

THE UNIVERSITY OF HULL

HOUSEHOLDER BEHAVIOUR AND DOMESTIC ENERGY USE

being a Thesis submitted for the Degree of

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by

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Summary of Thesis submitted for Ph.D. degree

by A.J.E. Crawshaw

on

Householder Behaviour and Domestic Energy Use

A review of research which points to the importance of behaviour in energy consumption is presented. The literature on ways of controlling energy consumption by behavioural means is reviewed. Understanding the consumer is highlighted as being important in explaining variation in energy utilization.

This thesis investigates the idea that consumption could be reduced through an understanding of people's beliefs. A variety of methodologies was used to this end.

(a) People in difficulties with paying their bills, contacted through a radio appeal, were interviewed.

(b) Objective measurements of occupant behaviour were obtained which suggested reasons for differences in energy consumption.

(c) Using a semi-structured interview and a ranking task a relationship was sought between knowledge of the relative running costs of appliances and energy consumption. Negative relationships were found.

(d) Two studies of consumer understanding of Economy 7 electricity bills were undertaken in the public and private sectors. In the former, but not the latter case, a significant relationship was found between the best understanding of Economy 7 and of bills, and lower costs.

(e) Semi-structured interviews were used to investigate householder understanding of thermostats in two types of homes: those with gas radiator systems and those with electric underfloor heating.

As a result of the studies many suboptimal strategies based on erroneous beliefs came to light.

The research reported here has not only enabled practical recommendations to be made for immediate implementation but has also demonstrated the fruitfulness of investigating consumers' understanding of their heating systems as a means of promoting the efficient use of energy.

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CHAPTER ONE

INTRODUCTION

In 1982 the total delivered energy consumption in the United Kingdom was 311.9 million tonnes of coal equivalent; domestic consumers used, and had to pay for, a sizeable 29 per cent of this (Department of Energy, 1983).

Paying for fuel already causes hardship in certain sections of the population. Between April 1980 and March of the following year, 173,860 consumers had their gas or electricity supplies disconnected through non-payment of bills and most were from low income families (Berthoud, 1981).

The problem is not going to go away, for in 1978 the government estimated that average energy prices must be expected to double in real terms by the year 2000 (Bradshaw and Hutton, 1982). The number of people in difficulties over payment of bills will probably increase therefore. It is likely that many people will want to reduce their fuel use, and for some of them the matter will be one of considerable urgency. Finding ways of helping people control their energy consumption is the subject matter of this thesis.

To see where reductions in consumption could be achieved, it is necessary to consider the physical fabric of buildings, the economic constraints, and the behaviour of the occupants who ultimately control energy use. There follows a review of relevant studies on the relative role of the consumer.

LITERATURE REVIEW, PART ONE

A REVIEW AND DISCUSSION OF RESEARCH WHICH INDICATES THAT THE PHYSICAL FABRIC OF HOMES AND THE SOCIO-ECONOMIC STATUS OF THE OCCUPANTS ARE NOT ALONE IN EXPLAINING ENERGY CONSUMPTION

In 1975 the Building Research Establishment published a document which drew attention to the potential for saving fuel that lay in the physical structure of buildings. It estimated that national energy consumption could be reduced by six per cent if well established conservation measures were applied to all homes. And indeed field trials in occupied houses have shown that well insulated dwellings do use less energy than poorly insulated ones

(Cornish, 1976;
Electricity Council, 1975;
Socolow, 1978;
Verhallen and Van Raaij, 1981).

However, a number of researchers (Box A, page 3) have recently reported that variations in fuel consumption, sometimes very large, exist among occupants of similar homes, even in three instances (marked with an asterisk) where the homes were well insulated. This indicates that the potential for cutting fuel bills lies not only in the structure of houses, but in the way people behave inside them.

BOX A: CONSUMPTION VARIATIONS IN SIMILAR HOMES

<u>Researcher</u>	<u>Reported consumption variation ratio</u>
Anderson (1977)	3 : 1
Brundrett (1977a)	78 : 1
Conan (1982)	4 : 1
*Cornish (1976)	6 : 1 for poorly insulated homes 2 : 1 for well " "
Davidson (1982)	10 : 1
Lundström (1980)	2 : 1
*Mayer and Robinson (1975)	5 : 1 for summer electricity 2 : 1 for winter gas
Minogue (1977)	8 : 1 in non-centrally heated homes 10 : 1 in centrally heated homes
Morrison (1975)	variations found but ratio not specified
Rosson and Sweitzer (1977)	variations found but ratio not specified
*Sonderegger (1978)	3 : 1
Verhallen and Van Raaij (1981)	variations found but ratio not specified

And indeed, attempts, summarized in Box B, page 4, to explain consumption variations by physical features alone have been found wanting.

BOX B: RESEARCH WHICH HAS USED PHYSICAL FEATURES OF
HOMES TO EXPLAIN CONSUMPTION VARIATIONS

Brundrett (1977a). In a study in which radiator sizes were assumed to be directly linked to the individual heat losses of 530 one- and two-bedroomed high rise flats, this researcher found no obvious relationship at all between space heating electrical energy consumption and design heat loss. He later noted that individual householders' consumption levels were significantly correlated from one year to the next and so concluded that householders had consistent habits which had a major influence on consumption.

Conan (1982). This researcher looked at how much of the variation in gas consumption in 113 houses of eight house types could be attributed to design heat loss. Since, however, heat loss figures were available for end of terrace houses only, terrace position was included in the regression equation as a "dummy" variable. It was found that design heat loss and terrace position together accounted for less than a third of the variance in winter consumption.

Morrison (1975) looked at total direct energy consumption in 97 single family detached dwelling units in the U.S.A. Through regression analysis she found that although physical factors (insulation, number of rooms, windows and doors, and construction materials) were indeed correlated with energy use ($\beta = 0.573$), certain social variables ($\beta = 0.310$) still had a substantial influence).

Rosson and Sweitzer (1977) used telephone directory sampling to obtain as near as possible a representative sample of Canadian consumers responsible for paying their own oil bills. The results of their regression analysis indicated that physical variables (heat loss and inside/outside temperature difference) accounted for 72 per cent of the variance in oil consumption. However this still left 28 per cent of the variance to be explained by behavioural factors, for this heterogeneous sample.

Sonderegger (1978), in what was essentially a replication of an earlier study by Mayer and Robinson (1975), looked at the gas consumption for space heating of 205 similar townhouses in the U.S.A. He found that 54 per cent of the total consumption variance could be attributed to number of bedrooms, position in terrace and double glazing. This still left 46 per cent of variance unexplained by physical features.

In their discussion, Mayer and Robinson (1975) noted that there was neither a negative correlation, which would have indicated a thermal preference, nor a positive correlation, which would have suggested that wasters-were-wasters, between winter gas consumption and summer electricity consumption. This was a strong indication that something other than thermal preference or profligacy directs occupant behaviour in the control of the thermal environment.

Verhallen and Van Raaij (1981). These authors looked at annual space heating gas consumption in 145 similar Dutch houses. Using stepwise multiple regression, they found that house characteristics (degree of insulation, position in terrace and the energy use of the neighbour) explained only 24 per cent of the variance in energy use.

These authors found that insulation had two opposing effects on the behaviour of the occupants, those of lower thermostat settings, but increased ventilation; this could go some way towards explaining why the physical variables fall short in their explanation of energy use.

In order to control completely for physical variables some researchers have looked at consumption in identical houses. Consumption variations ranging from a factor of two to a factor of six were found, none the less. The relevant research is summarized in Box C, below.

BOX C: CONSUMPTION VARIATIONS IN IDENTICAL HOUSES

Brundrett (1979) found that electrical space heating consumption varied by a factor of two in three small groups of identical well-insulated houses. Even homes with the same mean internal/external temperature difference used very different amounts of electricity. Ventilation habits were assumed to contribute towards the variations.

Courtney and Jackman (1976). In a study of three district heating schemes these authors looked at energy consumption in three groups of "nominally identical" dwellings. Consumption varied by a factor of six, wide variations being recorded even for the same air temperatures.

Electricity Council (1975). To estimate the effectiveness of insulation, field trials were conducted over several years with groups of insulated and uninsulated, but otherwise identical, houses. In both types of homes consumption varied by at least a factor of two. Overall, insulated homes used less energy, but there was an overlap in the consumption levels of the two types of homes, and on occasions the higher consumptions came from the insulated ones.

Munther (1974) derived a coefficient of variation (standard deviation divided by the mean) of 21 per cent for groups of "nominally identical" Swedish houses at one location.

Socolow (1978), as part of the Twin Rivers, New Jersey, study into residential energy use, found that average gas consumption for space heating varied by a factor of two in 28 identical houses. Following an insulation scheme on nine of the houses, average consumption fell from 17 ft³/°F-day to 10 ft³/°F-day, but the variation was still almost 2:1, and the rank ordering according to consumption remained virtually identical.

Weston (1951), while conducting heating research in occupied houses for the then Building Research Station, noted that the "thermal habits" of the occupants played a most important part in the results. Thermal input varied by a factor of two over a winter period in ten pairs of identical semi-detached houses.

Another technique to investigate the relative importance of physical and behavioural variables on consumption is to compare the consumption patterns of homes which have had a change of occupancy with homes which have had no such change. Researchers using this method report very much more stable patterns of consumption in the latter case than the former, thus highlighting the importance of occupant behaviour.

The relevant research is summarized in Box D, below.

BOX D: CONSUMPTION VARIATIONS IN HOMES WITH A CHANGE OF OCCUPANT

Lundström (1980) compared the electrical consumptions of 43 houses, each occupied by the same family during two consumption periods to that of 21 houses which had had a change of occupancy. In the former case, the correlation between before and after was 0.77 and in the latter only 0.005. The result indicated that houses do not 'remember' their earlier consumptions and that the families living in the houses had a decisive influence on the energy consumption levels.

Mayer and Robinson (1975) used 40 matched pairs of homes and found a significantly larger difference between consumption levels for two periods in houses which had had a change in occupancy compared with those which had had no such change. They concluded that a change in occupants significantly affects the level of consumption.

Sonderegger (1978) compared the relative consumption (a ratio of the consumption in the second winter divided by the consumption in the first) of 52 movers and 153 stayers and found that a change in ownership greatly disrupted the "traditional" consumption level of an individual house.

Earlier in the same paper Sonderegger had shown that 46 per cent of the variance in consumption could not be attributed to obvious design features. His data on movers and stayers enable him to state that "71 per cent of the variation, unexplained by conventional factors, is caused by occupant-related consumption patterns, and 29 per cent by persistent house-related quality differences".

All the studies in Boxes A - D indicate that occupant characteristics are important determinants of energy use. There is, in fact, considerable research interest in identifying those main determining characteristics. For instance, positive relationships have been found between income and energy expenditure,

(B.R.E., 1976;
Crossley, 1980;
Field and Hedges, 1977;
Heslop, Moran and Cousineau, 1981;
Hutton, 1982;
Levy, 1973;
Newman and Day, 1975)

and between number in household and expenditure

(Crossley, 1980;
Field and Hedges, 1977;
Gladhart, 1977;
Hutton, 1982;
Levy, 1973;
Lundström, 1980;
Mayer and Robinson, 1975;
Morrison, 1975;
Pearson, 1981;
Verhallen and Van Raaij, 1981),

but research summarized in Box E, page 8, indicates that social and economic factors are not alone in accounting for differences in consumption.

BOX E: RESEARCH WHICH HAS USED SOCIO-ECONOMIC FACTORS
TO EXPLAIN CONSUMPTION VARIATIONS

B.R.E. (1976) states that the link between energy expenditure and income is weak, for expenditure increases by only 1.7 for an eightfold increase in income. It would seem that income on its own cannot explain large variations in consumption.

Lundström (1980) looked at the effect of number of persons, number of children, income, and income tax allowances, on the consumption of families in similar houses.

Family size and number of children were the only variables which were significant and explained between five and 15 per cent of the variation. The remaining 85-95 per cent could not be explained. The author concluded that "this indicates that variables which are not quantifiable by means of published particulars concerning the occupants, such as their habits and attitudes towards energy saving, may have a great influence".

Hutton (1982) used two existing data sets, [the National Fuel and Heating Survey (1977) and the D.H.S.S. Family Expenditure Survey (1978)] and found that the main variables affecting household fuel expenditure, for the whole sample, were the number of rooms, the number of persons, and ownership of central heating. "Other relatively important variables were quarter of the year, fuel combinations used and income." However when the sample was disaggregated into "typical groups of households of different sizes with a given number of persons, the relationship between fuel expenditure and other variables, particularly income, was not so clear". Different variables seemed to be important for different households - a finding which suggested the important role of occupant behaviour.

Mayer and Robinson (1975) found that although the number of occupants in a house was a significant predictor of summer electricity consumption (which included air conditioning), neither this factor, nor income were significant predictors of winter gas consumption (used exclusively for space heating). Quite simply, people's habits varied.

Morrison (1975) looked at a combination of social and physical variables on consumption. Together they accounted for almost 50 per cent of the variation in consumption. Household size was the most significant variable; income was ranked only seventh. Overall, Morrison's social factors were correlated with energy consumption to a lesser extent than were the physical factors. Much variation remained unexplained however.

Pearson (1981). The main result of this researcher's multiple regression analysis was an equation accounting for 41 per cent of the variation in fuel expenditure with the main terms being the number in the household, household class and usage of appliances. But as the author pointed out, 59 per cent of the variance remained unexplained. She suggested that differences in overall lifestyle, special events, energy literacy and controllability of the heating system might play a part in this unexplained variation.

While the preceding studies have an unexplained category which would cover behaviour, a few studies have turned their attention directly towards household behaviour and have found that it is indeed a determinant of energy use. The research is summarized in Box F, below.

BOX F: RESEARCH WHICH HAS USED HOUSEHOLD BEHAVIOUR TO EXPLAIN CONSUMPTION VARIATIONS

Hutton, (1982). Use of central heating significantly increased consumption.

Lundström (1980). Half the overall consumption spread in all-electric households was explained by total (hot and cold) water consumption.

Morrison (1975). The number of rooms heated ranked fifth in this author's list of 17 explanatory variables.

Pearson (1981). Usage of appliances was one of this study's main explanatory variables.

Sansam (1981). As part of his thesis, this researcher carried out a survey to determine certain aspects of occupant behaviour relevant to fuel consumption. Through regression techniques, relationships were obtained which explained more than two thirds of the variance in mean useful energy input rate between houses. The important factors were hours of use of the central heating, window opening habits, and the closing of outlet registers.

Verhallen and Van Raaij (1981) found that the following household behaviours explained 26 per cent of variance of energy use: home temperature during absence, switching off the pilot flame in summer, bedroom temperature at night, home temperature during presence, and use of the hallway door. The authors designated certain events "special circumstances" and these explained 11 per cent of the energy use variance. They were as follows: the number of bedrooms used regularly, absence during weekends or working hours, presence of guests or illness during the investigation period, and changes in household composition.

CONCLUSION TO PART ONE OF THE LITERATURE REVIEW

The studies discussed in this section indicate that the physical fabric of homes and the socio-economic status of the occupants are not the only determinants of energy consumption. OCCUPANT BEHAVIOUR PLAYS A DECISIVE ROLE.

LITERATURE REVIEW, PART TWO

CONTROLLING ENERGY CONSUMPTION: A REVIEW AND DISCUSSION OF THE PSYCHOLOGICAL RESEARCH TO DATE

It was concluded in the previous section that occupant behaviour plays an important part in energy consumption. It follows then, that scope for controlling fuel use lies in changing householder behaviours.

As a direct result of the "Energy Crisis", caused by the Arab oil embargo of 1974, many researchers have already directed their attention towards finding ways of changing people's energy-related behaviours.

A review and discussion of this research follows, and will be dealt with under the following headings:

- A Changing Attitudes
- B The Provision of Conservation Tips
- C Prompting
- D Price Rises
- E Financial Incentives
- F Social Incentives
- G Energy Saving Controls
- H Consumption Feedback.

A: CHANGING ATTITUDES

The Energy Crisis sparked off many conservation programmes in the United States. They consisted of brief messages through the mass media, or information booklets about the reality of the crisis, the purpose being to persuade profligate American consumers to adopt more energy-conserving attitudes and, thereby, practices.

Numerous surveys were later conducted and are reviewed in

Lipsey, 1977;
 McDougall, Claxton, Ritchie and Anderson, 1981;
 Milstein, 1978;
 Olsen, 1978 and 1981;
 Shippee, 1980,

the purposes of them being to record

- (1) people's attitudes to the energy crisis,
- (2) whether they were conserving energy, and
- (3) the effectiveness of the conservation actions being taken.

The general conclusions reached were that many people expressed pro-conservation views, that the views were not necessarily translated into actions, and that if they were, the actions involved little inconvenience, small financial outlay and minimum reductions in comfort, and so to a large extent were ineffective.

This however was consistent with much previous psychological research on the relationship between attitudes and behaviour, reviewed by Wicker (1969), who in his summing up stated that "it is considerably more likely that attitudes will be unrelated to overt behaviours than that [they] will be closely related to actions."

From the above it seems that changing people's attitudes, certainly towards concepts with no immediate personal consequences for them, is not sufficient on its own to effect substantial changes in behaviour.

More recent research on attitudes in non-energy contexts, (Fishbein and Ajzen, 1975), indicates "that attitudes can be predictive of behaviour if the former are specifically related to the latter." In an energy context this would imply that attitudes related perhaps to comfort, a factor with some salience, could be predictive of behaviour. And indeed, a number of studies

(Gaskell, Ellis and Pike, 1981;
 Seligman, Kriss, Darley, Fazio, Becker and Pryor, 1979;
 Verhallen and Van Raaij, 1981)

have now looked at people's attitudes to issues which have important personal

consequences, and Seligman et al's (1979) study found the following salient factors to be predictive of behaviour as measured by actual energy consumption.

- (1) Health and comfort: if people saw conservation as leading to discomfort and ill health, they used more energy.
- (2) High effort/low pay-off: if conservation was seen as requiring great effort more energy was consumed.

This emphasizes, again, the importance of comfort and convenience, and implies that if people's attitudes to these factors could be changed their behaviour would change also.

It has been noted, however, by Carlyle and Geller (1978) that some of Seligman et al's (1979) explanatory variables appear to reflect self-reported behaviours rather than conservation attitudes. This again weakens the evidence for attitudes as predictors of behaviour, and highlights the importance of behaviour itself.

A very recent possible explanation (Green and Ventris, 1982) for discrepancies between attitudes and behaviour is that some people may believe that their (objectively) discrepant attitudes and behaviours are actually compatible. For instance, people could state that they were careful about energy use whilst wasting heat by not insulating a hot water tank, if they were not aware of the benefits of insulation.

The possibility that this explanation could be correct again points to the importance of actual behaviour.

In conclusion, therefore, it could be argued that attitude research has not been especially instrumental in indicating how behaviour might actually be changed.

B: THE PROVISION OF CONSERVATION TIPS

The possibility that people do not control their energy use optimally, because they are unaware how to, has been considered by many researchers.

Accordingly the following studies have evaluated the effectiveness of providing consumers with conservation tips:

Becker, Seligman and Darley (experiments 3 and 6), 1979;
 Craig and McCann, 1978;
 Geller, 1981;
 Hayes and Cone, 1977;
 Heberlein, 1975;
 Hirst, Maier and Patton, 1980-81;
 Hutton and McNeill, 1981;
 Kohlenberg and Anschell, 1980;
 Kohlenberg, Phillips and Proctor, 1976;
 Winett, Hatcher, Fort, Leckliter, Love, Riley and Fishback, 1982;
 Winett, Kagel, Battalio and Winkler, 1978;
 Winett and Neitzel, 1975.

But only three

(Craig and McCann, 1978;
 Hutton and McNeill, 1981;
 Winett et al, 1982)

were successful in effecting energy savings. Whereas many of the ineffective studies presented long written lists of tips which, it could be argued, did not attract the attention of consumers, the three successful studies were different in that the communication was either very simple, or in some respect novel.

Craig and McCann's recommendation was simply to ventilate (in order to save money on air conditioning). Hutton and McNeill's list of tips was accompanied by a shower flow-control device. Subjects were informed that its installation would lead to energy savings. Winett et al used films of actors turning down thermostats and putting on extra clothing to provide a powerful presentation for their tips.

Two field studies claim some achievements also. In the first, the index of success was the acquisition of insulation, and the cause was attributed to a British Government energy conservation programme called

"Save It". The campaign used intensive advertising, however, with a variety of media and concentrated largely on promoting insulation (Phillips, Mills and Nelson, 1978). The so-called success is open to question however for during the campaign the price of fuel rose, and insulation was promoted by more sources than just "Save It". It is difficult therefore to attribute increased sales to the campaign alone.

The authors provide evidence, however, that positive changes in people's energy-related attitudes, during the time the campaign was operational, were correlated with campaign publicity rather than price rises.

In the second, the Seattle City Light Neighborhood Energy Conservation Program (Olsen and Cluett, 1979), success was measured by reductions in consumption. Again, the consumers showing the greatest reductions in consumption had undergone a fairly intensive exposure to conservation information. Local community organizations were involved in the dissemination of information, in-house workshops had been attended and home energy checks had been carried out.

A possibility for the lack of success for long lists of tips, (and one not considered before) is that tips could be acted upon, controls could be adjusted, but energy savings might not necessarily follow if consumers have misunderstandings regarding the control of their energy system. For instance, people could be unaware of the existence of controls which are not immediately obvious, e.g. boiler thermostats, or they could misunderstand the function of a badly designed control.

In conclusion, it seems that tips in themselves are not necessarily enough. Their content and the way in which they are presented is important if they are going to change behaviour.

C: PROMPTING

A possibility considered by some researchers is that people's habits are so ingrained that they need frequent reminders, or prompts, to help them conserve.

And indeed conclusions reached in a recent review of the environmental prompting literature (Geller, Winett and Everett, 1982) indicate that prompts can be successful especially when

- (1) they clearly specify the desired behaviour, and who should perform it, or
- (2) they are presented "in close proximity with the opportunity to emit the requested response", or, lastly
- (3) they involve little personal effort.

In the energy context the prompting literature is small, but four studies

(Delprata, 1977;
Luyben, 1980;
Palmer, Lloyd and Lloyd, 1977;
Winett, 1977-78),

consistent with one or more of the above conclusions, achieved meaningful changes in behaviour.

The desired behaviour in the two former studies, and the last, involved little effort, simply turning out unnecessary lights in university rooms. In the first and last studies the prompts were placed strategically beside the light switches. All the studies made perfectly clear who should perform the desired behaviour.

The possibility that the effects of prompts might be only transitory, was confirmed in the Luyben and Palmer studies, but the former author was successful in reinstating energy-saving behaviours simply by sending an additional letter and conservation poster to the target subjects.

One study, however, (Luyben, 1982) reports disappointing results for a clearly-specified prompt. Thermostat settings were checked three days after President Carter asked Americans to set these controls to 65° or lower. Although 50 per cent of a sample who heard or read the appeal had their thermostats set at this temperature or lower, it was found that there was no difference in the observed settings of people who had, and had not, been exposed to the appeal.

A possible explanation for this lack of success is that people felt they would be uncomfortable at these lower temperatures. It has already been noted that people are unwilling to take actions they believe will lead to discomfort. It is likely, then, that in the area in which behavioural changes would be most meaningful - space heating - the effectiveness of prompts would be somewhat limited.

D: PRICE RISES

If increasing energy prices caused reductions in consumption, a simple means of controlling energy use would be to hand. Apparently the government believes just this, for pricing has been the principal tool in their energy policy over the last few years, as is demonstrated by the deliberate raising of gas prices. And, indeed, in 1982 the Parliamentary Under Secretary of State at the Department of Energy, David Mellor, stated that the idea behind the pricing policy, together with information and advice, was to persuade consumers to use energy efficiently (Mellor, 1982).

