09
Up	03	07	10	08	12	06	08

* Binomial $Z = 2{\cdot}09$ $p = 0{\cdot}0192$.
Chi-square comparison with control: $\chi^2 = 4{\cdot}5$, df. $= 1$, $p < 0{\cdot}05$.

both in terms of the information available to consumers, such as meters which display the financial costs of consumption, and the location of the device, placed more visibly in kitchens rather than in cellars or cupboards under the stairs (a particular problem in multi-occupancy dwellings typified by the Georgian premises in this research). Some work has been done on such displays (Houwelingen & van Raaij, 1989) but the devices were very primitive and required a considerable amount of manual recording of information on the part of the householders. The University of Bath is currently involved in further research on such devices.

Conclusions, limitations and speculations

The multiple regression analysis reveals that the feedback combined, compared with the control conditions and environmental attitudes and behaviour, have a marginal statistically significant influence on the total percentage difference of energy consumed (in kWh hours) for the period of the study. These results are very much in accord with previous studies by Cook and Berenberg (1981) and Hutton *et al.* (1986). Environmental attitudes had no statistically significant effect on previous (historic) consumption and while income and socio-demographic variables did, none of the income or socio-demographic features subsequently (with the exception of *hlmuse*) influenced consumption over the feedback period.

In terms of the nonparametric tests, chi-squares substantiate the importance of previous high consumption on the tendency to reduce, as well as the marginal influence of the feedback conditions. There is some evidence, however, that participants in the computer condition, unlike those in the other conditions, were more likely to be reducers than members of the control group. Furthermore, there is a statistically significant relationship between behavioural potential for change among those who reduced on every kind of consumption measure with those who had done least in the past being most open to change.

In laboratory experiments it is customary to ensure that participants within treatment conditions have pertinent characteristics in common in order to clarify the effect, if any, of the treatment conditions. Laboratory experiments are therefore controlled simplifications of the more complex interactions of the *real world*; field experiments are a kind of compromise between the two. In the current study, within conditions, there were households representing different age structures, household sizes and building tenure; each condition had this heterogeneity, the logic being that these three variables had all been identified in previous studies as having a significant influence on energy consumption. Thus, participants with a range of these characteristics (rather than just one) needed to be represented in all conditions in order to maximize the breadth of the applicability of the results. The consequences of these decisions have been large standard deviations within conditions which have tended to reduce the significance of differences between treatments. With hindsight there should have been fewer conditions, or if more resources had been available, greater numbers in each condition. Another alternative would have been to concentrate on only one age group, or on one type of tenure, but this would have led to the criticism of restricted applicability.

Much previous research has placed emphasis on the influence of attitudes and values on household energy consumption. This is a laudable activity, but it has a tendency to underestimate the *potential* for change that exists for individual households. Householders are not playing on a level playing field in this respect, with constraints such as the type of tenure they hold sometimes serving to exacerbate any differences. While environmental attitudes and beliefs are important in this context, financial considerations are of equal or even greater importance. Many consumer scientists and other social scientists tend to underestimate the importance of money, while on the other hand, economists treat attitudes, beliefs, values and the like as mere preferences and tastes exogenous to economic models. The qualitative interviews have shown that participants are aware of the interplay between attitudinal and financial influences and the interaction between individual action and government 'intervention', which is a more sophisticated situation than many academic models suggest. Economic psychology offers a fruitful approach in such circumstances where combined and sometimes antagonistic influences of broadly psychological and financial influences are central foci (Lea *et al.* 1987; Lewis *et al.* 1995).

There are three main policy implications raised by the study and these relate to behavioural potential (targeting), particularization and visibility.

Studies from across western industrialized societies have shown that the majority of people have favourable environmental attitudes but they are not always translated into appropriate behaviour;

the opportunities for translation may not be readily available or there may be financial or time costs involved. In addition, the connections between individual energy consumption and environmental problems are often not recognized by the public (MORI, 1990), resulting in energy conservation generally not being perceived as an environmental issue. Feedback, coupled with practical conservation advice, can, however, go some way to overcoming this situation if targeted at people who already hold positive environmental attitudes, as the results here suggest.

Consumers also want customized or particularized advice. General leaflets with often inappropriate information or vague statements were not viewed by the sample as useful. The only feedback form, irrespective of social or economic circumstances, in which the present study can place any confidence is information, some of it interactive, supplied by computer software. While placing computers in consumers' homes may not be a serious policy option, recent dramatic developments in computers and metering technology mean that sophisticated and household-specific systems will become available serving to increase the visibility of fuel used within the home.

Note

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(1) More details are available on request from the authors.

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