However there is little evidence that price rises are effective in their objective for average gas consumption in gas-using houses has actually risen (Leach, 1983) and results, described below, from research in the area are, at best, inconclusive.

Experimental studies of price increases have looked at the effects on consumption of

- (1) simple increases in unit costs, and
- (2) tariffs which increase as a function of increasing energy use (inverted rate structures).

Altered rates have been applied to

- (a) normal daily energy use, and
- (b) energy use in peak and off-peak periods. (For many utilities the energy problem is a peak-load one).

(a) Normal daily energy use

Kohlenberg, Martin, Barach and Anschell (1976) devised a method whereby they could find out the effect on consumers of

- (i) a 150 per cent unit cost increase, and
- (ii) a steeply inverted rate structure.

Their subjects were paid to participate, so long as they agreed to pay for any increase in electricity use (over the previous year's use, adjusted for degree days) at the higher experimental rate, or if they reduced their energy use, they would be money in pocket to the extent of the cost of the electricity saved at the experimental rate.

It was found that the steeply inverted rate structure had no effect but the 150 per cent rate increase had a conservation effect of about 6.5 per cent, maintained over a six month period.

Another study, (Kohlenberg and Anschell, 1980), was able to evaluate the effects of increased rates without having to resort to paying the participants, by exempting various groups of consumers from a real-life rate increase. The authors report "some" conservation effects in their group of non-exempted residential users, but they persisted for only a few months.

It is worth noting that the "General Quarterly" electricity tariff for non-domestic premises, provides reduced tariff costs each quarter for use in excess of 1000 units. Since Kohlenberg et al (1976) reported no conservation effects for a steeply inverted rate structure, it is possible that the "General Quarterly" style of tariff could actually encourage wasteful behaviour.

(b) Energy use in peak and off-peak periods

Results from research on peak-period pricing is mixed. Boggis (1974) and Caves and Christenson (1979) report that these rates were successful in reducing peak-load demand, but Kasulis, Huettnner and Dikeman (1981) found the method had no effect on people's behaviour as measured by verbal reports. In addition there were no significant differences in the peak and off-peak ratios of various experimental groups with different time-of-day tariffs. It is not clear therefore whether time-of-day pricing would be an effective way of controlling energy use.

The development by South Eastern Electricity Board of a scheme known as C.A.L.M.S. (Credit and Load Management Scheme) (Peddie, Frewer and Goulcher, 1983) is an indication of how seriously peak-load management is being treated by certain Boards. When the scheme is under way homes will be equipped with a micro-chip unit which will permit two-way information transmission, including reports of consumption to the Board's computer. There will be a peak and off-peak tariff, as at present, but in addition, a third tariff also, on a separate circuit, where consumers can choose to have particular appliances disconnected, in order of priority, at peak-load times.

It remains to be seen whether the scheme will be effective in operation.

An obvious disadvantage with price rises is that they strike hardest at the poorest sections of society (Bradshaw and Harris, 1983) and it is likely that these people are already economising to the best of their ability. Indeed, figures from Cunningham and Lopreato (1977, p.83) show quite clearly that people on higher incomes make more conservation efforts in response to price rises, presumably because prior to the rise they engaged in a greater number of energy consuming behaviours. But the same figures show also a levelling off in the number of conservation behaviours engaged in by all income groups as prices continue rising, indicating that there is a limit to the amount of discomfort and inconvenience people in any income bracket are prepared to tolerate. These facts are consistent with the adaptation factor noted by Kohlenberg and Anschell (1980), and together with the inequitous element, suggest that price rises may not be the best way to achieve conservation.

E: FINANCIAL INCENTIVES

In the discussion below, the terminology is loose but consistent with the energy conservation literature. "Incentives", "rewards", "rebates" and "prizes" are used to refer to "reinforcement" in psychological terminology.

Financial incentives are offers of money to persuade people to conserve, or money provided as a result of savings achieved.

There is a considerable literature on the effects of financial incentives. Perhaps this is not surprising, for it is well documented that people say they will conserve if this in turn will lead to monetary savings

(Bagshaw, 1981;
Cunningham and Lopreato, 1977;
Curtin, 1975;
Gollin, Smith and Youtie, 1976;
Gottlieb and Matre, 1976;
Kilkeary, 1975;
Milstein, 1976;
Perlman and Warren, 1977;
Phillips and Nelson, 1976).

Grants, tax credits and low-interest loans for items that aid conservation are common types of financial incentives, but their effects on consumption have not been evaluated in any systematic fashion.

Other monetary incentives used to date include rebates to consumers of part, or all, of the savings resulting from conservation efforts, and prizes to individuals or groups for excelling others in reducing consumption. These have been evaluated experimentally.

The evidence

(Kohlenberg and Anschell, 1980;
Slavin and Wodarski, 1977)

indicates that small rebates are unsuccessful in producing reductions in consumption. The first study failed to demonstrate a positive effect for conservation at all, and the second gained a significant effect only once out of a series of six tries over a three month period.

On the other hand large incentives seem successful in achieving their aim

(Hayes and Cone, 1977;
Kohlenberg, Phillips and Proctor, 1976;
McClelland and Belsten, 1979-80;
McClelland and Cook, 1980;
Newsom and Makranczy, 1977-78;
Slavin, Wodarski and Blackburn, 1981;
Walker, 1979;
Winett, Kagel, Battalio and Winkler, 1978;
Winett, Kaiser and Haberkorn, 1977;
Winett and Nietzel, 1975).

The feasibility of large rebates and prizes has been questioned however, as their cost has frequently exceeded the value of the energy saved. Moreover little is known of how long the positive effects would last.

In the U.S.A. a combination of a positive monetary incentive for conservation and a negative incentive for waste has proved very successful in reducing consumption. Specifically, McClelland (1980) found that dramatic reductions in energy use occurred when homes with utilities included in the rent, (a common practice in the U.S.) were changed over to direct-resident-payment for energy. As a result of this observation, and because alteration of metering arrangements is not always feasible, this author developed a

system whereby residents of master-metered apartments, rather than paying for energy in the rent, were separately billed for the previous month's actual energy use of the entire building, according to the number of square feet in the particular dwelling. Some incentive was thereby created for cutting back. Preliminary results indicate reductions in energy use of between five and 15 per cent.

The same potential for saving does not exist in the U.K., however, as individual metering is already the practice. To this, add the facts that small rebates are ineffective, and large ones expensive, and it seems that methods other than financial incentives are needed to help U.K. consumers control their energy use.

F: SOCIAL INCENTIVES

A very small number of researchers have looked at the effects of social incentives on energy consumption.

The conclusion of a study by Seaver and Patterson (1976) was that social commendation could be instrumental in helping people to reduce their domestic oil use. Subsequently this study was cited widely

(Allen, 1982;
 Battalio, Kagel, Winkler and Winett, 1979;
 Bittle, Valesano and Thaler, 1979;
 Bittle, Valesano and Thaler, 1979-80;
 Cook and Berrenberg, 1981;
 Cunningham and Lopreato, 1977;
 Davey, 1981;
 Ellis and Gaskell, 1978;
 Hake and Zane, 1981;
 Hayes and Cone, 1977;
 Katzev, Cooper and Fisher, 1981;
 Newsom and Makranczy, 1977-78;
 Palmer, Lloyd and Lloyd, 1977;
 Seligman and Darley, 1977;
 Shippee, 1980;
 Stern and Kirkpatrick, 1977;
 Stokols, 1978;
 Winett, Kaiser and Haberkorn, 1977).

But, in fact, because of an inappropriate analysis of its data, the conclusion must be questioned. A discussion of this paper is provided in Box G, below.

BOX G: A DISCUSSION OF SEAVER AND PATTERSON'S (1976)
PAPER

Households were assigned to one of three conditions - Control, Feedback, or Feedback plus Social Commendation (a sticker saying "we are saving oil"). The mean consumption rates of the previous year had been 0.160, 0.173 and 0.165 gallons per degree-day for members of the three groups respectively; there were no statistically significant differences among these rates.

The mean post-treatment consumption rate for the Control group was 0.146; for the Feedback group, 0.143; and for the Feedback plus Social Commendation group, 0.129 gallons per degree-day. It was found that the consumption rate of the Feedback plus Commendation group was significantly lower than that of either the Control or the Feedback group, which were not significantly different from each other. It was concluded that the sticker had caused this result.

However, because there was a difference in the pre-treatment rates of consumption, the comparison between post-treatment rates was invalid. The change in before and after rates was what should have been measured. Letters to the authors of this paper, requesting access to the original data, have proved unsuccessful. However, comparison with the pattern of the Seaver and Patterson analysis suggests that the reductions in rate of consumption for the Feedback and Feedback plus Commendation groups were probably not significantly different, while both were probably significantly greater than that shown by the Control group. The results could indicate therefore that feedback alone results in oil conservation, and that commendation in addition to feedback has no further effect on conservation.

A second study, however, does provide evidence for the positive effects of social incentives. Pallack and Cummings (1976) found that people who committed themselves publicly to conserve, and thus provided themselves with a strong personal incentive, showed a lower increase in fuel consumption

during the following month than people who had not done so. It was reported later, moreover, (Pallack, Cook and Sullivan, 1980) that the conservation effects from this treatment persisted for a whole year.

The above is a nice example of Cognitive Dissonance Theory (Festinger, 1957) in action. According to the theory, attitude change is likely in situations where people are persuaded to act, for little or no reward, in a manner which in normal circumstances would be against their better judgement. Thus Pallack and Cummings' subjects, rather than deciding that conservation was not, after all, important, would appear to have adopted new attitudes towards conservation.

It is difficult to see how public statements of commitment could be gathered nationwide at low cost, however. For the time being at least then, it is likely that social incentives are open to one of the criticisms levelled at financial ones; they would probably be expensive to put into operation.

G: ENERGY SAVING CONTROLS

Reducing energy use does not only save money. It can cause inconvenience and discomfort. It has already been noted (page 20) that there is a point beyond which people will not tolerate these even if energy costs continue increasing. Thus there should be a market for controls, the long term use of which would save money and minimise inconvenience, but which nevertheless would maintain comfort levels.

The ready acceptance and installation of freely distributed shower flow controllers by consumers in a study by Hutton and McNeill (1981), together with the increasing use of, for instance, programmers and thermostatically-controlled radiator valves, both of which are devices marketed as "energy-saving but comfort-maintaining", is an indication that there is a demand for such items. However, the following studies illustrate the need for the careful evaluation of all forms of controls.

Powell, Yerrell and Perkins (1983) pointed out, from their observations in primary schools, that "Buildings' occupants soon find ways of overcoming inappropriate system control sometimes to the detriment of the total system's efficiency."

Pimbert (1981) noted that only 50 per cent of a sample of 67 householders with clock-controlled heating actually used the clocks. Whether the reason was a lack of understanding of the control is not specified.

In a study of consumer use of Electricaire heating, Crawshaw and Dale (1980) found that of 24 subjects, only four acted wholly reasonably to questions concerning the appropriateness of control actions.

Kohlenberg and Anschell (Shower Study I, 1980, p.25) looked at the energy use per shower of several families with a shower flow controller and reported no conservation effects. Later the same authors (Shower Study II, 1980, p.27) reported meaningful reductions in energy use in three households with adjustable flow control valves.

Mertz and Darley (reported in Becker, Seligman and Darley, 1979), developed a control they called an Automatic Multi-Setback Thermostat. It permitted selection of separate minimum day and night temperatures and automatically maintained these. Householder action was required to override the minimum settings for desired periods of time. At the end of the periods the thermostat automatically returned to its minimum energy-conserving cycle.

Use of the thermostat resulted in a 19 per cent drop in summer air conditioning use in eight test houses and in a 31 per cent reduction in winter gas consumption in six other homes.

However, one family's consumption increased. It appeared that "before the thermostat was installed, the family, which was totally out of the house during the day, turned their thermostat up to 90°F. On almost all days, this prevented the air conditioner from coming on. However, when the thermostat was installed, a day time temperature of 77°F was chosen by the family due to a misunderstanding with [the] installers". Naturally, this brought the air conditioner into use frequently.

This was a very important finding, for as the authors point out, it illustrated how homeowners' understanding of the situation interacted with temperature settings, and consequently, energy savings.

Pimbert (1981) also drew attention to the way in which people interact with technology. He found that room-thermostat differential affected energy use, i.e. that the minimum temperature over the on/off cycle of fans and burners governed the preferred room-thermostat setting. He argued that if thermostat differentials were reduced, lower temperatures could be set, improved comfort levels could be achieved and energy savings would follow as well.

Engineers may be able to design energy-saving controls, but only careful evaluation, in laboratories and homes, can establish whether savings will be achieved. Misunderstandings or dissatisfaction can cause energy use to increase.

H: CONSUMPTION FEEDBACK

Consumption feedback, or knowledge of results, is the provision to consumers of information concerning their present rate of energy consumption, compared to their previous use or someone else's use, with the expectation that this will better enable them to control consumption. Its theoretical basis lies in the large body of psychological literature [reviewed by Ammons (1956) and Bilodeau and Bilodeau (1961)] which shows that knowledge of results improves performance.

It cannot be claimed that quarterly bills (monthly in the States) provide effective feedback, for aggregate energy use is uninformative about individual energy consuming actions, and about how consumption compares with some other standard. And indeed, aggregate use could actually discourage people from conserving if either fuel price increases, or cold spells of weather, caused increases in the "amount due", and thereby disguised any positive effects of small cut-backs.

The findings of feedback research are mixed. Some studies have found that it helps in the control of consumption. Kasulis, Huettner and Dikeman (1981) found that people reported rescheduling energy consuming activities into off-peak times as a result of feedback, and the studies listed below reported reductions in actual energy consumption or peaking behaviour of up to 18 per cent as a result of feedback

Bittle, Valesano and Thaler, 1979;
 Bittle, Valesano and Thaler, 1979-80;
 Blakely, 1978;
 Hayes and Cone, 1977 and 1981;
 Kohlenberg and Anschell, 1980;
 Kohlenberg, Martin, Barach and Anschell, 1976;
 Kohlenberg, Phillips and Proctor, 1976;
 McClelland and Cook, 1979-80;
 Palmer, Lloyd and Lloyd, 1977;
 Russo, 1977;
 Seaver and Patterson, 1976; (see discussion of this paper in
 Social Incentives section, page 23)
 Seligman and Darley, 1977;
 Winett, Kaiser and Haberkorn, 1976-77.

Other studies have reported that feedback was not effective in altering consumption patterns

(Becker, 1978;
 Becker and Seligman, 1978;
 Becker, Seligman and Darley (Experiments 3, 4, 6 and 7), 1979;
 Bittle, Valesano and Thaler, 1978;
 Gaskell, Ellis and Pike, 1981;
 Katzev, Cooper and Fisher, 1980;
 Kohlenberg and Anschell (Informative Bill Study), 1980;
 Newsom and Makranczy, 1976;
 Winett, Kagel, Battalio and Winkler, 1978;
 Winett, Neale, Williams, Yokley and Kauder, 1978-79).

Several studies have provided feedback in conjunction with one or more additional features (e.g. rebates, price rises, mechanical signalling devices, mechanical controllers, consumption goals, modelling videotapes). Reductions in consumption up to 30 per cent, and in peaking up to 50 per cent, have been reported for various combinations of these factors

(Becker, 1978;
 Becker and Seligman, 1978;
 Hayes and Cone, 1977;
 Kohlenberg and Anschell, 1980;
 Kohlenberg, Martin, Barach and Anschell, 1976;

Kohlenberg, Phillips and Proctor, 1976;
 McClelland and Belsten, 1979-80;
 Newsom and Makranczy, 1977-78;
 Winett, Hatcher, Fort, Leckliter, Love, Riley, Fishback, 1982;
 Winett, Kagel, Battalio and Winkler, 1978;
 Winett, Kaiser and Haberkorn, 1976-77;
 Winett, Neale and Grier, 1979;
 Winett, Neale, Williams, Yokley and Kauder, 1978-79).

The feedback provided in the above studies varied in several ways.

- (1) Medium of communication (e.g. in writing or by mechanical device or visual display).
- (2) Frequency (e.g. monthly, weekly, daily or continuous).
- (3) Term employed (e.g. kilowatt hours or monetary cost).
- (4) Energy-use time scale (e.g. use during the previous day, or cumulative use since the first day of the experimental period).
- (5) Comparison baseline (e.g. one's own consumption in the past, or the consumption of others during the same period).
- (6) Alone or in combination (e.g. sometimes feedback was provided in combination with additional informative or motivating features).

The groups of consumers provided with feedback has also varied. Sometimes it was provided to individuals and sometimes to groups (e.g. whole dormitories). Sometimes high energy users were the focus, at other times low users.

Broadly, the most successful feedback was presented to individuals rather than groups, and to high rather than low energy users. It was presented frequently (i.e. at least twice weekly), in written form, in a cumulative time scale, based on one's own, rather than someone else's, consumption in the past, and presented together with one or more additional informative or motivating features.

The best term to employ remains unclear to date. (see (3) above).

The question however of the feasibility of providing personalized information at very regular intervals arises. For this reason it is encouraging that four studies

(Hayes and Cone, 1981;
Kohlenberg, Martin, Barach and Anschell, 1976;
Russo, 1977;
Seaver and Patterson, 1976)

that provided less frequent feedback (i.e. weekly and even monthly) of a really workable kind (e.g. additional information from the utility company) were able to achieve meaningful reductions, and one study (Winett, Neale and Grier, 1979) demonstrated the effectiveness of self-monitoring.

The above findings indicate that carefully presented feedback can help in the control of energy use. Systems like C.A.L.M.S. (page 19) have the potential for success therefore. But more research is needed firstly in order to clarify particular aspects of the presentation, (e.g. should it be kWhrs. or money), and secondly because negative findings in some of the studies emphasize the need to identify more closely the most effective channels of communication.

CONCLUSION TO THE LITERATURE REVIEW

The literature review has described various research methods, the idea behind all of them being to change people's energy consuming behaviour. This thesis, rather than pursuing any one of those methods, develops an idea which arose several times during discussion in the review, that behaviour might more effectively be changed if it were first understood.

This idea is consistent with one put forward by Williams (1982) who said "... in the world of the free choosing consumer it may be essential to consider man the agent - as a person - with intentions that may be at variance with (and indeed utterly surprise) the engineer who designed the equipment that he appears to be misusing".

A good example which illustrates his point is a finding of McGeevor's (1981) that many people misunderstand the function of thermostats, and operate them like heat taps, believing that increasing the setting helps the house warm up faster. It is possible that advice to such people, not to raise settings, would go unheeded, unless accompanied by an explanation of the way in which thermostats function.

Similarly, people's intentions may be at variance with conservationists and educationists who provide the advice they appear to be ignoring, for Bagshaw (1981) found that some people believe that "cold comes in" rather than "heat goes out". With a belief like this, even specific advice to insulate a loft could be considered irrelevant. The advice needs to be pertinent to the individual's understanding.

This is also consistent with current thinking in cognitive psychology. Studies by Bransford and McCarrell (1977) led them to conclude that "comprehension results only when the comprehender has sufficient non-linguistic information to use cues specified in linguistic input to create some semantic content that allows him to understand".

A result of the proposed scheme of research could be more efficient design and operation of energy systems. In its turn this could lead to increased comfort levels for little effort and perhaps less cost. Since the importance of comfort, cost and convenience was noted several times in the review discussion, it is likely that such improvements would be viewed favourably by consumers.

The review has clearly highlighted the importance of consumer behaviour in energy efficiency, and the review discussion has pointed to the importance of understanding that behaviour. But which particular facet of behaviour would repay concentrated research effort does not emerge. Indeed the answer probably lies in the interaction of attitudes, knowledge and beliefs with the economic and physical realities of the world. The nature of this process remains elusive. If a label had to be applied then 'life style' would be an appropriate one. Such a concept is, however, unlikely to gain substantially from an examination of specific aspects of consumer behaviour, like window opening, or understanding time switches; and yet it is specific problems such as these that may hold the key to practical energy management advice.

It is for this reason that this thesis departs from the traditional single-problem, in-depth strategy of many theses, to a more eclectic, broad-canvas approach. Thus a variety of consumer behaviours are investigated here, by several methodologies, including questionnaires, simple experiments and full scale observations. In this way it was hoped to gain an insight into what is probably a complex labyrinth - human understanding of energy systems.

THESIS OVERVIEW

- Chapter Two An ethological analysis of people's behaviour in their homes, the purpose being to highlight how specific behaviours affect energy use.
- Chapter Three An investigation into consumer knowledge of the relative running costs of household appliances. This was undertaken because feedback research had shown that knowledge of results helped in energy control, and a possible inference was that householder energy-related knowledge might be inadequate. Results from an investigation of this nature could provide an indication of the type of advice consumers need. It could also identify myths about household energy use and suggest ways in which they could be corrected.
- Chapter Four documents responses to a radio appeal made to invite people in difficulties with paying bills, or with understanding their heating systems, to come forward.
- Chapter Five An investigation into the relationship between understanding electricity bills, and energy consumption.
- Chapter Six looks at householder understanding of thermostats in homes with
- a) gas central heating, and
 - b) electric underfloor heating.

On the basis of its findings, each chapter makes specific recommendations as to how problems could be overcome, and greater energy efficiency achieved.

CHAPTER TWO

OBJECTIVE MEASUREMENT OF OCCUPANT BEHAVIOUR

'Behaviour' and 'understanding behaviour' were highlighted in the review as being important in energy efficiency. This chapter investigates the former.

Although something is already known about the relationship between specific behaviours and energy utilization in different samples (Box F, page 9), there has been very little measurement of the full range of householders' everyday, idiosyncratic, energy-consuming behaviours which could verify the notion that wide differences in patterns of behaviour exist between people.

Pearson (1981) compared the lifestyles of two similar families whose fuel expenditure varied by almost a factor of two. She attributed the difference in outlay to appliance use, thermostat settings and "open" or "closed" use of the house; but her conclusions were based on verbal reports, not measurements.

"The Home Energy Project" (Stafford and Walker, 1982) is a Birmingham-based investigation into patterns of energy use. Unfortunately the final results are not yet available. A problem with the study is that an 'energy diary' is the research technique involved, and it has been recognised by the authors that an interaction between diaries and respondents could result in misleading or false replies.

The Open University (Horton, 1984) is currently undertaking actual measurements of occupant behaviour but, again unfortunately, the results of these are not yet available.

Clearly many behaviours will affect energy demand. Those about which there are some data are discussed below.

Temperature

The literature on thermal comfort (Bedford, 1964; Fanger, 1972) indicates that there is a wide range in the temperatures which people find comfortable. Nevins, Rohles, Springer and Feyerherm (1966) and Fanger (1972), in chamber experiments, showed that there was a 15°C difference, (from 18° - 33°), between the highest and lowest temperatures which people found comfortable.

Measurements in people's homes sometimes show even wider variations. Hunt and Gidman (1981) recorded temperatures (at various times of the day) ranging from 8° to 29°C in the living-rooms of a large random sample of U.K. householders. However these need not necessarily have reflected 'comfortable' temperatures.

The smaller range of temperatures recorded in the two studies below are representative of occupied rooms and are therefore more likely to reflect personal preferences.

Pimbert and Fishman (1981) found that 10 p.m. temperatures in 30 homes varied from 16° to 26° C.

The Electricity Council (1979) recorded evening temperatures varying from 17.7° to 23° C in 24 Scottish houses where the main source of heat was provided by direct-acting wall-mounted heaters.

In addition this latter study found that estimated focal point fire consumption in the homes varied from 63 to 1641 kWh for a heating season. This did not represent an overall temperature preference, for the house with the lowest focal point fire use maintained a higher mean 24-hour

temperature in the living-room (20.1° compared to 18.6° on weekdays, and 20.4° compared to 19.1° at weekends) than the one with the highest use.

Brundrett (1982) has since suggested that the occupants of these homes had three needs for the focal point fires:

- (1) a warm, cheerful, log-effect glow (which, of course, would scarcely affect consumption);
- (2) a powerful radiant energy source which could defrost them when they came home cold;
- (3) a localised pool of heat into which they could put their feet.

Clearly lifestyle and individual preference will strongly affect the need for the above, and categories (2) and (3) could have major effects upon consumption.

Differences between people of this kind could be crucial for energy expenditure and most especially so in houses fitted to receive off-peak electricity.

Window opening

Just over half of Pearson's (1981) sample of 150 subjects reported that they opened their living-room window in winter.

Brundrett (1978) found that "most" housewives reported that they opened their living-room window in winter. Forty per cent said they closed it again in less than an hour but 19 per cent said they left it open for longer than four hours.

In another study (Brundrett, 1977b) it was found from actual observations that open windows were common in Britain throughout the year; and from people's reports apparently the duration varied from a minute to continuous in all rooms.

In her pilot study Conan (1982) found that householder reports of window opening varied from two to 52 "open window hours" per day. Corroboration was provided for these wide-ranging reports from actual observations in her main study.

Since opening a window can increase the air changes to a room from one to 20 per hour (Chapter Three, page 100) this habit could have a major effect upon consumption.

Door opening

Very little is known about this habit. Brundrett (1978) reported that the "majority" of the 42 families who were interviewed said they kept the living-room door shut, and that they did this to save energy and avoid draughts.

Three quarters of both Conan's (1982) and Pearson's (1981) samples reported that they kept their living-room door closed in winter. (Children and pets were associated with greater door opening in the latter study.)

In conclusion: most of the above studies rely on subjective measures only. The following research is an attempt to rectify this situation. An investigation on ethological lines was planned where a few key energy-related behaviours would be actually measured through the use of fairly low-level technology.

THE SUBJECTS AND THE HOMES

In order to clarify comparisons of between-subject energy use it was decided to conduct the investigation in ten identical all-electric houses. This would control for some variations in energy use and at the same time bypass the need to consider gas consumption.

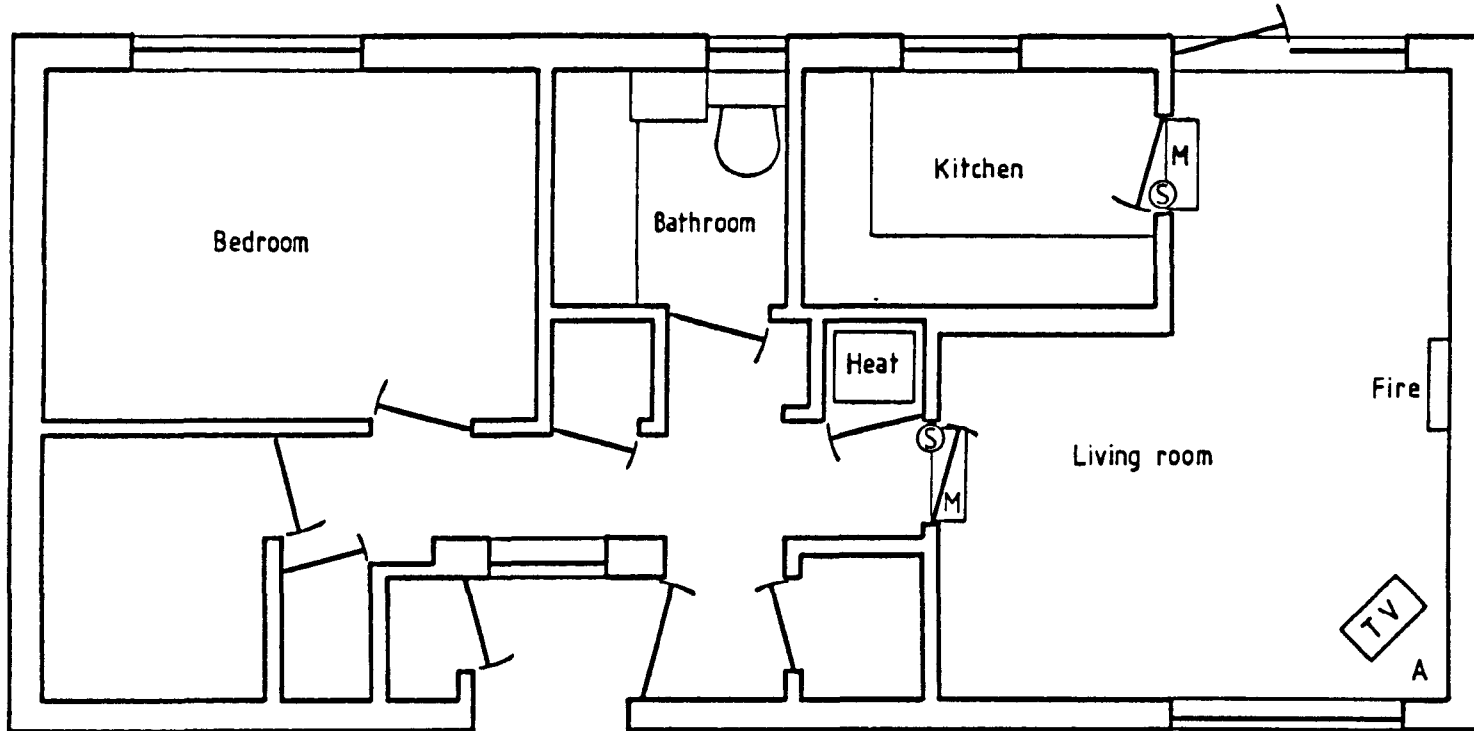
In Hull there are many all-electric houses in Council-owned estates. Those with underfloor heating are occupied mostly by families, and those with warm air heating by pensioners. One-person households in the latter category were sought for the Study because this permitted further control of consumption variations.

Unfortunately, in the end, it was not possible to control for number in household. Some households used in the Study had two occupants, others one. There were two reasons for this. The first was the difficulty in obtaining any people willing to participate in the Study at all; and the second was the technical problems, described later, which rendered results from several one-person households unusable.

The homes were one-bedroomed bungalows situated in an area of the city called North Bransholme. Illustration 2 : 1 (page 38) shows a plan.

The research described in this chapter was, in fact, carried out after that in Chapter Three. The households in this chapter were a subgroup of those used in Chapter Three. Since all those one-person households were female, the subject here, in the two-person households, was the wife.

2:1 Plan of the Electricaire bungalows



- S switch actuated by door
- M pressure mat under carpet
- A position of recording apparatus

THE HEATING SYSTEM

Each home was fitted with an AB8/54 (eight kilowatt) Creda warm air storage heating system, called Comfortaire, but more generally known as Electricaire (Illustration 2 : 2, page 40).

The overnight charge to the heating system could be altered by adjusting the Night Input Control (more generally known as the 'charge control') (Illustration 2 : 3, page 40). Input could be varied from 22 kWh on the 'mild' setting to 54 kWh on the 'very cold' setting. The location of the storage heating unit is shown on the plan.

Warm air could be distributed, by means of a fan, to a total of six outlet registers in various rooms. Illustration 2 : 4 (page 41) shows the position of one of the two living-room (or lounge) outlets.

A small lever beside each outlet enabled an adjustment to be made so that the register could be open or closed, as desired (Illustration 2 : 5, page 41).

The system could be brought into operation by means of a fan-switch, situated in the living-room. The fan was under the control of a room-thermostat, positioned near the fan-switch (Illustration 2 : 6, page 42).

THE TARIFF

Each home was on the Economy 7 tariff enabling it to receive seven hours of cheap electricity overnight. This fact could prove to have far-reaching consequences, for the impact of consumption variations between householders (if found) could actually be accentuated if those variations also involved interactions with off- and on-peak use.



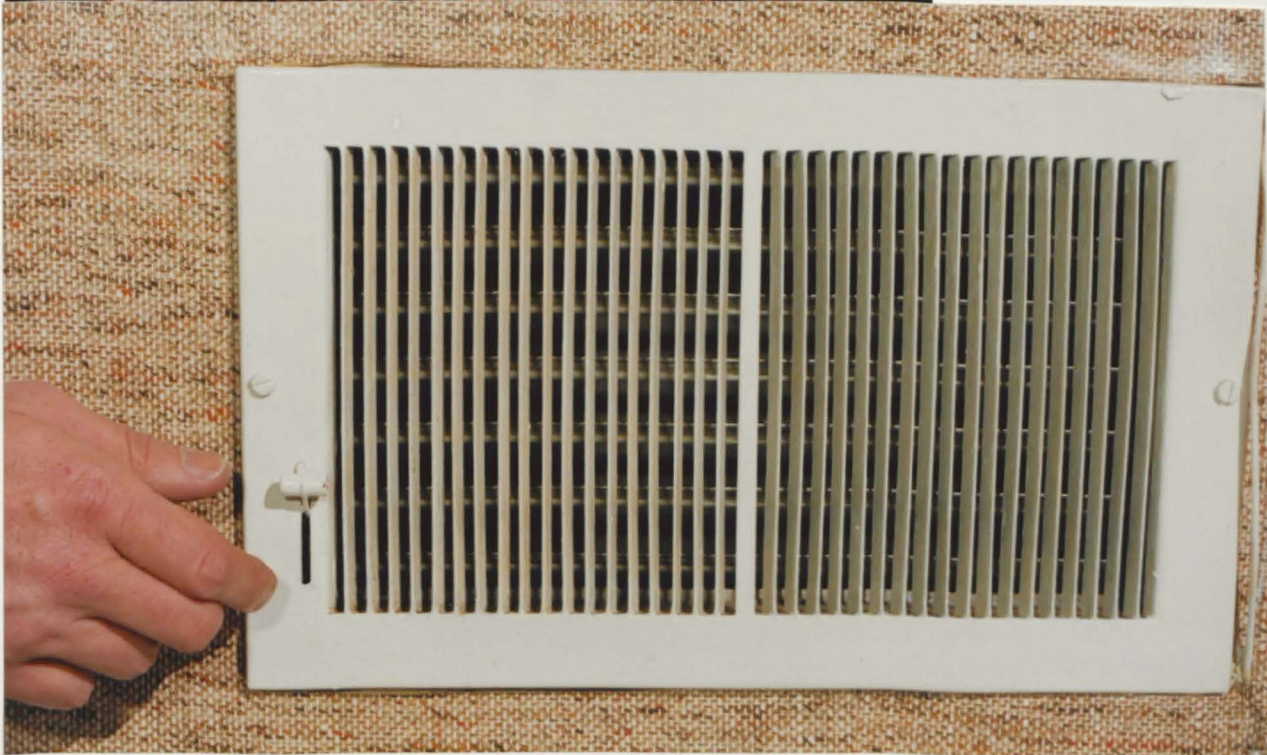
2:2
The Electricaire storage heating unit



2:3
The charge control on the Electricaire



2:4
Living room, showing
outlet register



2:5 Outlet register, showing control lever



2:6
Room thermostat
and fan switch



2:7 The recording apparatus

THE RECORDING DEVICE

A recording device was developed which could be left in a household, unattended, for up to four days. It measured inside and outside temperatures continuously, appliance operation, and, by recording door-closings, etc., behaviours of the occupants.

Illustration 2 : 7 (page 42) shows the recording device in operation, in the living-room of one of the subjects. Its position is indicated on the plan. (It was located similarly in all the test houses, as was the television). The temperature sensing unit is situated on the left of the apparatus. It was fitted with two sensors. One of these was taken through the window behind the apparatus and positioned outside. (This did not prevent the window from closing.) The other remained inside the living-room. The monitored temperatures were recorded continuously on a potentiometric recorder (in the centre of the apparatus).

An Everett Edgcumbe multi-channel event recorder (on the right of the apparatus) was connected to the following eight (or in some cases, seven) locations.

- (1) A sensor mat under the carpet near the living-room/hall door (Illustration 2 : 8, page 44). Its position is indicated on the plan. It enabled a recording to be made of every movement to and from the living-room and hall.
- (2) Another sensor mat under the carpet near the living-room/kitchen door. This enabled a recording to be made of every movement to and from the living-room and kitchen.
- (3) A sensor mat under the cushion of each subject's favourite chair. This enabled a recording to be made of the number of times they sat

2:8
Sensor mat



2:9
Magnetic switch on door lintel

down each day and the length of time they remained seated. (The position of the chair varied from house to house, but was always at a point between the fire and the television.)

- (4) A magnetic switch on the lintel of the living-room/hall doorway (Illustration 2 : 9, page 44). This recorded door-closings and door-closed time.
- (5) Another magnetic switch on the lintel of the living-room/kitchen doorway.
- (6) A switch on the television. This enabled television on-time to be recorded. (During the test period subjects operated their appliance by this switch only. Their usual control was concealed with adhesive tape [Illustration 2 : 10, page 46].)
- (7) The electric fire (Illustration 2 : 11, page 46, plan, page 38). Here a heat sensor (red wire) enabled a measurement to be taken of fire on-time.
- (8) The coal effect (glow) of the electric fire (Illustration 2 : 11). Not every home had a coal-effect fire, but in those that did a light sensor (grey wire) enabled measurements of glow on-time to be taken.

DURATION OF RECORDING PERIOD

Four days was chosen for the recording period because it was felt that this was sufficiently long to enable a picture to emerge of occupant behaviour. This intuition received some support from the research in Birmingham where it is emerging that heating patterns are "relatively stable over time" (Stafford and Walker, 1982).



2:10 Switch for TV to enable recording of on-time



2:11 Electric fire fitted with heat- and light-sensitive switches

TECHNICAL PROBLEMS

Recording began in late January, 1982. This should have allowed adequate time to investigate, for four days, behaviour in ten households, before the end of the heating season. However two technical problems arose.

The first came to light at the end of the first, otherwise trouble-free, recording period. The temperature sensing unit seemed to have developed a fault at some stage during the four days. The temperature recordings had drifted and become inaccurate.

There were delays while the unit was repaired and further delays while it was tested. Finally, after several overhauls and the necessary testing periods, the unit produced valid readings.

A second household was monitored only to discover that the fault had recurred. At this point it was decided to obtain external temperature data from the Hull Weather Centre, and to record indoor temperatures on a thermograph.

The second hitch was also discovered at the end of a four-day monitoring period. This time it was a fault in the take-up spool of the multi-channel recorder, which had the effect of halting the flow of the paper-roll a couple of hours after the apparatus had been left unattended. Event recordings were thus rendered indecipherable.

Recording proper did not begin until 25th March. As the heating season could well have been drawing to its close, it was decided to reduce subsequent recording periods to three days.

It was possible, in the end, to monitor only six homes for the shortened period. Whereas the intention had been to leave the apparatus unattended

for the duration of the recordings, in fact daily visits were made to each household to check up on the behaviour of the equipment.

RELATIVE HUMIDITY MEASUREMENT

Since it was necessary to visit the homes daily, it was decided that a measurement of relative humidity would be taken on each occasion. This was achieved with a whirling hygrometer.

FUEL CONSUMPTION MEASUREMENT

At the start and finish of every recording period subjects' electricity meters were read. A note was made of both 'normal' and 'low' consumptions (representing on-peak and off-peak use). From these data two consumption measurements were calculated per subject.

- (1) Total expenditure over the three-day period, and
- (2) a ratio of off-peak to on-peak units used in the three-day period.
(Larger ratios would represent more thermal comfort for less cost.)

OBSERVATIONS

After each three-day recording period observations were made of thermostat and charge control settings and the number of outlets in use.

REPORTED BEHAVIOUR

Subjects were asked daily if, and for how long, their homes had been unoccupied.

After each recording period subjects were asked about the following:

if they had altered their thermostat setting during the monitoring period;
if they had altered their charge control setting during the monitoring period;
the number of smokers in the household;
window opening;
blows through*;
curtain closing at night;
door closing in rooms where recordings were not made;
draught exclusion;
hot water use;
clothes washing;
clothes drying;
condensation;
activities while sitting;
appliance ownership;
pets;
frequency of visitors in the house.

RESULTS AND DISCUSSION

Monitored and reported behaviours, temperature and humidity measurements, energy consumption, and other relevant data are displayed in Table 2 : 1 (page 50). There, subjects have been arranged in rank order according to energy expenditure over the three-day period. (In March 1982 off-peak units cost 1.82p and full-rate ones 5p.) For convenience in the discussion, subjects were labelled with numbers only

*

For an explanation of a 'blow through' see Chapter Three page 100. Blows through were enquired about in the present research, for curiosity had been aroused as to their pervasiveness, and because of the important energy implications of this behaviour.

Subjects arranged in order of expenditure	Expenditure (£)	Use at off-peak rate (%)	Household size (No.)	Charge control setting	Thermostat setting (°C)	No. of outlets used (out of 6)	Time glow on (%)	Time fire heating on (%)	Temp. when fire heating put on (°C)	Mean indoor temp. over entire period	Mean indoor temp. when at home (°C)	Range of indoor temp. (°C)	Mean outside temp. (°C)	Living-room door openings (No.)	Time living-room door open (%)	Kitchen door openings (No.)	Time kitchen door open (%)	Movements between living room & hall (No.)	Movements between living room & kitchen (No.)
1	1.94	70	2	mod	18 (day) 21 (evening)	3	31	0.4	18	16.5	17.5	12.5 - 20	7.9	153	51	71	42	441	616
2	2.47	85	1	cold	21 or 24	4½	16	2	16, 13	17.6	19	13 - 24	8.1	54	50	21	37	176	257
3	2.63	80.6	1	cold	24 (morn. & eveng) 16 (day)	5	no glow	13	19, 16, 20.5, 19	17.8	19.7	13 - 24	5.3	89	8	73	9	201	305
4	2.81	81	1	cold	18	6	no glow	13	16, 20.5, 21, 21.5, 22, 22.5, 23, 23.5	19.5	20.5	14 - 24	8.6	103	12	75	26	221	278
5	2.84	80.2	1	v.cold	24	5	38	8	23, 23, 23.5, 23, 23	21.4	21.9	17.5 - 26	6.7	96	2	63	15	228	344
6	3.90	57	2	mod	16-18	3½	no glow	53	19.5, 14.5, 16.5, 16, 20, 18, 17, 19.5	20.8	21.4	14.5 - 26	6.2	63	14	22	49	211	284

Subject	Reported strategy for other doors	Reported strategy for windows (open)	Reported blow-throughs	Smokers in household	Reported curtains (No.)	Draughte excluder on outside doors	Visitors	Pets	Times S sat down (No.)	Time spent sitting (%)	Time t.v. on (%)	Reported sitting activities	Reported machine washing	Reported drying strategy	Reported baths	Condensation	Mean relative humidity (%)	Time absent from house (%)	Appliances extra to those all Ss owned
1	closed	Kitchn whn cookg, bedrm 2 hrs, bathrm ½ hr	15 mins daily	0	closed	no	frequent	dog	49	34	25	knitting crochet	1/wk	outside line	2/wk each	bedrm only	57	10	fridge-freezer colour t.v.
2	closed	Kitchn when cooking	never	0	closed	yes	frequent	none	107	39	34	knitting puzzles	1/2wks	living rm outlet	1/wk	none	47	6	colour t.v.
3	closed	Kitchn whn cookg, bedrm 2 hrs, bathrm all day	15 mins daily	0	closed	no	frequent	none	36	19	21	none	1/2wks	bathrm outlet drying rm	1/2days	much	54	12	colour t.v.
4	closed except bedrm	living rm 1hr, bedrm 1hr	10 mins daily	1	closed	no	rare	2cats	72	38	29	none	1/wk	bathrm outlet	1/2days	slight	50	4	colour t.v.
5	day any-how, night closed	living rm when cooking	never	1	closed	yes	frequent	none	101	50	30	none	1/wk	living rm outlet	daily	none	48	0	fridge-freezer
6	closed	Kitchn & living rm whn cooking, bathrm all day	5 mins daily	2	closed	yes	rare	none	79	39	27	none	1/wk	washing dried elsewhere	1/wk each	none	48	9	fridge-freezer colour t.v.

TABLE 2 : 1. MONITORED AND REPORTED BEHAVIOURS, TEMPERATURE AND HUMIDITY MEASUREMENTS, ENERGY CONSUMPTION AND OTHER DATA CONCERNING SUBJECTS IN THE ETHOLOGICAL ANALYSIS. (Subjects are arranged in rank order according to energy expenditure).

after their rank order had been calculated. Thus numbers serve a dual function, identification and position in the rank order. Low numbers represent low expenditure.

The results of the monitoring are displayed in Illustrations 2 : 12 to 2 : 17 (pages 52 to 57). (Door openings, and on-chair times, lasting less than 15 minutes have been ignored in the illustrations, but have been taken account of in Table 2 : 1.) Subjects' idiosyncratic patterns of behaviour can be readily discerned.

It can be seen that a wealth of data was generated during the course of the investigation. Lifestyles varied enormously, with fire on-time ranging from 0.4 to 53 per cent being just one example. Lifestyles are reflected in expenditure which varied by a factor of two.

It was not felt necessary to analyse every behaviour pattern in detail, so the following analyses are just a few among many which could have been performed.

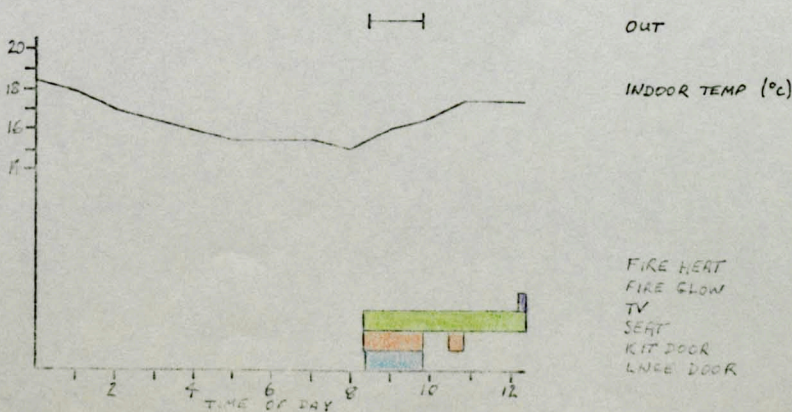
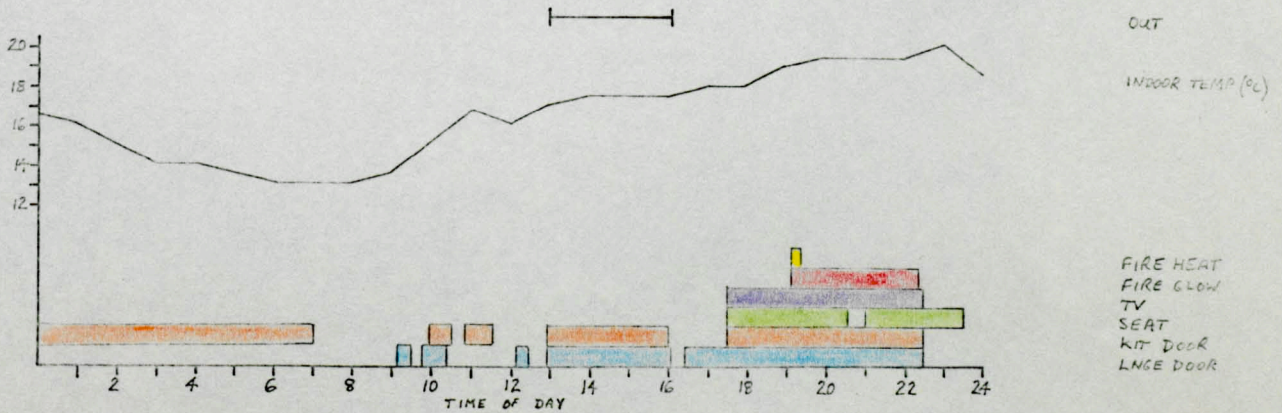
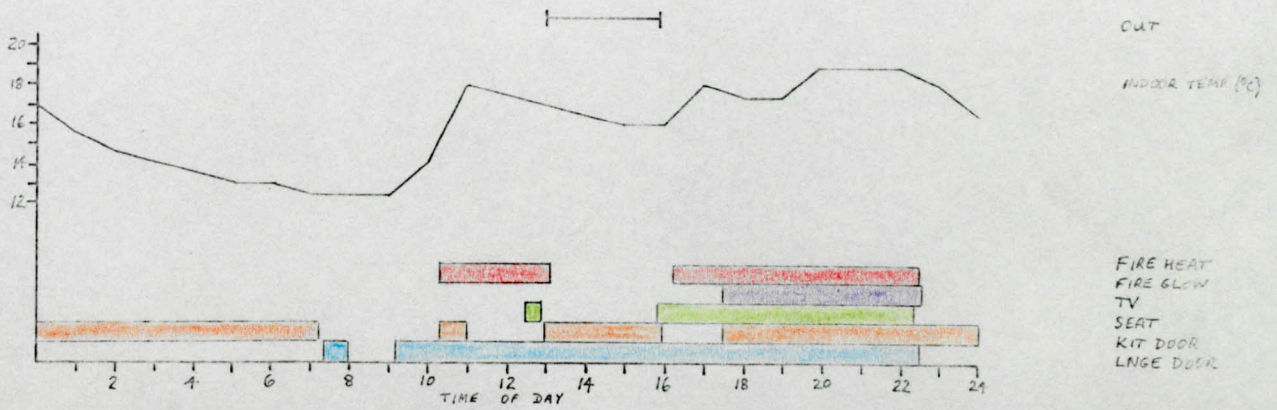
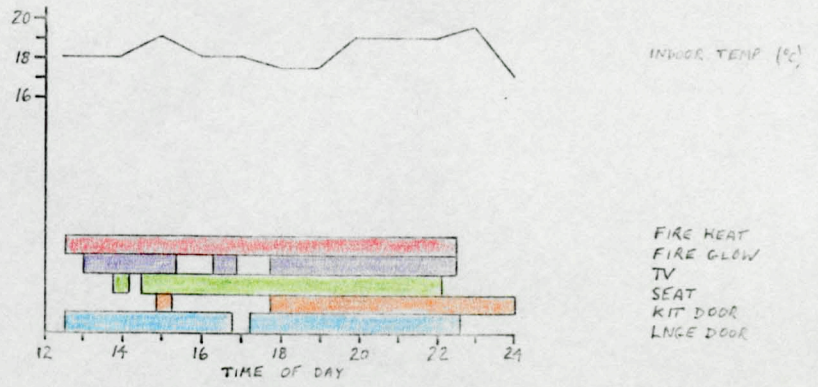
Subjects 1 and 6

Some interesting data are those of Subjects 1 and 6. The latter's expenditure was almost exactly double the former's for the three-day period and both were from households with two members.

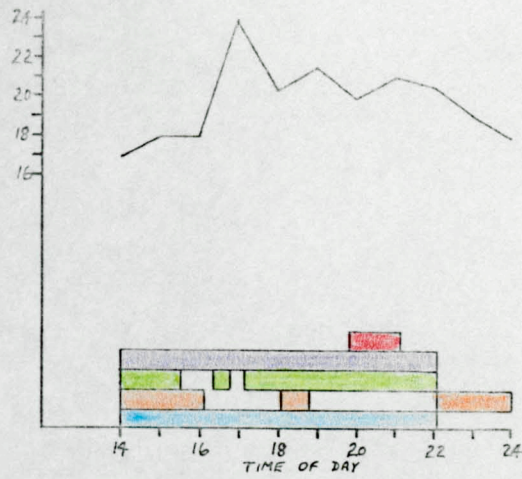
While it is recognised that the outside temperature was lower during Subject 6's monitoring period, this was not a complete explanation for the difference in expenditure, for the weather was even colder for Subject 3.

As it happens the lifestyles of Subjects 1 and 6 were similar in many respects: e.g.

- (a) charge control settings;
- (b) outlet registers in operation;
- (c) time absent from the house;

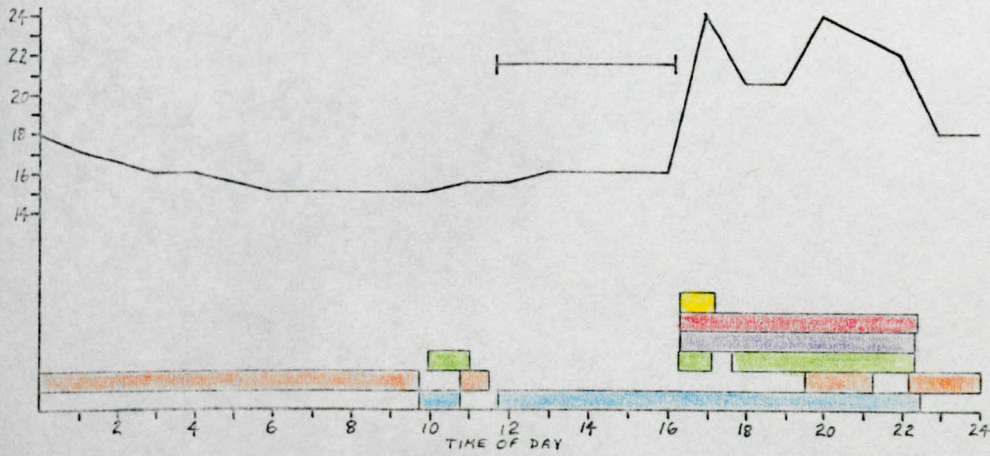


2:12 Subject 1's monitored behaviours and indoor temperatures



INDOOR TEMP (°C)

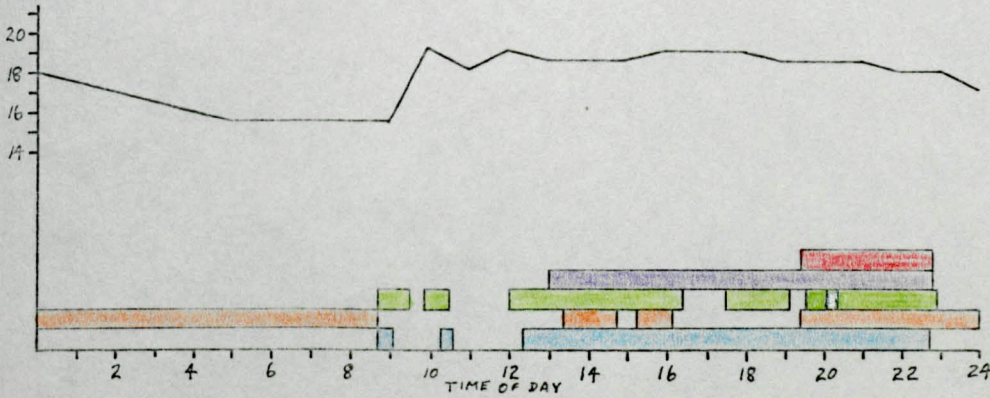
FIRE HEAT
 FIRE GLOW
 TV
 SEAT
 KIT DOOR
 LNGE DOOR



OUT

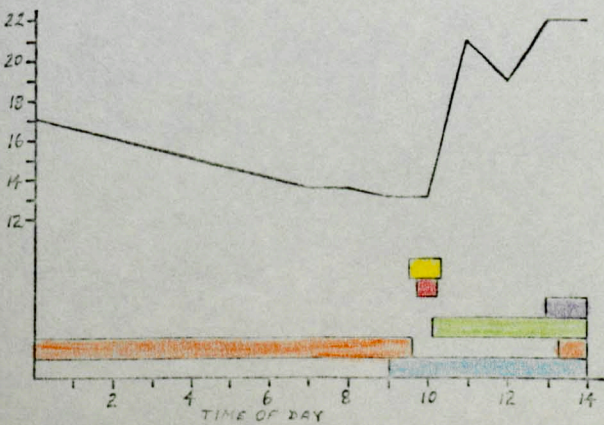
INDOOR TEMP (°C)

FIRE HEAT
 FIRE GLOW
 TV
 SEAT
 KIT DOOR
 LNGE DOOR



INDOOR TEMP (°C)

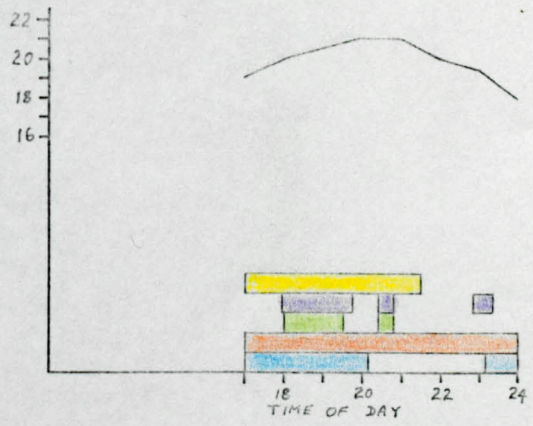
FIRE HEAT
 FIRE GLOW
 TV
 SEAT
 KIT DOOR
 LNGE DOOR



INDOOR TEMP (°C)

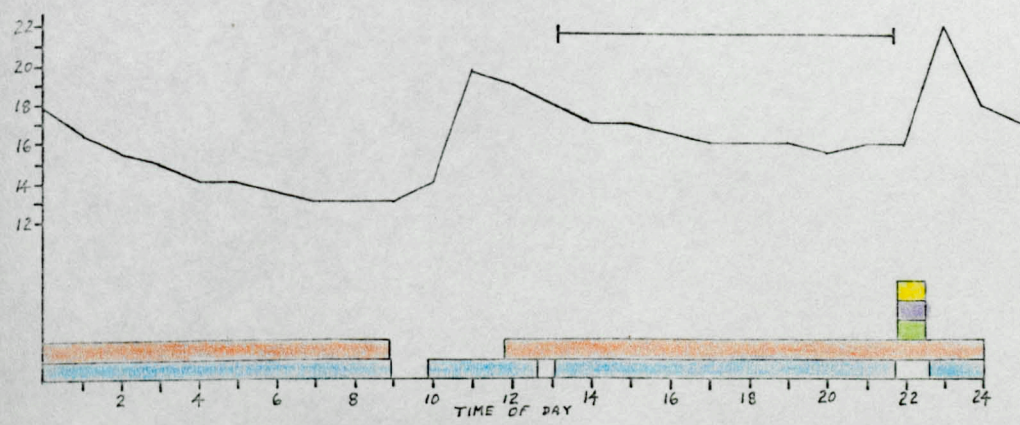
FIRE HEAT
 FIRE GLOW
 TV
 SEAT
 KIT DOOR
 LNGE DOOR

2:13 Subject 2's monitored behaviours and indoor temperatures



INDOOR TEMP (°C)

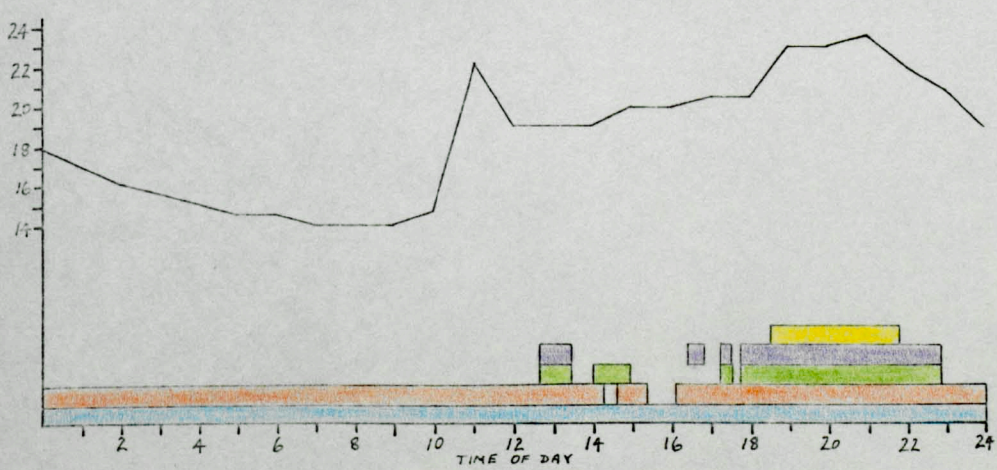
FIRE HEAT
TV
SEAT
KIT DOOR
LN&E DOOR



OUT

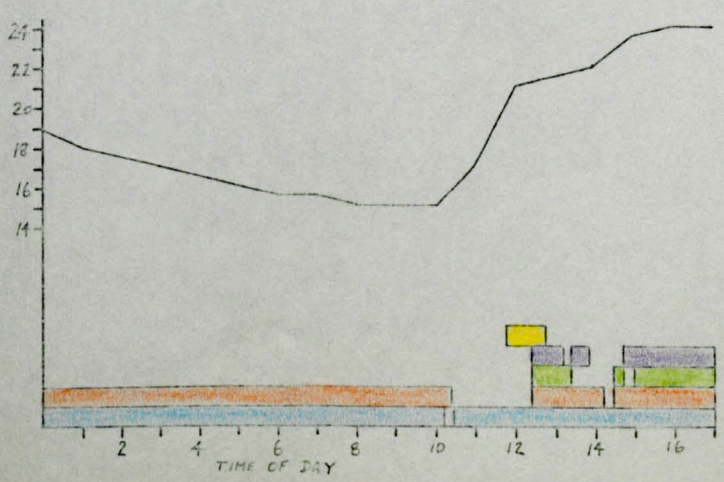
INDOOR TEMP (°C)

FIRE HEAT
TV
SEAT
KIT DOOR
LN&E DOOR



INDOOR TEMP (°C)

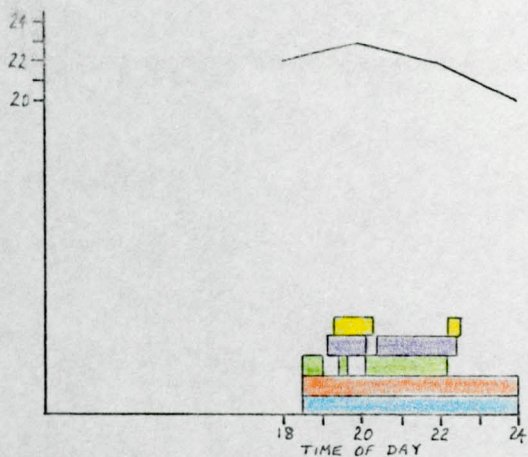
FIRE HEAT
TV
SEAT
KIT DOOR
LN&E DOOR



INDOOR TEMP (°C)

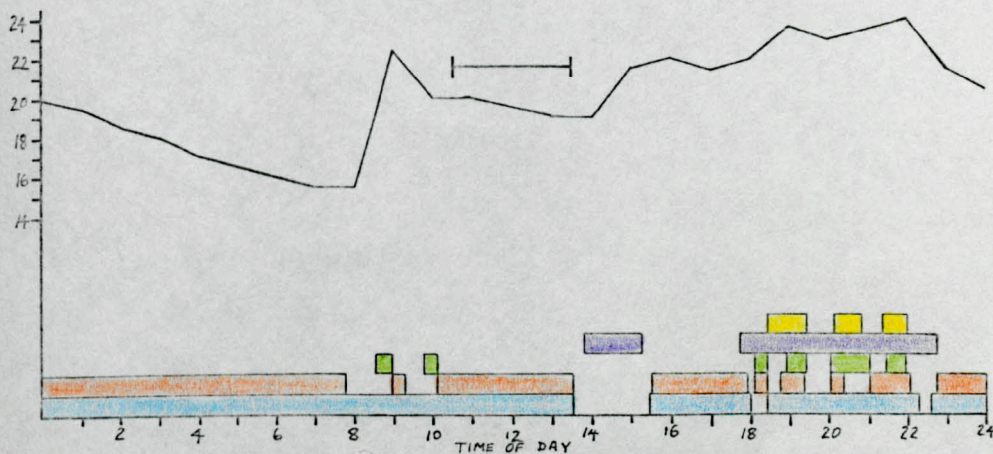
FIRE HEAT
TV
SEAT
KIT DOOR
LN&E DOOR

2:14 Subject 3's
monitored
behaviours
and indoor
temperatures



INDOOR TEMP (°C)

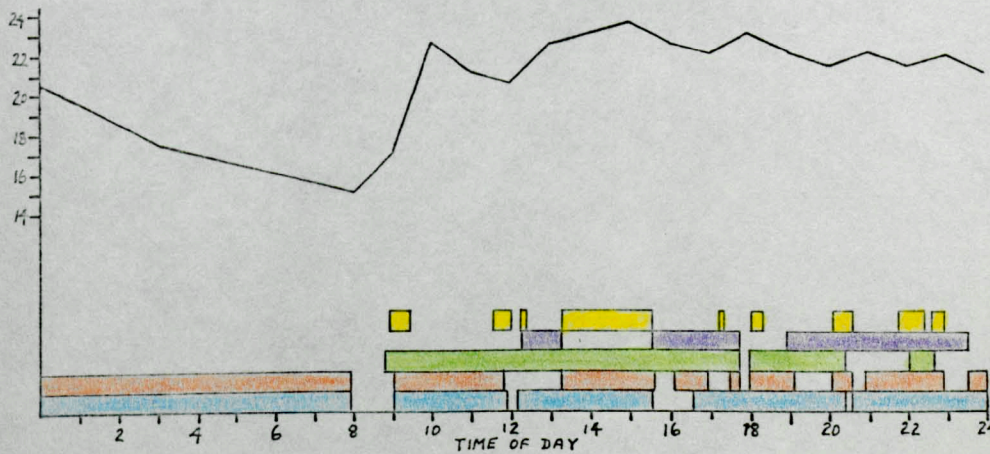
FIRE HEAT
TV
SEAT
KIT DOOR
LNGE DOOR



OUT

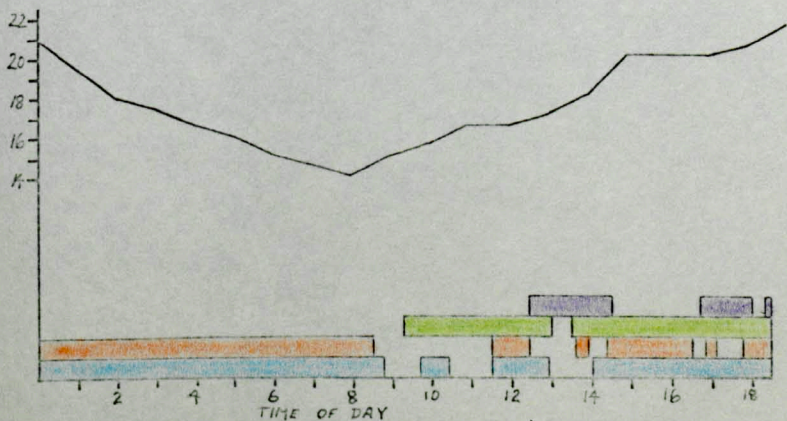
INDOOR TEMP (°C)

FIRE HEAT
TV
SEAT
KIT DOOR
LNGE DOOR



INDOOR TEMP (°C)

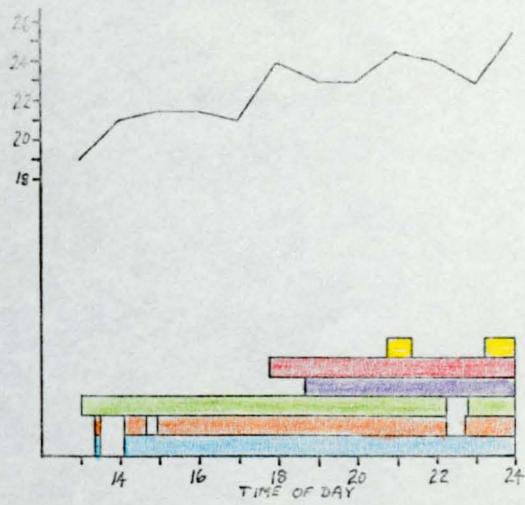
FIRE HEAT
TV
SEAT
KIT DOOR
LNGE DOOR



INDOOR TEMP (°C)

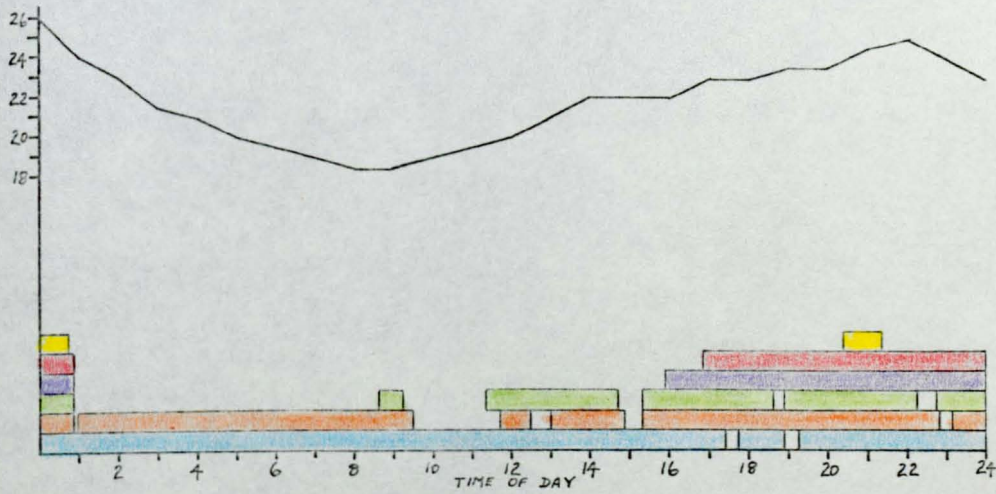
FIRE HEAT
TV
SEAT
KIT DOOR
LNGE DOOR

2:15
Subject 4's
monitored
behaviours
and indoor
temperatures



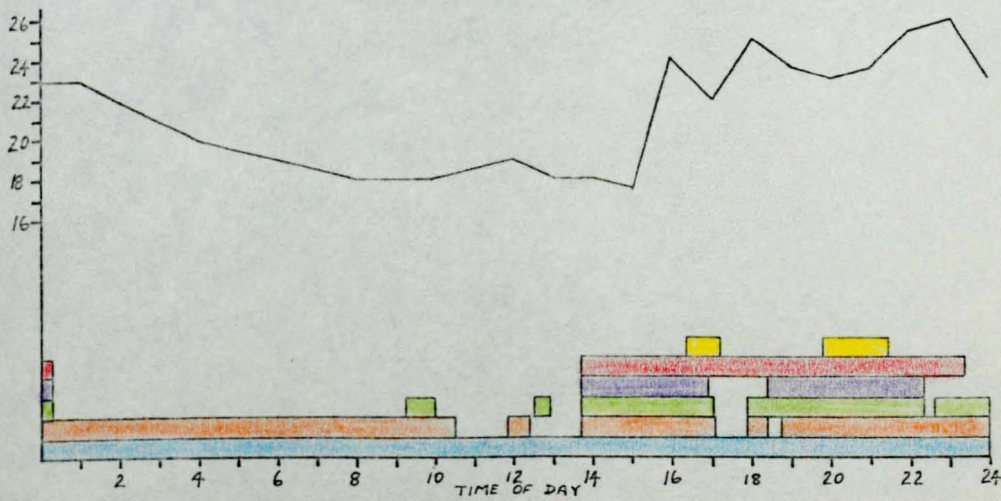
INDOOR TEMP (°C)

FIRE HEAT
 FIRE GLOW
 TV
 SEAT
 KIT DOOR
 LNGE DOOR



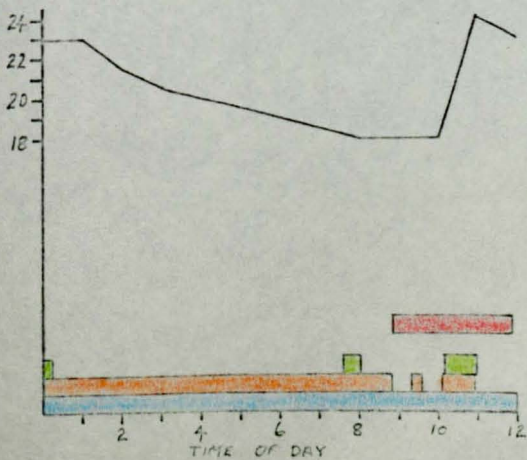
INDOOR TEMP (°C)

FIRE HEAT
 FIRE GLOW
 TV
 SEAT
 KIT DOOR
 LNGE DOOR



INDOOR TEMP (°C)

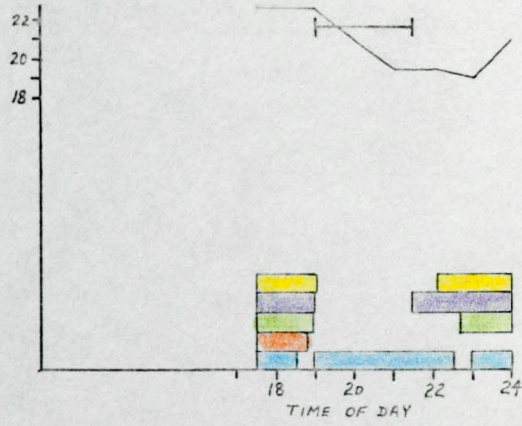
FIRE HEAT
 FIRE GLOW
 TV
 SEAT
 KIT DOOR
 LNGE DOOR



INDOOR TEMP (°C)

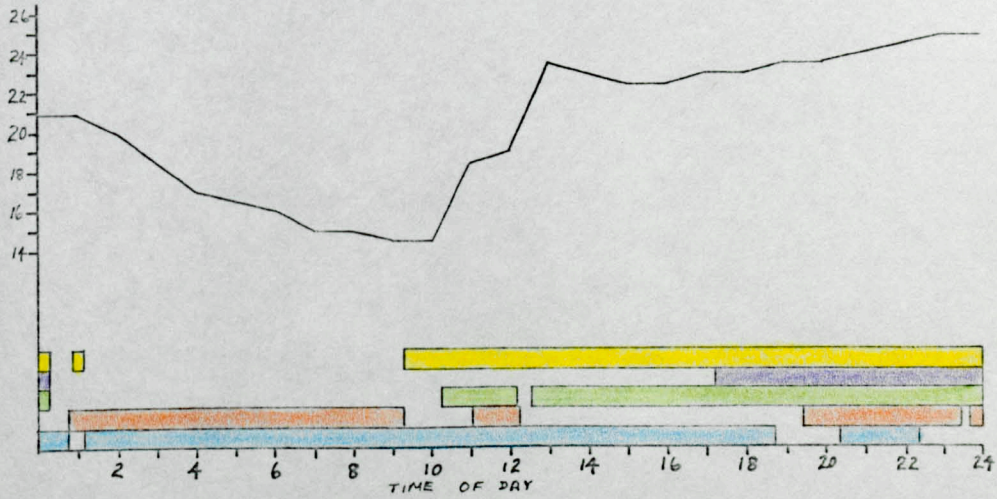
FIRE HEAT
 FIRE GLOW
 TV
 SEAT
 KIT DOOR
 LNGE DOOR

2:16 Subject 5's
 monitored behaviours
 and indoor
 temperatures



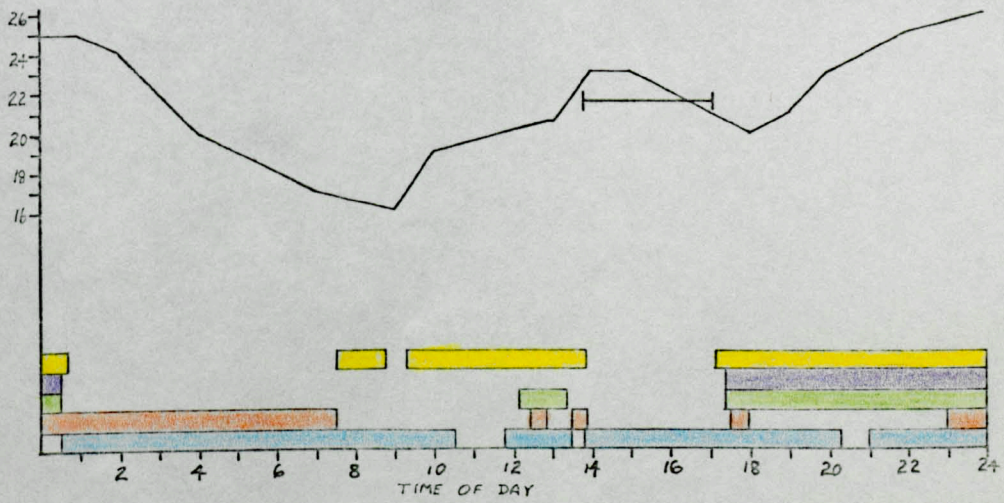
OUT
INDOOR TEMP (°C)

FIRE HEAT
TV
SEAT
KIT DOOR
LNGE DOOR



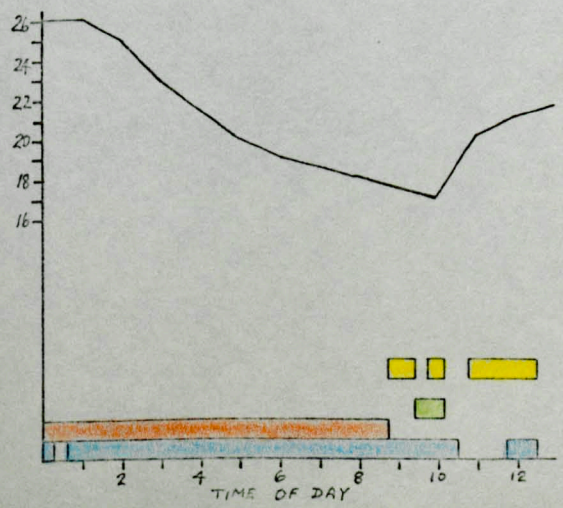
INDOOR TEMP (°C)

FIRE HEAT
TV
SEAT
KIT DOOR
LOUNGE DOOR



OUT
INDOOR TEMP (°C)

FIRE HEAT
TV
SEAT
KIT DOOR
LNGE DOOR



INDOOR TEMP (°C)

FIRE HEAT
TV
SEAT
KIT DOOR
LNGE DOOR

2:17 Subject 6's monitored behaviours and indoor temperatures

- (d) per cent time kitchen door was open;
- (e) strategies for curtains and other doors;
- (f) window ventilation (despite the fact there were two smokers in Subject 6's household);
- (g) time spent sitting (although Subject 6 got up from the chair more often);
- (h) television on-time;
- (i) washing machine use;
- (j) strategies for drying the washing;
- (k) appliance ownership.

In some ways Subject 1's lifestyle was actually the more energy-intensive: e.g.

- (a) higher mean thermostat setting;
- (b) greater numbers of living-room and kitchen door openings;
- (c) the living-room door remained open for longer;
- (d) blows through lasted for longer;
- (e) no draught excluder had been fitted;
- (f) frequent visitors;
- (g) possession of a dog.

Factors which caused Subject 6 to have the higher expenditure can be identified as:

- (a) almost constant use of the electric fire in waking hours (resulting in a low percentage of consumption at the off-peak rate); and
- (b) a preference for higher indoor temperatures.

It is possible that Subject 6's (comparatively) inactive lifestyle, reflected in the figures for movements to and from the living-room, made

the higher temperatures necessary; but had she adopted Subject 1's thermostat setting - or even a higher one - thus bringing the Electricaire into operation more frequently, she would have maintained her comfort level for less cost.

Subjects 5 and 6

The data from Subjects 5 and 6 were considered interesting because the former managed to maintain a higher temperature for less than three quarters the cost.

While it is true that twice as many people lived in Subject 6's household as Subject 5's, and that this could have been a reason for the former's greater expenditure, it could equally well be argued that the actual number living in these pensioner homes would not, in itself, affect heating requirements, or appliance use. Some support was provided for this hypothesis when attention was directed towards hot water usage.

All six households spent virtually identical amounts on hot water. (See Table 3 : 5, page 96. Subjects marked with "I" are the households under investigation here.) For this reason it was felt that a comparison between Subject 5's and Subject 6's lifestyles was worthwhile.

There were, in fact, some ways in which Subject 5's lifestyle was, of the two, the more energy-intensive: e.g.

- (a) higher mean temperatures in the day time and over the entire period, (despite the fact that she was remarkably active, making more movements to and from the living-room than Subject 6 and husband put together);
- (b) higher charge control setting;
- (c) higher thermostat setting;

- (d) greater number of outlet registers in operation;
- (e) greater numbers of living-room and kitchen door openings;
- (f) other doors sometimes open;
- (g) frequent visitors;
- (h) washing dried indoors;
- (i) never absent from the house.

Once again the difference in expenditure is explained by Subject 6's scarcely unabated use of the electric fire, the time her monitored doors were open, and the blow through. Adoption of Subject 5's maximum overnight charge could have provided equivalent thermal comfort for less cost.

ALL SUBJECTS

It is of great interest that Subjects 1, 2 and 5, who had coal-effects on their fires, made extensive use of them and operated their radiant sources very much less frequently than people without this facility. Perhaps on many occasions cheerful glows are what people need rather than radiant sources.

It is also of interest that room temperatures for individuals were seldom the same, when, on different occasions, the need was felt for the fire heat. On the same theme, it can be seen from Day 2, (Illustration 2 : 13,) that Subject 2 put her fire on when she came in from outside, despite the fact that prior to going out, she had not used it, and yet the temperature had been lower then.

Thus, people are not simply "passive responders to their environment" (Williams, 1982). They seem to use glow-effects and fires to make themselves "feel better as well as keep.....warm." This fact has important design implications. Fires with glows and smaller bars could fulfil the function of standard glowless one-kilowatt fires, while still saving energy.

CONCLUSIONS

The aim of the investigation was realised for this research illustrates that a technology exists to study lifestyle and energy consumption objectively.

Clearly with such a small sample conclusions are speculative only. None the less, reasons do emerge which go some way towards explaining differences in consumption across households.

For instance, several people could have reduced their bills without long-term inconvenience or reductions in the quality of life by adopting what once might have been considered 'straightforward' conservation practices, like keeping electric fire use to a minimum, and abandoning grand-scale ventilation. It seems likely, from the present analysis, that even these activities are not necessarily associated with energy expenditure.

Some subjects could also have reduced consumption in a manner running totally contrary to expectation, by increasing charge control and thermostat settings and perhaps by even obtaining a coal-effect fire.

Specifically then, it seems that advice is needed on maximising the advantages of Economy 7 and, more generally, that energy advice cannot be too elementary.

A very precise account of daily life, albeit not exhaustive, emerges from these simple recordings. It is easy to imagine how, with additional mats, and monitors on windows, front doors and other appliances, the picture would become increasingly detailed and better able to explain between-household variations.

The methodology could be invaluable for testing specific research hypotheses relating behaviour to consumption. Equally it could be used to

identify the main occupant needs from a proposed heating system. (To give just one example: where are localised heating sources required?) It could even be used to study patterns of movement in, perhaps, an office. Knowledge of such patterns could clarify both heating and ventilation needs.

CHAPTER THREE

THE RELATIONSHIP BETWEEN KNOWLEDGE OF THE RELATIVE RUNNING COSTS OF HOUSEHOLD APPLIANCES AND ENERGY CONSUMPTION

Feedback research, described in Chapter One, indicated that when householders have appropriate knowledge of results about their energy use they are able to reduce consumption.

The question arose, Can other forms of energy-related knowledge produce reductions in consumption also?

Since one of the important features of feedback is that it helps identify major energy-using appliances and thus allows maximally effective cut-backs to be made, if desired, it could be argued that knowledge of the running costs of appliances is the information which consumers need.

The questions raised in this chapter are these:

- (1) Do householders know the relative running costs of their various household appliances?
- (2) If they do not, what are their misconceptions?

A specific hypothesis is also proposed, which is that people with the best knowledge of running costs of household appliances will have the smallest bills.

A discussion of existing research on consumer knowledge of running costs of appliances follows.

DISCUSSION OF EXISTING RESEARCH ON CONSUMER KNOWLEDGE
OF THE RUNNING COSTS OF HOUSEHOLD APPLIANCES

Existing research can be classified as follows.

A: Consumers are asked about their beliefs concerning the importance of specific energy-conserving practices in actually saving energy.

As part of a survey into social factors affecting energy use and conservation in the home, Crossley (1980) obtained information on respondents' (a representative sample of Australians) beliefs in relation to the importance of fifteen specific energy-conserving practices in actually saving energy. Although, overall, there was a "medium-strength belief amongst the study population that the questionnaire's energy-conserving practices were important in saving energy", responses to certain items were of interest. For instance, the very important energy-conserving practices "Set the control on your hot water heater no higher than the "warm" position instead of on the "hot" position" and "Wear more clothes instead of turning on a room heater" were rated as "not important" or "slightly important" by as many as 41 and 36 per cent of the sample respectively. Thus it may be inferred that there was a considerable lack of knowledge among the sample concerning the running costs of space heating and hot water.

B: Consumers are asked energy-related questions in a telephone interview.

Using telephone interviews and what appears to have been as near a representative sample as these will allow, Milstein (1976) assessed certain limited aspects of the labelling knowledge of several thousand American consumers. One of his findings provided support for the present hypothesis,

namely that among other reasons, including inconvenience, many consumers did not conserve energy because they lacked the appropriate knowledge. Forty six per cent of the sample did not know that over the year the water heater used more energy than any other appliance in the home. Thirty six per cent did not realise that lower wattage light bulbs used less electricity.

C: Consumers are presented with a list of electrical appliances and asked to name the one which makes up the largest part of the bill.

Pearson (1981) as part of a study into domestic fuel expenditure and behaviour patterns, asked 150 Hull Council householders which of five common electrical appliances made up the largest part of the bill. (Space heating and hot water were not included as the homes were heated by gas). She concluded that only a minority of respondents made a direct connection between appliance use and cost. In general they tended to "pay up and look happy" (page 37). Cutting heating costs was one of the most popular reported ways of keeping bills down, but whether this was coupled with a knowledge of its real cost is not specified.

D: Consumers are asked to say how much it costs to run appliances for particular periods of time.

(i) The Consumers' Association (1978) conducted a survey on a cross-section of the British public to assess the likely effects of a proposed E.E.C. energy efficiency labelling scheme. Part of this survey was an attempt to find out consumers' knowledge of the running costs of different appliances. The Association claims to have found that few people have any idea of the actual running costs of the appliances they use and that overwhelmingly they overestimate them.

There would be a certain irony in this fact, if it were true, since informing people of the true costs could actually lead to increased consumption.

However the inappropriate use of arithmetic means instead of medians in this study has led to misunderstanding of the data. Most of the medians do reveal slight overestimations but in the case of hot water there is a gross underestimation. The national average cost of hot water each week in 1978 was £1.98. The mean estimate by the subjects in this study was quite close, at £1.70, but the median estimate was only 11p.

Some examples of the questions in this survey are these:

- (a) What is the cost of heating your water in the average week?
- (b) How much does it cost to heat a typical living room for 12 hours with an electric fan heater?
- (c) What is the cost of using your vacuum cleaner for half an hour?

There are three criticisms of these types of questions. One, that the time periods varied. Confusions in estimating running costs could have arisen here. Two, that the actual cost of running some of the appliances for the time periods suggested was so low as to make overestimations likely. For instance, a vacuum cleaner cost only ½p for half an hour's use in 1978. Three, there is the possibility that consumers found themselves faced with questions they were quite unable to answer and made wild guesses.

A small pilot investigation conducted by the author before the main study, described later in this chapter, gives some support to the above criticisms. The questions posed were in the Consumers' Association's format and elicited two kinds of response: gross overestimations and complete inability to make any sort of estimation at all. It seems likely that responses to questions of this kind mask rather than reveal knowledge. It could be argued moreover that precise knowledge of running costs is

irrelevant so long as consumers are aware of the major energy users (i.e. space heating and hot water, the former accounting for 60 per cent of the average annual energy bill and the latter 20 per cent, [Consumers' Association, 1978]).

The Association claims that their study shows exactly this, that their interviewees knew that heating and hot water were the major fuel users. However hot water has already been shown to have been underestimated and the same is also true for space heating if medians are again substituted for means.

Thus the Association's conclusions should have been

- (1) that asking consumers to state the cost of running minor energy-consuming appliances for short and varying periods of time leads to overestimations that probably mask knowledge, and
- (2) that people grossly underestimate the running costs of space heating and hot water.

Because of the methodological flaws in this study even this latter revised conclusion must be treated with caution.

(ii) Craig and McCann (1977) used a task, similar to that of the Consumers' Association, on a sample of "heavy energy users" who were predominantly well-educated and affluent.

They too found that their subjects made gross overestimations.

E: Consumers are asked to rank appliances according to energy use.

(i) Craig and McCann (1977) found that whereas their heavy energy users overestimated the real costs of operating appliances [see D (ii)], the same people could rank order them according to energy use. Since heavy users had good knowledge, this study appears to suggest that knowledge is not all

that is necessary to keep energy consumption down. However the results need not be treated as conclusive since the appliances used in the ranking task did not include the key energy users. They did include air conditioning, but on average this is ranked only fourth (Becker, Seligman and Darley, 1979) among affluent groups in the States, where the study was carried out.

(ii) Phillips and Nelson (1976) were also successful in their use of a ranking task as a tool to assess knowledge. They claim that following the British government "Save It" energy conservation campaign, a representative sample of the public were able to rank order correctly "according to the different uses of energy within the household" the following appliances: space heating, water heating, cooking, other appliances, lighting. Before the campaign the ranking had been space heating, cooking, water heating, lighting, all other appliances.

While this indicated good knowledge of the main energy user both before and after the campaign, and also that people actually learned something from the campaign itself, there are problems (outlined on page 71) with using representative samples, and with educating people about average energy use.

(iii) Becker, Seligman and Darley (1979) assessed knowledge of relative running costs of appliances of 43 well-educated middle to upper class American consumers. They used three ranking tasks; firstly in terms of how much energy particular appliances used while operating. This was not a particularly useful measure of knowledge as toasters, for instance, score highly on this dimension and yet economies with toasters would not be particularly beneficial. Secondly, in terms of how much energy particular appliances used in an average month, and lastly, in an average year. Space heating was not included in this survey, but hot water and air conditioning were. In both the monthly and the annual task water should have

been ranked first. In the monthly task less than half the householders ranked it first. In the annual task only a quarter of the subjects positioned it correctly. The conclusion reached from all three tasks was that knowledge was inadequate.

Of the three ranking tasks, ranking in terms of annual energy consumption seems best able to highlight real awareness of the major energy-consuming appliances. For instance, some major users, e.g. space heating and air conditioning, are only used for part of the year. For this reason householders may view them as less significant than they are.

In a second small pilot study conducted by the author before the main research described in this chapter, subjects were given a ranking task in terms of annual energy consumption. The task was readily understood and completed.

F: The relationship is looked at between (1) consumers' knowledge and reported conservation behaviours and (2) consumers' actual energy cut-backs and energy literacy.

Using two samples of Londoners drawn from publicly and privately owned accommodation, Gaskell, Ellis and Pike (1981) found a low but significant correlation between people's knowledge of the "comparative levels of consumption of different appliances" and their reported conservation behaviours, a finding which gives some support to the hypothesis proposed here. It has to be recognised however, and the authors do so, that there is some doubt about the reliability of self-reports (Olsen and Cluett, 1979).

It is not possible to comment upon the methodology used to assess labelling ability in this study as it is not described. Moreover, it is not clear whether major energy-using appliances featured in the labelling

task. Two letters to the authors requesting further information have received no replies.

Gaskell et al report what at first sight appears to be an interesting finding, that people who made "significant savings in gas and non significant savings in electricity" as a result of experimental treatments became in some respects more "energy literate", i.e. comfort became significantly less important to them and they reported significantly more conservation behaviours, another finding consistent with the present hypothesis. However despite the claim of "significance", no such tests were in fact performed on the data relating to consumption. Gaskell and Pike (1982) stated their intention of conducting these tests in the near future, but meanwhile they continued to talk of consumption "savings" arising from particular experimental treatments when these might have been nothing more than natural weekly variations in energy use.

Although, at first sight, this study appeared to support the present hypothesis, in fact it contributes little to the understanding of the relationship between knowledge and energy consumption.

EXISTING RESEARCH:
FURTHER METHODOLOGICAL CRITICISMS

(a) Several criticisms of individual studies have already been raised. A further criticism can be levelled at the majority of them. The methods used have frequently involved the researchers comparing respondents' answers to so-called 'correct' answers, or orders, based on average appliance use. This average may not be correct for particular individuals. There are people who seldom cook and who would be correct in ranking cooking low on their list. Studies which use this method may be producing gross pictures of knowledge but not accurate assessments. To determine more precisely whether consumer responses are correct, a measure must also be taken of their actual appliance use. It could be that certain people are not so lacking in knowledge as some studies have implied.

If conservation campaigns provide information about average energy use, as "Save It" did, the consequences might not be the desired ones. If a person reads an energy information pamphlet which states that the category "all other appliances" (Phillips and Nelson, 1976) uses just a little more than lighting, then he might well feel that increased use of his tumble drier would go virtually unnoticed on his bill. He would be wrong.

(b) The samples used in the studies described have varied from large, and representative of all social classes, to small subgroups of the population. A problem with representative samples is that if good knowledge is found, on average, [as with Phillips and Nelson (1976)], it remains unknown whether there were subgroups of the population where knowledge was lacking.

There is also a problem with using a well-educated subgroup. As it happens, Becker et al (1979), found considerable ignorance among their sample, which was strong evidence for the more general existence of ignorance

among the population. But if they had uncovered good knowledge among the well-educated, a further less well-educated sample would then have had to have been tested, in order that they could make confident statements about knowledge levels in the general population. It makes more sense to begin with less well-educated groups.

WHOSE KNOWLEDGE COUNTS?

An aspect of the studies which was treated in differing ways was the question "Whose knowledge counts?" or "Which member of the household should be asked the knowledge questions?"

Phillips and Nelson (1976) kept this part of their study representative, i.e. 50 per cent male and 50 per cent female. Becker et al (1979) interviewed either the husband or the wife, whichever was willing. The Consumers' Association (1978) and Pearson (1981) selected the householder who was responsible for paying the bill. Craig and McCann (1977) directed their attention towards the heavy energy user. Finally Gaskell et al (1981) focussed exclusively on members of the family who made energy-related decisions.

From the point of view of the present research, where a relationship was to be sought between knowledge and size of bill, something like Gaskell et al's choice seemed the most appropriate. The focus therefore became the person in the home mainly responsible for energy-related decisions. This choice was made while at the same time recognising that all members of households sometimes use appliances.

Conclusions to be drawn from the discussion of
existing research on consumer knowledge of the
running costs of household appliances

1. Studies asking for precise cash knowledge of running costs, in short and varying time periods, do not provide an accurate picture of consumer knowledge.
2. Ranking tasks in terms of annual energy consumption can reveal whether consumers are aware which appliances are the major energy consumers. A case can be made that knowledge of the major consumers is all that is necessary to make effective economies.
3. There is little information of substance regarding consumer knowledge of the relative cost of space heating - the key energy user.
4. One study which did indicate good relative knowledge of space heating used a large representative sample which could have masked knowledge lacking in subsections of the population.
5. Since it is possible that the better educated are more informed on energy matters, it makes sense to find out, first of all, the state of knowledge among the less well educated.
6. Only one previous study has considered the relationship between knowledge and energy use and criticisms have been raised concerning it.
7. If the relationship between knowledge and size of bill is to be investigated, the person whose knowledge counts is the one who makes the main energy-related decisions in the home.
8. If consumers are asked "Which of your household appliances uses the most electricity in a year?" it is not possible to assess the accuracy of their answers without first obtaining a measure of how much they actually use them.

THE STUDY

The conclusions drawn from the discussion of existing research directed the planning stage.

The Subjects

Thirty female pensioners who lived in council houses and who were mainly responsible for making the energy-related-decisions in the home were chosen as subjects.

The reasons for using less well-educated samples were provided on page 72. These ladies were suitable for two reasons. Firstly because it was likely that they had received the minimum statutory education, and that, many years previously; and secondly, because it was possible they had never worked outside the home, which could have the effect of making them more out of touch with energy information.

Subjects were recruited on a catch-as-catch-can basis. They were approached in their homes and asked if they would like to take part in a survey about electricity. If they agreed they were asked if they were responsible for operating the heating and hot water in the home. Only two ladies who would have been suitable subjects refused to take part in the survey.

The Homes

It was decided that subjects should live in all-electric homes as this would allow the natural inclusion of space heating and hot water in a knowledge survey.

It was decided moreover that subjects should live in identical homes with identical heating systems as this would control for many possible

causes of consumption variations. A relationship might then more readily be found between knowledge and energy consumption.

It was decided therefore to use a sample of people from homes like the ones described in Chapter Two (page 37).

A representative of Hull City Council assisted in the search for subjects by supplying many names of roads where this type of home could be found.

Method

A ranking task in terms of the annual electricity consumption was selected to assess knowledge of the running costs of appliances. Annual consumption would highlight consumer awareness of the cost of space heating, despite its non-use for part of the year.

To assist the operation of this task, subjects were asked to rank-order cards bearing the names of the electrical appliances they owned. Appliances with very small annual electricity consumption were not included, e.g. hair-driers.

The Interview

The form of the semi-structured interview is presented on page A 1 of the Appendix. It was designed

- (1) to assess subjects' knowledge of the relative running costs of appliances they owned;
- (2) to assess the accuracy of subjects' rank ordering by asking them questions concerning their actual appliance use etc. [see (a) (b) (c) and (d) below];
- (3) to investigate the reasons underlying any erroneous responses.

THE METHOD FOR ASSESSING THE ACCURACY OF SUBJECTS' RANK ORDERING

The method consisted of

- (a) asking each subject detailed questions concerning the frequency of their use of their own appliances;
- (b) asking subjects at what time of day they used their appliances (during the day, or overnight at the cheap rate);
- (c) (in the case of lighting) actual observations of light bulb wattage;
- (d) calculating the costs of running appliances with different wattages, for various lengths of time, at low or normal rate tariffs. These calculations are presented in the Appendix from page A 4 to page A 14, and Table A : 1 on page A 15 of the Appendix presents all subjects' 'correct' running costs.

A 'correct' rank order of appliances, derived from (a) (b) (c) and (d) above was constructed for each householder.

THE KNOWLEDGE MEASURES

The main knowledge measure consisted of a correlation, for each subject, between their reported rank ordering of appliances, and their calculated 'correct' rank order.

Since a case can be made that a lack of knowledge concerning low energy-consuming appliances is unimportant, so long as people are aware of the major or 'key' energy-using appliances, a second knowledge measure was devised. In this, people who underestimated one or more of their key appliances by two or more ranks were considered to have poor knowledge.

PERMISSION FOR CONSUMPTION DATA TO BE SUPPLIED BY THE Y.E.B.

All subjects were asked, and gave permission, for their electricity consumption records to be supplied by the Yorkshire Electricity Board (Y.E.B.). (This was also the case for subjects in subsequent studies described in this thesis). Illustration A : 1 on page A 16 of the Appendix is an example of the consent form.

THE VALIDITY MEASURE

A hypothetical annual electricity bill was constructed for each householder, again derived from (a) (b) (c) and (d) on page 77. A significant correlation between this hypothetical bill, and actual consumption data from the Y.E.B., would indicate whether the methods for calculating the 'correct' rank order had any validity.

The interviews were conducted in June, 1981.

RESULTS AND DISCUSSION

DECISIONS TO INCLUDE SUBJECTS IN OR EXCLUDE THEM FROM THE ANALYSES

Consumption data was obtained from the Y.E.B. for all 30 subjects, but it was decided to exclude four subjects (10, 15, 18 and 24) from the analyses because they heated their homes with calor gas. Space heating would not therefore have been the most expensive part of their electricity bills and their annual consumption would have been disproportionately low.

Subject 21 was excluded from the analyses because she had no low-rate consumption. She will be returned to on page 84.

Subject 14 had not been converted to Economy 7. She was on the Domestic White Meter. This gives eight hours of cheap electricity at night, and only space heating and hot water are obtainable on the cheap tariff. Since normally all the heat would have been stored in the first seven hours of the cheap period Subject 14's data have been included in the analyses and she has been treated as if she had been on Economy 7. An adjustment was made in the annual cost of running her fridge however, since it would not have run on the cheap rate at night.

The total number of subjects used in the analyses was 25.

THE Y.E.B. CONSUMPTION DATA

In 23 cases consumption data was from July, 1980 to June, 1981. In two cases the subjects (9 and 28) had only recently moved into their houses so no data was available for the above dates. Their data is from April, 1981 to March, 1982 and January, 1981 to December, 1981 respectively.

In every case consumption data was for a complete year.

THE LEVELS OF SIGNIFICANCE ADOPTED IN THIS RESEARCH

Since the research described here was applied (not every aspect could be controlled) and the sample size was not large, levels of significance up to 0.1 have been considered appropriate in the analyses. (This is also the case for subsequent chapters).

Although directional hypotheses have been proposed, significant differences in either direction would be of interest. Two-tailed tests have therefore been employed.

VALIDITY: DOES ANNUAL CONSUMPTION CALCULATED ACCORDING
TO THE METHOD ON PAGE 77 CORRELATE
WITH ACTUAL Y.E.B. CONSUMPTION DATA?

The correlation between annual consumption (calculated according to the method on page 77), and actual Y.E.B. annual consumption figures was significant ($r_s = 0.423$, $p < 0.05$). While this was not a very high correlation it did provide justification for the method of calculating 'correct' rank orders and thus gave support to the knowledge measures. Higher correlations might have been attained had account been taken of the very different ways in which people heated their homes. But the way in which the data were gathered did not permit this. It was known before the survey that heating was the most expensive part of every bill. In the calculations for space heating (Appendix page A 13) no account was taken of electric fire use. Heating costs were based on average Electricaire use, and indeed it proved to be more expensive to run than any other appliance. This was sufficient information to allow 'correct' ranked lists to be constructed.

KNOWLEDGE OF THE RELATIVE RUNNING COSTS OF APPLIANCES

Table 3 : 1 page 82 presents the correlations between each subject's reported rank order of appliances, and their 'correct' rank order. Correlations were not significant in only six cases, implying that overall, knowledge was good.

SIZE OF HOUSEHOLD AND ANNUAL ELECTRICITY CONSUMPTION (Y.E.B.)

Table 3 : 2, below, shows the lowest, median and highest annual bills (Y.E.B. data), to the nearest pound, of people living in one- and two-person households. Because of the difference in the medians for the two groups it was decided to perform a Mann-Whitney U test to see if the difference was significant. If it were found that the difference between the bills for the two types of household was significant then, in the next analysis, knowledge and size of bill would have to be looked at separately, for the two groups.

In the event the test just failed to reach significance ($U = 46$).

However, since significance was so nearly attained, it was decided, none the less, to treat knowledge and size of bill separately, for the two groups, in the next section.

Table 3 : 2. THE LOWEST, MEDIAN AND HIGHEST ANNUAL BILLS (Y.E.B. DATA) OF PEOPLE LIVING IN ONE- AND TWO-PERSON HOUSEHOLDS.

	£ lowest bill	£ median bill	£ highest bill
one-person households (n = 10)	178	253	357
two-person households (n = 15)	217	292	426

Table 3 : 1. INDIVIDUAL SUBJECTS' CORRELATIONS
BETWEEN REPORTED AND 'CORRECT' RANK
ORDERS OF THEIR APPLIANCES

S	r_s	Two-tailed significance	Number of appliances owned
1	0.787	$p < 0.05$	10
2	0.586	NS	9
3	0.500	NS	10
4	0.845	$p < 0.01$	9
5	0.695	" 0.1	8
6	0.728	" 0.05	9
7	0.778	" 0.05	9
8	0.477	NS	9
9	0.774	$p < 0.05$	10
11	0.778	" 0.05	8
12	0.529	NS	10
13	0.787	$p < 0.05$	10
14	0.912	" 0.01	9
16	0.904	" 0.01	9
17	0.695	" 0.05	9
19	0.607	NS	7
20	0.678	$p < 0.1$	9
22	0.683	" 0.1	8
23	0.957	" 0.01	10
25	0.879	" 0.01	9
26	0.778	" 0.05	9
27	0.817	" 0.01	10
28	0.731	" 0.1	8
29	0.916	" 0.01	8
30	0.444	NS	10

THE RELATIONSHIP BETWEEN KNOWLEDGE AND BILLS

The correlations between knowledge of the relative running costs of appliances (where knowledge was the correlation between reported and 'correct' ranked lists) and size of bill, for one- and two-person households were not significant. r_s for one-person households was -0.451 and for two-person households -0.134. It should be noted however that the correlations were negative and therefore in the predicted direction, i.e. greater knowledge was associated with lower bills.

A possible explanation for the non-significant correlations between knowledge and size of bill was that since knowledge was good overall, ceiling effects militated against significance.

Alternatively it could have been that some people with good knowledge preferred higher temperatures, wore lighter clothes, got up sooner, went to bed later, went away less, had more money to spare, than others with poor knowledge, so consequently had higher bills.

The converse could explain how someone with poor knowledge had a low bill.

Moreover, it would be possible for a person lacking in knowledge to live quite economically in a home with Electricaire and Economy 7, so long as he never touched any switches, if, in the first place, those switches had been set for economical use.

It turned out to be also possible for a person with good knowledge, and all switches set for economical use, to have an extraordinarily high bill.

Mrs. McC. - A Case Study

Mrs. McC. (Subject 21) lived on her own. When asked which appliance made up the largest part of the bill, she replied "heating". She added, moreover, that she never used hers because she could not afford her bills. Her knowledge of running costs appeared to be good. She ranked her three key energy-using appliances correctly, and the correlation between her reported and 'correct' ranked lists was significant ($p < 0.05$), again indicating good knowledge. She reported that she heated her water at night only. And yet her bill in December, 1980 had been £194.

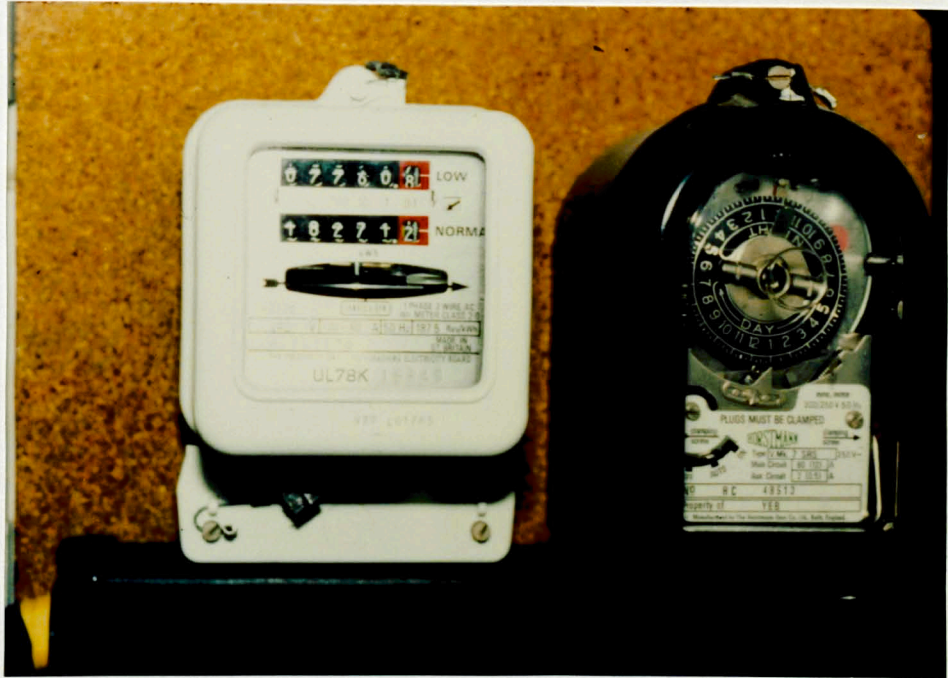
When her consumption data was obtained from the Y.E.B. it became apparent that her annual bill amounted to £533 and none of it was at the off-peak rate. The next highest bill for a single person was £357.

The Y.E.B. was contacted. It turned out that the time-switch which transferred her consumption to the off-peak meter at night was faulty. All consumption had therefore been recorded on the normal-rate meter. As a result, her use of the two tariffs was monitored for two weeks by the Y.E.B. and she received a very large rebate.

Illustration 3 : 1 shows a reconstruction (from Y.E.B. data) of Mrs. McC.'s bill for December, 1981. That all her consumption was at the expensive rate was not obvious to her.

Chapter Five will show that Mrs. McC. was not alone in her inability to understand the uninformative format of the bill.

Illustration 3 : 2, page 86, shows an Economy 7 electricity meter (on the left-hand side) with its Board time-switch (on the right). The meter is more informative than the bill, in that low- and normal-rate consumption are labelled, but since the meter is in a locked cupboard, it is unlikely that many people actually look at it. Perhaps this information should be provided on the bill.



3:2 Economy 7 electricity meter with its time switch

KNOWLEDGE OF THE MAJOR ENERGY-USING APPLIANCES

Table 3 : 3 (page 88) presents the lowest, median and highest amounts spent annually by the subjects on running their various appliances (calculated according to the method described on page 77). It can be seen that firstly space heating, then either hot water or cooking, were the three major energy-using appliances in every instance.

Table 3 : 4 (page 89) presents data concerning the three key appliances. It shows the subjects who underestimated one or more of these by two or more ranks. It can be seen that 13 people, (over half the sample), underestimated, considerably, the relative cost of one or more of these appliances. Viewed from this perspective, knowledge was not so good.

Column C shows that in ten of the 13 cases annual bills (Y.E.B.) were above the median (for one- or two-person households, whichever was appropriate). This finding was significant ($p < 0.1$, Binomial Test).

Perhaps then, people do need more information about the relative running costs of appliances if they are to make effective cut-backs.

THE RELATIONSHIP BETWEEN KNOWLEDGE AND OFF-PEAK/FULL-RATE CONSUMPTION

For people on Economy 7 sensible use of electricity might be reflected not so much in the size of the bill as in the proportion of off-peak to full-rate electricity used, for wise use of off-peak electricity can result in more thermal comfort for less cost. At the same time, for people on this tariff, good knowledge of relative running costs of appliances implies some knowledge of low- and normal-rate electricity prices. At the time the interviews took place a low-rate unit cost only 1.82p while a full-rate unit cost 5p. Since the Y.E.B. consumption data consists of two separate amounts, one for electricity used at the low-rate, and one for normal-rate this made

Table 3 : 3. THE LOWEST, MEDIAN AND HIGHEST AMOUNTS SPENT ANNUALLY
ON RUNNING APPLIANCES

(calculated according to the method on page 77)

	<u>Lowest</u>	<u>Median</u>	<u>Highest</u>
	£	£	£
Space Heating	*	155.00	*
Hot Water	32.40	50.00	137.00
Cooking	39.18	48.76	61.84
Fridge Freezer	*	26.34	*
Fridge	15.00	15.00	18.25
Colour T.V.	6.00	15.75	30.00
Black and White T.V.	7.09	10.13	28.38
Lighting	4.00	10.00	30.00
Vacuum cleaner	*	1.30	*
Iron	*	1.30	*
Twin Tub (excluding hot water)	1.20	1.20	2.00
Single Tub (" " ")	0.20	0.40	1.60
Spin drier	*	0.40	*

* indicates that the cost of operating this appliance was estimated as the same for every subject (see pages 4, 5, 8 and 13 of the appendix).

Table 3 : 4. THE CONSUMPTION OF SUBJECTS WHO CONSIDERABLY UNDERESTIMATED THE RELATIVE RUNNING COSTS OF KEY ENERGY-USING APPLIANCES

S	A	B	C	D
2	water	2	*	*
3	water	3	*	*
7	cooking	3	*	*
9	cooking	3	*	*
12	water	7	*	*
13	cooking	3	*	
19	cooking	3	*	*
20	water	3		*
22	water	3	*	
25	cooking	2		
26	cooking	2	*	*
28	water and cooking	2, 2		
30	heating and water	5, 4	*	*

- A : The key appliances, the relative running costs of which were underestimated by two or more ranks.
- B : The number of ranks by which appliances were underestimated.
- C : *denotes that the subject's annual bill was above the median for her particular size of household.
- D : *denotes that the subject's proportion of off-peak to normal-rate consumption was below the median.

an additional measure of competence feasible. A relationship could be sought between knowledge and the proportion of low-rate to normal-rate electricity used. Thus it was hypothesised that those with the best knowledge of running costs would have the highest proportion of low- to normal-rate consumption.

Column D in Table 3 : 4 (page 89) shows that in nine of the 13 cases, people lacking in knowledge about the running costs of the key appliances used less than the median proportion.

This result was in the hypothesised direction but a Binomial Test indicated that it was not significant. However, the correlation between knowledge of the complete range of appliances, (where knowledge was the correlation between reported and 'correct' ranked lists), and the proportion of off-peak electricity used, was significant ($r_s = 0.387$, $p < 0.1$) indicating that better knowledge was indeed associated with using greater proportions of low-rate electricity.

In answer to question number 34 in the Interview, no one knew how much cheaper night-time electricity was than day-time. Four subjects hazarded a guess of "half price". Presumably therefore people who knew about it made use of it because it was cheaper without needing to know precisely how much cheaper it was. Two subjects, however, mentioned particularly that they had never heard of cheaper electricity at night. In retrospect, it is possible that responses to question 34, recorded as "don't know", actually masked a lack of knowledge about cheap electricity per se, rather than a lack of knowledge concerning the difference in the two unit costs. Since information concerning off-peak electricity is non-existent on the bill (Illustration 3 : 1 page 85) this seems quite likely.

MISCONCEPTIONS ARISING FROM THE 'RUNNING COSTS' INTERVIEW

This section is concerned with subjects' misconceptions about energy use. These sometimes certainly did, and sometimes could have involved them in unnecessary expenditure. Subjects referred to in this section are marked with an asterisk if their annual bill (Y.E.B.) exceeded the median (for one- or two-person households, whichever was appropriate).

The misconceptions came to light in several ways:

- (1) in answers to questions designed to provide explanations for a lack of knowledge in the ranking task;
- (2) in subjects' descriptions of the ways in which appliances were operated;
- (3) in conversations arising from the semi-structured interview.

Misconceptions will be dealt with in the following categories: those concerning

- (a) space heating
- (b) heating water
- (c) other appliances
- (d) ventilation.

A comparison of the costs and benefits of heating by off- and on-peak electricity precedes section (a); an account of the way in which the hot water systems operated is presented before section (b); and section (d) is preceded by an explanation of the purposes of ventilating, and a discussion of whether it is necessary.

SPACE HEATING: COMPARING THE COST OF HEATING THE
HOME WITH OFF- AND ON-PEAK ELECTRICITY

Many different strategies were employed by subjects, always in the interests of economy, in their use of fires and Electricaire (the operation of the Electricaire system was described in Chapter Two [page 39]), and it was necessary to make gross calculations of the cost of the strategies before passing judgement on them.

Meter observations indicated that heating the Electricaire unit, from cold, with the charge control at the "very cold" setting, (i.e. maximum charge), used 45 (off-peak) units.

The comparative costs of three different methods of home heating, and the heat obtained thereby, are given below.

	<u>Daily Cost</u>	<u>Heat obtained</u>
Electricaire on the 'very cold' setting	82p	45 (off-peak) units
Electricaire plus one bar of fire for three hours in the evening	97p	48 (off- and on-peak) units
Two bars of an electric fire for 15 hrs.	£1.50	30 (on-peak) units

Use of the Electricaire in mid-winter therefore provided most heat for least cost. The ideal strategy in Spring and Autumn was not so clear-cut. Some days mild settings on the Electricaire would have been best, on other days, intermittent use of a bar of the fire. An ability to predict the weather was necessary to get value for money here.

It should be noted that each full-rate Economy 7 unit was dearer by 0.3p than ordinary Domestic tariff units; so people on Economy 7, who liked to use electric fires in preference to the Electricaire, were doubly penalized for their preference/ignorance.

BELIEFS ABOUT SPACE HEATING

Subjects 6 and 9* both switched their Electricaire off in the afternoons "to allow it to build-up again", during which time they used their electric fires. But unknown to them no such build-up process actually took place. (It is possible that these people had lived previously in homes where they did receive an afternoon boost, because there are such Electricaire homes in Hull).

Subject 12* said that she used the Electricaire for an hour, but then she used the electric fire. She preferred to save the remaining six hours of the Electricaire for the evening. She said that since the unit absorbed heat for only seven hours it could produce only seven hours'-worth of heat.

Subject 5* said she did not use the Electricaire because it made the hairs come off the dog's back. She used the electric fire instead.

Subject 19* said she preferred electric fires to the Electricaire because they were "more cosy".

Subject 20 said that more heat came out of fires because you could see them glowing.

Subject 18 was one of the people who had gone over to calor gas. When asked why she had made the change she said it was because she had not obtained enough heat from the Electricaire, so she had had to use the electric fire a great deal and this had been expensive. When asked if she had ever altered the charge control, or the thermostat, when the weather had been cold, she replied, "It was all set at particular settings and we never altered it. I think what used to happen was that at particular times of the year they turned it down at the power station."

The commercial engineer at the Y.E.B. was contacted and asked whether voltage variations could have been the cause of the above observation. The

reply was that the variations were not generally detectable. The fact that this subject did not adjust her controls was the cause of her discomfort.

A pilot subject who used electric fires denied that electricity was cheaper at night, saying, "They tell you it's cheaper at night, but I've been out and looked at the little wheel and it goes round much faster at night." The observation was accurate, but the assessment of the situation was not.

Subject 28 said she was trying to reduce her costs so she was cutting back on her use of the electric fire because she had heard it cost "just over 5p an hour" to run. When it was explained that it cost precisely 5p an hour to run she said, "Oh good, now I can use it more."

Subject 25 indicated her inability to see the relationship between warmth and money by commenting that she would not bother to have insulation laid because the place was warm enough already.

Thus it can be seen that people's beliefs and lifestyles, at first sight unconnected with energy use, were at times major factors in energy consumption.

THE HOT WATER SYSTEM

The hot water systems in the bungalows were operated by two switches:

- (i) an on/off switch beside the cylinder (Illustrations 4 : 12 and 4 : 13, page 127)

and

- (ii) a switch in the hall labelled Day/Night (Illustration 4 : 14, page 127).

If the switch by the cylinder was 'on' and the Day/Night switch was set to 'Night', then a time-switch permitted the occupant to obtain, each morning, without the necessity for any further operation of controls, a tank of hot water at the cheap rate. If additional hot water was required during the day-time, the Day/Night switch could be set to 'Day', in which case the water would be obtained at the dearer rate.

If the occupant wanted no hot water at all, night or day, then it was necessary to put off the switch by the cylinder. (A confusion which arose from the fact that the Day/Night switch glowed red when the cylinder switch was 'off' is dealt with in Chapter Four [page 126]).

BELIEFS ABOUT HOT WATER

Table 3 : 5 (page 96) shows the various strategies used to heat water, (again always in the interests of economy), and the annual cost incurred, calculated according to the method described on page 77 and page A 4 of the Appendix. The range in the annual cost is almost £100.

It can be seen that a convenient and economical strategy was to heat the water each night at the cheap rate. The annual cost of doing this was calculated to be £50 (and subsequent meter checks showed that the

Table 3 : 5. THE STRATEGIES USED TO HEAT WATER AND THE ANNUAL COST INCURRED (calculated according to the method described on page 77 and page A 4 of the Appendix).

	The no. of times a week that S's water was heated for the full 7 hrs. at the economy rate	The no. of hrs. each night that S's water was heated at the economy rate for only part of the night	The no. of times each week, and the length of time that the day-time-switch was on	The no. of kettles boiled each week for washing or washing-up	Annual Cost £	No. in household
	0	1½		2	39.00	1
1	7		All day always		137.00	2
2	7		once for ½ hr	28	89.00	2
3	4		3 times for 1 hr	35	95.00	2
4	7			2	52.50	2
5	7				50.00	2
6	7				50.00	1
7	7				50.00	2
8	7				50.00	1
9	2			21	40.47	1
10	2			21	40.47	2
11	7		once for ½ hr		53.90	1
12	7				50.00	2
13	7				50.00	2
14	7			4	55.00	2
15	7		3 times for 1 hr		73.40	1
16	0	1½	once for 1 hr	14	55.19	2
17	7				50.00	1
18	7				50.00	2
19	7				50.00	1
20	7				50.00	2
21	7				50.00	1
22	7			1	51.25	1
23	3			14	38.78	1
24	7				50.00	2
25	7				50.00	2

‡ Households monitored in Chapter Two.

calculations were correct). But unless subjects knew about Economy 7, and the different unit costs, and could read their meters, they had no way of knowing this. They therefore tried their own ways of doing things economically.

Subject 2* had the highest bill for water (£137), and she believed, moreover, that her lighting (£10) cost more than her water. She kept the cylinder switch 'on' and the Day/Night switch set to 'Day' permanently. Had she drawn hot water during the night she would have obtained it at the cheap rate, because this is a feature of Economy 7. However, as she was in the habit of going to bed before 11 p.m., she gained scarcely any benefit from the off-peak rate, because hot water drawn at around 11 p.m. would mostly have reheated before the onset of the cheap time, which occurred around 1 a.m.

Strangely this subject knew that water could be heated cheaply overnight. However she had a belief which overrode this knowledge, and it was that heating water in the day-time was not expensive because water is thermostatically controlled. In her mind, heating water up from cold was expensive, but maintaining it at a given temperature was not.

One subject, whose bill was not expensive, none the less wanted some economy tips. Since her use of hot water was minimal, it was suggested that she switch off her cylinder switch on alternate nights, thus heating her water on alternate nights only. It became clear that she had not realised that she could do this. She thought the Day/Night switch was the only hot water control.

Several people believed that boiling kettles for washing, or washing-up, was a cheap strategy. However, Table 3 : 5 page 96 shows that Subject 4* paid almost twice as much for her hot water by using this strategy than if she had heated her cylinder every night with off-peak electricity;

and four people (Subjects 11, 12*, 20 and 28) seemed to be inconveniencing themselves, with all their kettle-boiling, for paltry savings. Subject 12* believed that the kettle-boiling strategy kept the cost of heating her water (£40.47) under the cost of running her iron (£1.30).

There were other firmly-held but incorrect ideas about the cost of water. For instance, Subject 6 believed that hers cost less than cooking, for the simple reason that she did a lot of cooking (see Table A : 1 on page A 15 of the Appendix for actual costs). Subjects 3*, 13* and 22* all believed they spent less on hot water than on their fridges (actual costs are again provided in Table A : 1 on page A 15 of the Appendix) because their fridges were on all the time, but their hot water only at night.

Once more beliefs, based on a lack of information, were sometimes the cause of unnecessary, and sometimes excessive, energy expenditure.

BELIEFS ABOUT OTHER APPLIANCES

The idea (already mentioned) that if appliances are used frequently, or are 'on' a great deal, they will consume more electricity than less frequently used ones, was met on several occasions. Subject 2* ranked her vacuum cleaner highly for this reason.

Subject 3*, on the other hand, ranked her vacuum cleaner highly because it was noisy and therefore had a "big pull". Subject 21 maintained that spin driers, because of their noise, have "heavy power" and therefore use more electricity than fridges.

Appropriate energy information could teach people to ignore these false cues and redirect their attention towards the key appliances.

VENTILATION

The Victorians attributed disease to impure air (Hood, 1844 in McIntyre, 1980) and therefore attached much importance to fresh air. Disease is now attributed to bacteria and viruses and the purposes of ventilating buildings are now

- (1) "the provision of air for respiration
- (2) the dilution of odour
- (3) the removal of excess moisture
- (4) the dilution of contaminants (including bacteria etc.)
- (5) the provision of air for combustion
- (6) temperature control" (McIntyre, 1980).

It is, however, in the consumer's own interest to keep ventilation down to the minimum necessary for comfort, for it is costly, since, in winter, the incoming cold air has to be heated.

Table 3 : 6. THE MINIMUM AIR CHANGES RECOMMENDED PER HOUR TO KEEP VARIOUS CONTENTS OF THE AIR AT ACCEPTABLE LEVELS.
(Barrett, 1974)

Contents of the air	Minimum air changes necessary per hour
Oxygen	0.04
Carbon dioxide	0.2
Body odour	0.8
Humidity	1.0
Smoking	2.0
Kitchen smells	5-10

Table 3 : 6 shows the minimum air changes recommended per hour to keep various contents of the air at acceptable levels.

According to Masterman, Dunning and Densham (1935), and Harris-Bass, Kavarane and Lawrence (1974), the air infiltration rate for small to normal rooms is something like 1.0 per hour. The implication to be drawn from this

fact, together with the information in Table 3 : 6, page 99, is that if no one is cooking or smoking, no windows need be open at all, in order that the contents of the air be kept at acceptable levels.

If someone has been smoking, or a meal has been cooked, then opening a small window should be sufficient to keep the atmosphere pleasant, for window-opening with doors shut creates up to 20 air changes an hour; if doors are open as well, this figure rises to 30 (Masterman et al, 1935).

SUBJECTS' VENTILATION HABITS

Table 3 : 7 (a) (b) and (c) page 101 shows the subjects' winter window-opening habits. The day-time bedroom figure is large, but many people kept their bedrooms unheated. Apart from this, window-opening was not excessive.

The finding that only four people (16 per cent) slept with the bedroom window open is consistent with a similar finding by Crawshaw and Dale (1980) but inconsistent with a finding of Brundrett's (1977,b) which was that 30 per cent of the adults' bedrooms and 13 per cent of the children's bedrooms, in the investigation, had a window open at night. However the fact that the bedrooms were on the ground floor in this instance could have been a contributing factor, since several people mentioned their fear of intruders.

A 'good blow through', Table 3 : 7 (d), apparently consisted of the outside front and back doors standing wide open, simultaneously, for about 15 minutes during the morning so that the whole house would be 'freshened up'.

Table 3 : 7. SUBJECTS' VENTILATION HABITS

(a)	KITCHEN WINDOW	Number of subjects
	Open just when cooking	21
	Never open	3
	Nearly always open	1

(b)	BEDROOM WINDOW	Number of subjects
	Open day-time only	14
	Open night-time only	2
	At night and at some stage in the day as well	2
	Always open	1
	Never open	6

(c)	LIVING-ROOM WINDOW	Number of subjects
	Sometimes open	6
	Never open	19

(d)	ENTIRE BUNGALOW	Number of subjects
	A good blow through	3

BELIEFS ABOUT VENTILATION

Subjects 9*, 27 and 28 volunteered the 'good blow through' information. It is of interest that Subject 9* had been a midwife. She emphasised several times the importance of fresh air for health, thus illustrating the resistance to change of long-held beliefs which become part of a culture. It is not known how many other subjects, had they been asked, would have replied that they too engaged in a 'good blow through'.

That many subjects were not aware that ventilating cost money is evident from the responses to Question 27, presented in Table 3 : 8 below.

Table 3 : 8. SUBJECTS' RESPONSES TO THE QUESTION "DO YOU THINK OPENING WINDOWS MAKES MUCH DIFFERENCE TO YOUR ELECTRICITY BILL?"

Number of subjects	Reply
11	Yes
11	No
3	Don't know

CONCLUSIONS

1. KNOWLEDGE OF THE RELATIVE RUNNING COSTS OF APPLIANCES

- (a) Overall, householders' knowledge of the relative running costs of the complete range of their appliances was good. The correlations between reported and 'correct' rank orders were significant for 70 per cent of the sample.
- (b) Knowledge was not so good when viewed from another perspective however. Over fifty per cent of the sample considerably underestimated the running costs of one or more of their key energy-using appliances.
- (c) In individual cases there was an alarming lack of knowledge concerning the key energy-using appliances.

2. THE RELATIONSHIP BETWEEN KNOWLEDGE AND CONSUMPTION

- (a) The hypothesis that people with better knowledge of the running costs of household appliances would have smaller bills received some support.

Greater knowledge of the running costs of the complete range of appliances was associated with lower bills, but the correlation was not significant. However people with better knowledge of the relative running costs of key energy-using appliances did have significantly smaller bills than people with poorer knowledge.

- (b) The hypothesis, proposed later, that people with better knowledge of running costs would use higher proportions of off-peak to on-peak electricity also received some support.

Use of greater proportions of off-peak electricity was associated with better knowledge of running costs of key appliances; and better knowledge of the relative running costs of the complete range of

appliances was significantly correlated with use of greater proportions of off-peak electricity.

- (c) Sometimes, in individual cases, people's mistaken beliefs were shown to have a major detrimental influence upon their energy consumption.

3. MISCONCEPTIONS CONCERNING RUNNING COSTS

There were misconceptions in the sample concerning

- (a) the comparative costs and benefits of heating spaces and water by off- and on-peak electricity;
- (b) the principles involved in the operation of the Electricaire and the hot water;
- (c) the relationship between warmth and money;
- (d) the cost of keeping water hot;
- (e) running costs of noisy appliances;
- (f) appliances which are 'on' all the time;
- (g) the cost of ventilation.

RECOMMENDATIONS

A Energy educationists should recognise the fact that some people's knowledge of the running costs of appliances is inadequate, and that this can be the cause of unnecessary energy expenditure.

Information provided should be based on people's known misconceptions.

For example:

- (i) Just because your vacuum cleaner is noisy does not mean it uses a lot of electricity.
- (ii) If you want to make effective economies, cut back on your use of space heating and hot water. They are very expensive.
- (iii) If you have an Electricaire system use it, rather than your electric fire.
- (iv) If you are on Economy 7, heat your water at night.
- (v) If you are on Economy 7, heating your water at night is likely to cost less than using kettles in the day-time.
- (vi) Ovens are expensive to use. Cook several dishes at once, or use the rings.
- (vii) Ventilation costs money. All that cold air has to be heated.

B Since information concerning the comparative costs and benefits of heating spaces by off- and on-peak electricity was found wanting, and it cannot be usefully displayed in homes as costs change frequently, Boards (or Councils or installers) should consider providing consumers with any form of storage heating, with comparative information. The information should include:

- (i) The cost of one day's storage heating (heated over-night)
 - (a) with a maximum charge,
 - (b) with a medium charge,
 - (c) with a minimum charge;

(ii) the cost, in the day-time, for a one-kilowatt bar of an electric fire for

- (a) one hour,
- (b) five hours,
- (c) ten hours,
- (d) fifteen hours;

(iii) the day-time cost of two one-kilowatt bars of an electric fire for (a) (b) (c) and (d) above.

C Cylinder switches in homes with Economy 7 should bear the information "Switch off when no hot water is needed night or day".

Since cost information concerning different ways of heating water was found wanting and it cannot be displayed usefully near cylinder switches because costs change frequently, Boards should consider providing their Economy 7 consumers with hot water cost information, possibly in enclosures with quarterly bills. The information should include:

- (i) the cost of heating a cylinder of a particular size, from cold, over-night;
- (ii) the cost of completely heating the same cylinder from cold in the day (i.e. having it on for about two and a half hours);
- (iii) the cost of heating the same cylinder for about an hour at night;
- (iv) the cost of heating the same cylinder for about an hour in the day;
- (v) the likely cost of leaving one's hot water 'on' for a whole day
 - (a) for a couple with two small children;
 - (b) for a couple with two older children;
 - (c) for a couple on their own;
 - (d) for a single pensioner;

- (vi) the likely daily cost of heating water in kettles for (a)
(b) (c) and (d) above.

D Since misunderstandings concerning the capabilities and operation of the Electricaire system led to unnecessary energy expenditure, information regarding its principles and use should be displayed on the front of the unit itself. This could include:

- (i) the units used over-night with different settings of the charge control;
- (ii) the fact that the system can provide more than seven hours of heat;
- (iii) that the system can be used all day (or not, if that is the case);
- (iv) that the charge control should be turned up if the system 'runs out' of heat early in the day.

CHAPTER FOUR

RESPONSES TO A RADIO APPEAL MADE TO INVITE PEOPLE IN DIFFICULTIES WITH ELECTRICAL HEATING SYSTEMS AND BILLS TO COME FORWARD

A conclusion reached in Chapter Three was that both misunderstandings and lack of knowledge can be the cause of unnecessarily high bills. Uncovering other misconceptions, or occasions when a lack of knowledge resulted in high bills, seemed worthwhile. Interviewing people who had had their electricity supply disconnected seemed a possible means of gathering data.

It seemed likely that social workers would have, among their clients, people who had, at some stage, been "cut-off". The Director of Social Services in Hull was contacted, and his permission sought to accompany social workers on their visits to any such clients. No reply was received.

Radio Humberside was contacted. A request that people who have difficulty paying their electricity bills be contacted through local radio was received favourably. This resulted in a personal broadcast being made in March, 1982, asking for interviews with the following groups of people:

- (a) those who had, at some time, been cut-off by the Electricity Board;
- (b) those who had difficulty understanding the controls on their electric central heating and thought they were paying more for their electricity because of it;
- (c) those who thought they paid more for their electricity than other people they thought were in similar circumstances.

It was explained that an interview might lead to a misunderstanding being clarified or an economy being suggested, which, in turn, might lead to a smaller bill.

A departmental secretary received telephone calls from interested listeners. A total of 38 calls was received. Each caller was asked for his name, address and, where possible, telephone number, and was told he would be contacted sometime in the following fortnight. Wherever possible, the next contact with respondents was through another telephone call. This was to assess the need for an interview and to make an appointment to visit should an interview be necessary. People with no telephone were called on repeatedly until they were found at home.

Eleven respondents had problems which were not relevant to the present research. One man wanted help with a leaking radiator, another to complain about the water rate. Three calls were received from people who were about to be disconnected but the reasons were entirely financial, not based upon misunderstandings.

Many misunderstandings and misconceptions came to light through interviews with the remaining 24 people, however. In nine instances misunderstandings are best explained in the form of case studies. In almost every instance the question respondents asked was either "Why is my bill so big?" or "How can I cut back?".

CASE STUDY I

Mrs. L.

Mrs. L. lived in a bungalow very similar to those described in Chapter Two. She had never had any instructions for the Electricaire heating system. She knew that at times she was able to obtain cheap electricity but she did not know how much cheaper it was. She did not know what tariff she was on. Her bill was consulted. It appeared she was on an off-peak tariff, as the unit prices were not those of Economy 7. Illustration 4 : 1 (page 110) shows Mrs. L.'s bill.

For anyone experienced in reading bills it was obvious that she was not using enough off-peak electricity. She was asked to explain how she used her Electricaire. She explained it was broken, that some men had been to mend it, but that it was still not working properly. For the last several months she had been

using a one-kilowatt bar of an electric fire, and a two-kilowatt convector heater in her living room, and another two-kilowatt convector heater in her hall.

For someone with knowledge of such matters it was apparent that the use of these fires was causing her large bill.

That she could not work this out for herself is hardly surprising. To do it she would have required knowledge of the following:

- (a) that she had cheap electricity at some stage each day;
- (b) that cheap and expensive electricity feed into two different meters;
- (c) which of two identical unlabelled meters was the off-peak one; [Illustration 4 : 2 (page 112) shows Mrs. L.'s two unlabelled identical meters].
- (d) reading electricity meters;
- (e) her particular tariff; (It is necessary to switch off hot water when calculating Electricaire consumption, if one is on an off-peak tariff, for storage heating and water both feed into the off-peak meter at off-peak times. If the tariff is Economy 7 however, all other appliances must be switched off before consumption of storage heating can be calculated).
- (f) the kilowatt hour ratings of her convector heaters and fire;
- (g) that a unit of electricity is the same as a kilowatt hour;
- (h) the unit prices, or how to find them on a bill;
- (i) using a calculator or doing long multiplication.

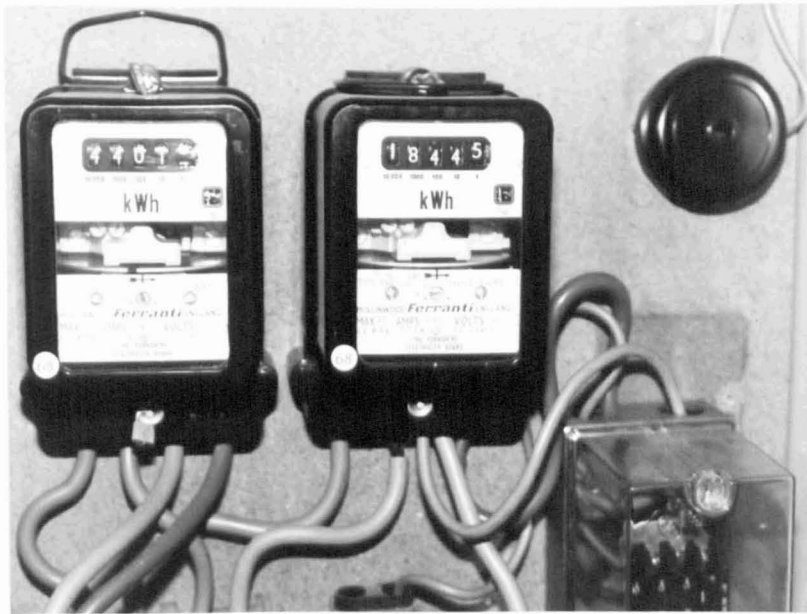
In view of the complicated nature of the above, it was felt advisable to suggest, merely, that she get her Electricaire mended as soon as possible.

Mrs. L. thought, however, that her bill was large, not because of the convector heaters and fire, but because the electricity she used for hot water was being recorded simultaneously on her two meters. In order to put this to the test it was necessary to know precisely what tariff she was on, so that a further call could be made to her house when an off-peak period of availability was occurring, for people on off-peak tariffs can obtain hot water during off-peak periods only.

The Y.E.B. was contacted and Mrs. L.'s tariff was given as N.E. That is, she obtained off-peak electricity at night (N) and during the evening (E) (19.00 - 08.00 h).

A call was duly made to the lady's house one evening. Candle in hand, the meters were consulted for information about where hot water consumption was being recorded. No movement of either meter wheel was observed. Yet this was a time when she should have been receiving the off-peak supply.

A further enquiry was made to the Y.E.B. concerning her tariff. The information forthcoming this time was that maybe she was on N.D. (night time and day [i.e. three hours in the afternoon]). Since N.E. and N.D. have the same unit prices it was possible she was on either, they said.



4:2
Mrs L's two
unlabelled
identical
meters



4:3
The heating mains
switch operated
by Mrs L



4:4
The switches on the
wall above the
heating unit in
Mrs L's house

Eventually it transpired that, indeed, she was on N.D. A call made to her house one afternoon allayed her fears concerning the meters. They were working perfectly. Units used for heating the water were feeding into one meter only, presumably the off-peak one.

Perhaps her belief that hot water consumption was being recorded by both meters arose when she checked her meters at a time when she mistakenly thought hot water was the only appliance 'on'. A fridge, and she had one, is easily forgotten in these circumstances and would, of course, have been recorded on the on-peak meter. Both meter wheels would have been revolving.

Some time was spent at Mrs. L.'s house trying to decide whether her heating system was really broken. She was asked to describe how she had operated it when it had been in working order. It turned out, in fact, that it was broken, but the way she had been accustomed to using it was of interest.

The only controls she had used were as follows:

- (a) the heating mains switch in the hall (which was not really intended for regular use, and should have been labelled as such) (Illustration 4 : 3, page 112);
- (b) the fan switch in the living room (Illustration 2 : 6, page 42) and
- (c) the switches on the wall above the heating unit (Illustration 4 : 4, page 112). It was surprising, and probably luck, that she operated these latter switches correctly, for they were somewhat inscrutably labelled, as Illustration 4 : 5, page 114 shows. It can be seen that one label had come unstuck and had fallen off. Labels which formed part of the switch casing would have been preferable.

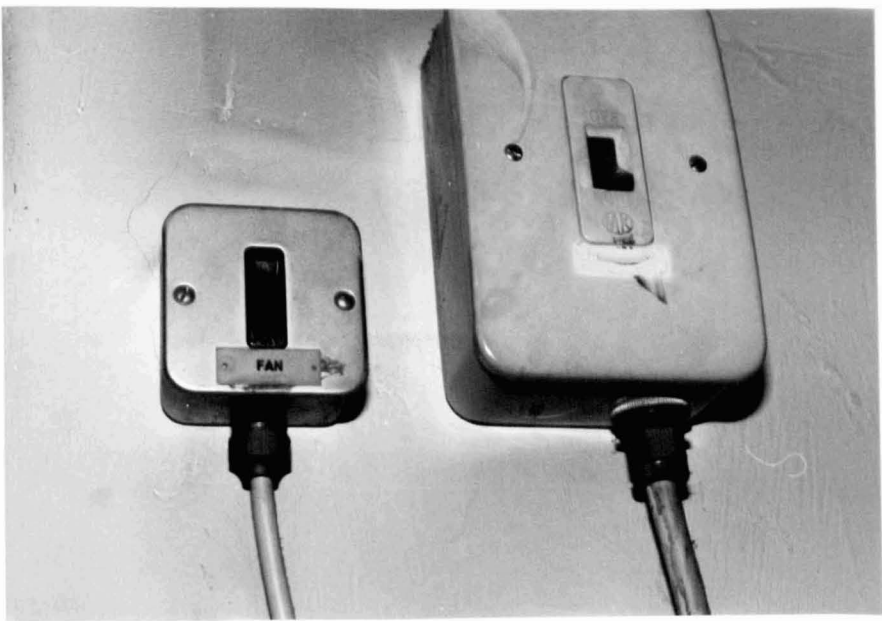
However, in fact, Mrs. L. did operate all the above switches correctly. But she used no other controls at all.

The charge control was marked merely 'high/low' (Illustration 4 : 6, page 114). It was set to 'high'. At the extreme ends of the heating seasons she could have saved money had she turned it down. But she did not know what it was for.

The thermostat was set at 65°F. She said she had never touched it in all the time she had lived in the house, because, again, she did not know what it was for. (Chapter Six will show that Mrs. L. was not alone in her ignorance of the function of this control).

It transpired that an unmarked rocker switch (Illustration 4 : 7, page 114) on the front of the heating unit was, in fact, a switch to control the fan speed. When this information was given to Mrs. L., she argued that it was not, and said she had been told by a workman once, that it was a 'noise' switch.

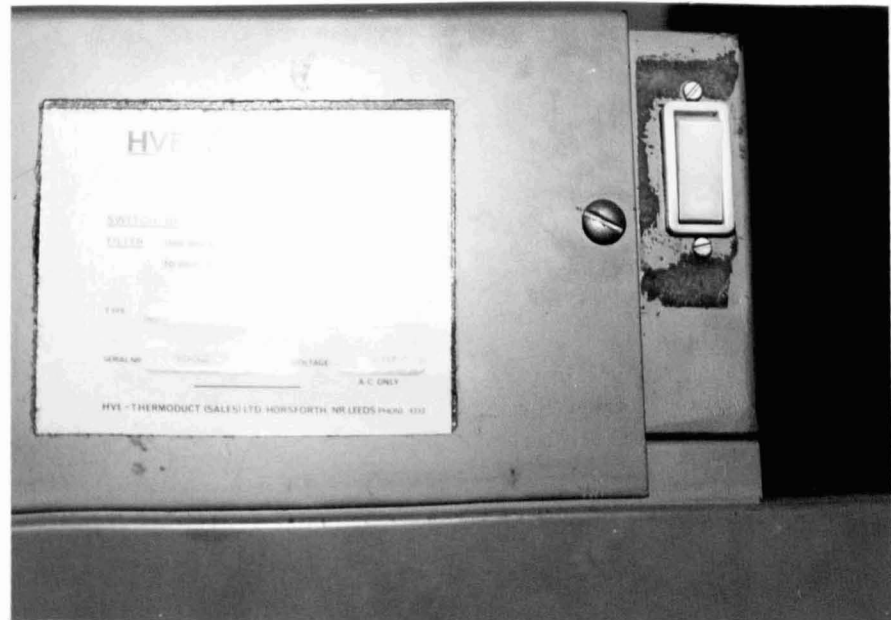
What had happened was this. The heating unit was in her bedroom. She had explained to the workman that the noise from it prevented her from sleeping. She asked him if he could do anything about it. He rocked the switch and said, "That'll stop the noise." And it did. In fact, of course, what he had done was change the fan speed from high to low.



4:5
Inadequate labelling
on the switches above
the heating unit in
Mrs L's house



4:6
The insufficiently labelled
charge control in Mrs L's
house



4:7
The unlabelled
fan-speed switch
in Mrs L's house

Mrs. L. had, it appeared, tried unsuccessfully to find out for herself what the matter was with her heating. She had fiddled with some controls she had been in the habit of using. She had discovered, and was rather worried by the fact, that when the heating mains switch was off in the hall, the fan still functioned if switched on in both the bedroom (by the unit) (Illustration 4 : 5, page 114) and in the living room. Although there are sound engineering reasons for this being the case, it is a confusing anomaly for someone in Mrs. L.'s position. Logically, if a heating mains switch is off, nothing concerned with the heating should be working.

Mrs. L.'s story illustrates several points. Firstly, that it is an extremely difficult task for the average householder to work out for himself whether it is more or less expensive to use one form of heating or another. Many respondents wanted to be able to do this. Secondly, that should a householder want to find out how to work his heating, it can prove more difficult than he ever imagined. Information from experts can be wrong. Feedback from the system itself can be confusing as in the example of the mains switch not isolating all components of the system. (Another more familiar example is that of the electric oven indicator light. It can be 'off', when the oven is 'on'. The information may be relevant for engineers but not for the housewife. Ovens have been inadvertently left on as a result. A further example of one of these anomalies is provided in Case Study IX). Thirdly, that the function of a control should be inherent in its design (McCormick and Ilgen, 1980) and those which are intended for the householder to adjust should be labelled as such. Fourthly, that people will impose meanings of their own on situations they do not understand. Research on cognitive processing (Chapter One, page 30) indicates that comprehension involves an active contribution on the part of the comprehender, and that the contribution depends on the current state of knowledge of the comprehender. In Mrs. L.'s mind, the fan booster switch was a 'noise' switch.

In the absence of a label it was an understandable deduction. Lucky for Mrs. L. that 'quiet' heating systems are not more expensive to run than noisy ones.

The meaning the next respondent imposed on a bewildering situation was more unfortunate.

CASE STUDY II

Mrs. M.

Mrs. M.'s bill was £220 for the quarter ending March, 1982. She lived in an Electricaire house. She was, unknown to her, on the Economy 7 tariff. (Chapter Five will show that she was not alone in being unaware of this information). She was asked what temperature she had her thermostat set to. She looked at it and said it was at 20 (°C). It was suggested that perhaps she could set it a little lower, that this would save her some money. But she said that if you turned it down it did not work. She said you had to turn it up until you heard it click, and then the heat blew out. Even then, she said, it sometimes stopped blowing heat out, so then you had to turn the thermostat up again.

The click occurs, in fact, when the thermostat setting corresponds to the temperature in the room. If the heating is on, but not blowing out, it merely indicates that the room is already either at, or above, the thermostat setting.

Her thermostat strategy was costing her money.

A suggestion made by Crawshaw and Dale (1980) to aid consumer understanding of thermostats was that perhaps they could be marked with an expanding red strip "to indicate an increase in the temperature for a movement of the control". A label "Room Temperature Required" was also suggested. Whether labels like these would have helped Mrs. M. is not known, but the function of the thermostat certainly needs clarification.

A request was made to see Mrs. M.'s bill (Illustration 4 : 8, page 117). Again it was immediately apparent to the trained observer that she was not using enough low rate electricity. Here was another example of a person unable to extract relevant information from the bill for herself.

She was asked to explain how she used the central heating, and this is what she said. "When I go to bed I put those switches off (*on the wall above the heating unit*) (Illustration 4 : 9, page 118) and also those three (*rocker*) switches (*on the front of the heating unit*) (Illustration 4 : 10, page 118). When I come down in the morning I put them all on again."

Yorkshire Electricity Board
 FE XG2 Linwood Approach Leeds LS15 8TB
 T. REGISTRATION NUMBER 238 5679 21

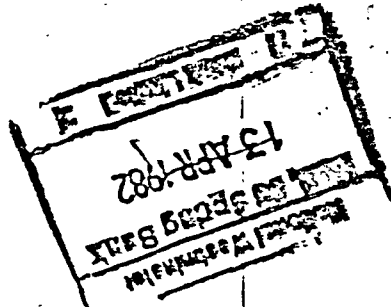


please quote this reference
 when making enquiries

MRS M

HULL
 N HUMBERSIDE

meter number		18 MAR 1982	tax point and date of issue	23 MAR 1982	units and unit rates charged		fixed charges	amount	
estimated	customer's own reading	units supplied			rate	total	£		
12284	07754	04530		4530	AT	5.00P	7.05	233.55	0
	REBATE			4530	AT	0.34P		15.40CR	0
09618	09456	00162		162	AT	1.82P		2.95	0
	REBATE			162	AT	0.34P		0.55CR	0



AMOUNT NOW DUE AND PAYABLE £ 220.55

E - estimated
 R - customer's own reading

IF ANY QUERY ON THIS BILL RING HULL 492211

Illustration 4 : 8. Mrs. M.'s bill,
 quarter ending March, 1982.



4:9
The switches above the heating unit that Mrs M put off each night



4:10
The rocker switches that Mrs M put off each night

Mrs. M.'s actions were effective from the point of view that she succeeded in obtaining heat from the unit; but at a price. It was the day-boost switch which was providing her heat, at the on-peak price; and for someone on Economy 7 this is higher than for the ordinary General Domestic rate.

She operated her hot water in a similar fashion, in that she always switched it off at night, and used it when she needed it in the day time.

It was explained that she should not put off the switches above the heating unit, that the heating was 'storage' and that switching-off stopped cheap electricity being stored over night. Mrs. M. replied that her husband had told her, before he died, that electricity was dangerous, and that she must always switch everything off at night. -

This lady's beliefs were reasonable ones for households with no storage heating and she did not know that that was what she had. No explanation had ever been given to her about how to operate the heating. (Y.E.B. housecraft advisers make three attempts to visit new tenants and provide advice. After this they give up). She had not read the instructions beneath the rocker switches.

It need not be inferred from this that it is pointless giving explanations to such people. In this subject's case subsequent explanations have resulted in satisfactory operation of the thermostat, the water and the central heating, and very much lower bills. Illustration 4 : 11, page 120, shows Mrs. M.'s bill for the quarter ending September, 1982. It can be seen that already, even in a summer quarter, her off-peak consumption has risen.

Perhaps after their first or second visit Y.E.B. advisers could put a post card through the door, asking the householder to return it, stating a time when it would be convenient to call. In this way people who are frequently out would be less likely to slip through the net.

Yorkshire Electricity Board

PB XG21 Wood Approach Leeds LS15 8TB

V.A. REGISTRATION NUMBER 238 5679 21

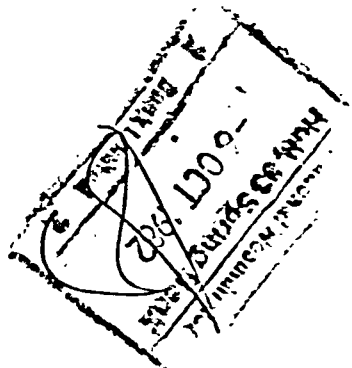
MRS M

HULL
N HUMBERSIDE



Please contact the Board when making enquiries

meter reading date		21 SEP 1982		tax point and date of issue		28 SEP 1982		fixed charges	amount £	VAT %
present	previous	units supplied	units	unit rates	charged	per	per			
13965	13300	00665	665	AT	5.40P		8.15	44.06	0	
11122	10587	00535	535	AT	1.90P			10.16	0	
AMOUNT NOW DUE AND PAYABLE £									54.22	



* - estimated
 F - customer's own reading **IF ANY QUERY ON THIS BILL RING HULL 492211**

Illustration 4 : 11. Mrs. M's bill, quarter ending September, 1982.

CASE STUDY IIIMrs. J.

Mrs. J. had underfloor heating and she wanted to complain about it. She was on a tariff known as N.E.D.W. [off-peak electricity at night (N), in the evening (E), three hours in the afternoon (D), and all the time at weekends (W)]. She complained about the cost of operating this particular type of heating and about its lack of controllability. She pointed out that if the weather became suddenly and unexpectedly warm the house became too hot. She said turning the thermostat down did no good because it was not possible to stop the heat coming out once it was in the floor.

It was explained that the ideal strategy for a householder with underfloor heating on the N.E.D.W. tariff, was to try to listen to the weather forecast during the week, and if a hot day were expected, to turn the thermostat down, in advance, so that less heat would be stored overnight. At weekends, with the continuous availability of 'cheap' electricity, the thermostat should always be lowered.

But unlike Mrs. M., Mrs. J. would not be advised. She said that if you did not make sure you turned the thermostat up till it clicked before you went to bed, then the heating did not charge up. Moreover she maintained that the thermostats were broken in all the houses near her. They all clicked at different numbers.

She was right that the floor did not store any heat until the thermostat clicked, but she was wrong to believe that she had to make sure it clicked before she went to bed. The thermostat for underfloor heating allows the floor to store heat only when the temperature has fallen below the setting on the thermostat. Mrs. J.'s thermostat, if left alone, would have 'clicked' the system into operation some time later in the night. That thermostats, if played with, clicked at different numbers in different houses, indicated only that different homes had different temperatures.

CASE STUDY IVMrs. R.

Mrs. R. lived in an Electricaire bungalow which was on the Economy 7 tariff. She was under several misapprehensions. One of these was mentioned previously in Chapter Three. She believed that Economy 7 could provide only seven hours heat. (It must be added that many people who stayed at home for most of the day, while they did not actually believe this, stated that the Electricaire started blowing out cold air around 5 p.m. and had to be switched off. This feature of the system would reinforce a misconception about a seven hour-heat limit. It could also render any adjustment of the charge control pointless, in cold weather, in the mind of someone holding this belief, although no evidence that this was the case was actually found).

The other misconceptions concerned her thermostat. In her words, "My thermostat is set at 65°F, and yet the thermometer in the room says 70°F. That's good isn't it? I must be saving mustn't I? But then there's no one here except me opening and closing doors and wasting heat."

The explanation for the discrepancy in temperatures could have been any one of several reasons including thermostat differential and faulty calibration. What is important here is that she believed she was getting free heat from the system. A person who believes this is unlikely to turn his thermostat down.

The second part of her comment about thermostats indicated a misunderstanding of their function. True, a room will stay warm if doors are not opened, but the function of a thermostat is to maintain a temperature, despite door opening. Had she known that the thermostat functioned in this way she might have been prepared to lower it.

Her original enquiry was, "Why is my bill so big?". Her belief about thermostats could certainly have been a contributing factor. Better labelling of the control could perhaps have prevented her mistakes.

CASE STUDY VMr. H.

Mr. H. wanted some tips about how to economise. His previous bill had been £128 and he thought this too large. He lived in an Electricaire bungalow. As he did not use the central heating, but an electric fire instead, it was suggested that the former could work out cheaper. The unit prices were explained to him (his bill was similar to Mrs. L.'s, Illustration 4 : 1, page 110), and it was pointed out that he could obtain more heat for less money by taking advantage of the off-peak electricity. He replied that while he had realised that he could obtain off-peak electricity he had not realised that it was so much cheaper, and he certainly had not known which figures on the bill represented the unit prices.

It appeared that Mr. H. had removed a fitted electric fire with two 1-kilowatt bars from his living room, and had replaced it with a large coal-effect fire, each bar of which had a 1.31-kilowatt rating. His surprise was considerable when he learned that bars can use different amounts of electricity.

Currently information regarding wattage rating is out of sight on most fires. Perhaps information about the units a bar will use in an hour could be displayed prominently on fires. Even supposing the concept 'unit' was not understood at point of purchase, it would be obvious that one type of fire used more electricity than another.

The above suggestion receives some support from research on energy efficiency labelling which has found that

- (a) consumers would like to have energy efficiency labels on the electrical appliances they buy (Consumers' Association, 1978); and
- (b) people notice energy labels (Anderson and Claxton, 1981).

The research has also clarified some of the conditions under which energy efficiency labelling is most effective.

- (i) It has a greater impact when it states model performance relative to other models, rather than stating only absolute consumption data (McNeill and Wilkie, 1979).

- (ii) It is more effective if emphasised by sales staff than if it is presented on appliances only (Redinger and Staelin, 1981).
- (iii) It is more effective when presented with additional supporting energy information (e.g. audio-visual displays) (Worrall, 1976).

CASE STUDY VI

Mrs. O.

Mrs. O. wanted some economy tips. She was well-informed on how to operate her Electricaire. She was on the N.E.D.W. tariff, and as she did not like the house to be heated in the morning, she turned the charge control down over night. She turned it up at lunchtime to take advantage of the afternoon boost in order to have some stored heat for the evening.

It became apparent that the reason she did not like to heat the house in the morning was that she was in the habit of opening every window at that time, and did not want all her heat escaping. The reason she opened her windows was that her bathroom was situated centrally in her flat and had no window of its own, just an extractor fan. She liked to make sure that this room was properly ventilated daily.

The interesting thing was her reaction to a suggestion that all the ventilating was costing money, despite the fact she kept her heating off in the morning. It had never occurred to her that rooms which do not feel especially warm can still lose heat.

Explanations or not, Mrs. O. felt she could not give up ventilating on a grand scale. If this habit were found to be widespread among people with this design of house, then perhaps bathrooms with windows would actually be energy savers.

CASE STUDY VIIMr. L.

Mr. L. was on Economy 7. During the last quarter of 1981 he received an unexpectedly high bill. When he enquired about it, it became apparent that his problem was identical to that of Mrs. McC.'s (Chapter Three, page 84) (i.e. the Y.E.B. time-switch had developed a fault and was not changing consumption over to the low rate at night). As a result of his enquiry the Board monitored his consumption for a fortnight, and on the basis of this he was told he would receive a rebate.

In January, 1982 he received another inexplicably large bill, for £187, and in March, 1982 the same thing occurred, this time the sum being even greater, £316.

At this stage Mr. L.'s financial predicament was such that he had to sell his black and white T.V. and have his telephone disconnected, in order to help towards paying for his electricity bill. Why he himself made no further enquiries to the Board is not clear, except to say that he was a particularly diffident man.

The following are the results of enquiries made on his behalf. In January, 1982 he should have received a £129 rebate - a consequence of the monitoring - but by mistake the Y.E.B. added the rebate on to the total of £187, instead of subtracting it, and sent out the March, 1982 bill, demanding £316.

As a result of the intervention Mr. L. received his rebate.

The important point to note from the above case study is that bills should be clear and explanatory. Unless an individual has the confidence to make enquiries for himself, he is at present unlikely to solve problems by consulting the bill. Bills in their present state are enigmatic documents. The researcher, with some experience in bill deciphering, could make no sense of unlabelled figures which seemed to appear from nowhere.

CASE STUDY VIIIMr. I.

Mr. I. was also on Economy 7. His bill was £120 and he, like some others, wanted to know how he could reduce it. His use of the Electricaire seemed sensible. His comments regarding the way in which he heated his water were of interest, however.

He rarely used his immersion heater. Instead he boiled kettles. He was a committed meter reader and declared that boiling kettles used fewer units than heating the immersion.

It was explained that the units for the immersion, if used over night, were less than half price, and that for no extra cost he could have twice as much hot water.

He had considerable difficulty in coming to terms with this idea.

This case study illustrates the need for energy education. Half price electricity at night, when you do not need it, is a strange concept. A more explanatory bill would, once again, seem to be the most appropriate channel for additional information.

CASE STUDY IXMrs. D.

This lady was on Economy 7. She wanted to know how she could "cut back". It was discovered that the day-boost switch on her Electricaire was in operation. First of all, therefore, the function of this switch was explained and its use strongly discouraged.

Mrs. D. was the second respondent found using this control inappropriately. Perhaps the provision of a control of this nature, the misuse of which can have catastrophic financial consequences, should be questioned.

Attention turned next to her use of hot water. She explained that she never touched her Day/Night control which was set to "Night" (for that was how it had been when she moved in). She added that since she lived alone and did not use much hot water, she sometimes put off the immersion heater switch, inside the airing cupboard, during the day, to save some money (Illustration 4 : 12, page 127). Illustration 4 : 13 on the same page shows the two water switches in relation to one another. The Day/Night switch is on the right, in the hall, and the immersion-switch is on the left inside the airing cupboard.



4:12
The switch by Mrs D's
immersion heater



4:13
Mrs D's two water switches:
on the right the Day/Night
control, on the left the
immersion heater switch



4:14
Mrs D's Day/Night
control glowing red
while the immersion-
switch was "off"

It was explained that putting the immersion-switch off in the daytime, when the Day/Night control was set to "Night" would result in no savings. And it was also explained that putting the immersion-switch "off" at night, when the Day/Night control was set to "Night" would result in savings; and similarly putting the immersion-switch "off" in the daytime when the Day/Night control was set to "Day" would also result in savings.

The switches were operated for her, to demonstrate the energy-saving options. During this demonstration it became apparent that the red light glowed in the Day/Night control, when the latter was set to "Day" while the immersion-switch was set to "off". Illustration 4 : 14, page 127 shows this very situation. The red light is glowing, yet the immersion-switch was "off".

A meter check revealed that no energy was being consumed with the switches thus arranged. So this was another anomaly. Perhaps it was relevant information for engineers but it was also very confusing information for householders.

The remaining misunderstandings, many of which were concerned with hot water use, are dealt with, not in the form of case studies, but in terms of the misunderstandings themselves.

It is a fact that the most economical way to use an immersion heater on the General Domestic tariff, is to operate it manually (i.e. only when it is needed) (personal communication, Electricity Council, 1981).

Conversations with many respondents revealed that they believed that because their hot water was thermostatically controlled it was not necessary to switch it off in order to run the system most economically. That there are standing losses, and that these must be compensated for, was not appreciated.

It is of interest to note that Radio Humberside ran a phone-in programme in January, 1983, where an expert from the Y.E.B. answered listeners' questions concerning electricity. One question was "What is the cheapest way to use the immersion heater?" The expert replied that there was no easy answer and that it all depended upon the needs of

the individual. A precise answer to the question would almost certainly have resulted in some lower bills. It should have been explained that any person preferring the convenience of continuous hot water has to pay dearly for it.

Advice to one respondent that she turn down her cylinder thermostat to economise, revealed that she had not previously understood the function of this control. Here was some corroborating evidence for the suggestion in Chapter One that energy saving controls might not be sufficient in themselves to produce reductions in consumption, but that consumer knowledge of the controls is necessary too.

One respondent (who did not have off-peak electricity) frequently enjoyed the luxury of deep baths. He had no idea that they were costing around 40p each.

Another respondent spoke innocently of his scalding hot water. "My friends always say they burn their hands in it." He had not realised that money is wasted every time cold water must be added to hot to create hand-hot temperatures.

During 1983 the Y.E.B. began incorporating a small advertisement into the format of their bills. It read "Less than half price electricity with Economy 7" (Illustration 5 : 6, page 170). They might in the future consider incorporating energy messages concerning hot water use. These, unlike explanations concerning central heating, need not be long to be informative. Some ideas for bill tips, arising from the present research would be

- (a) Save money. Turn your immersion heater off when you do not need it;
- (b) Ask about having your cylinder thermostat turned down. Scalding water costs money; and
- (c) Enjoy shallow baths. Deep baths could be costing you as much as 40p each.

It is quite likely that people would benefit from an economy tip presented at the moment when greatest attention is being given to how the bill will be paid.

Two respondents wanted some suggestions as to why their bills were larger this winter than last, when recently they had been making more efforts than usual to economise.

In the Consumption Feedback section of Chapter One it was noted that quarterly bills do not provide useful feedback of energy use. These respondents illustrated this point nicely. Conversations with them established that their appliance ownership had not changed and neither had their lifestyles. The weather had changed however. But the relationship between cold spells several weeks ago, and high bills was not immediately apparent. They thought their economies had been ineffective and were tempted to abandon them. After explanations they began to believe that their bills would have been even bigger had they not made cut-backs.

It was also noted in Chapter One that feedback must be carefully presented in order to be effective. Future research will determine the optimal way in which feedback on bills should be presented, but that it should take account of weather changes and price rises would seem essential.

Russo (1977) describes an unfortunate side effect which occurred when a utility company in the U.S.A. presented customers with inadequate feedback on monthly bills. It consisted of the kilowatt hours used currently, together with a statement of how many were used in the same period last year, plus the percent change in energy consumption that this represented (Illustration 4 : 15, page 131). Although a three per cent reduction in consumption was obtained, the scheme had to be abandoned.

Billing Period: Nov 30 to Dec 29			Amount Due
Consumption (Kwhr)			\$118.30
Current Billing Period	Same Period Last Year	Change in Energy Consumption	
2275	2472	8% drop	Date Due Jan 15

Illustration 4 : 15. A bill with inadequate feedback (Russo, 1977).

What happened was that despite decreased energy use, the bills of many customers increased. Not because of the weather this time but because electricity prices rose. "Angered by the increase in rates that was made clear by the billing format, many complained to the customer service department. Eventually the negative effects of customer complaints became so great that the program was cancelled."

Perhaps additional information consisting of how great the bill would have been had cut-backs not been made, or how much less it would have been had last year's amount not been exceeded, would have avoided these negative effects.

A SUMMARY OF THE MAIN FINDINGS FROM THE
RADIO APPEAL, AND CONCLUSIONS

A Information at present provided on bills is inadequate. This fact came to light in various ways.

- (i) Several people received large bills through suboptimal use of off-peak electricity. The information provided on the bill was insufficient to help them rectify the situation. Particularly inscrutable were the unit costs and the tariff, and these could have been helpful.
- (ii) One respondent received a large bill when a rebate was accidentally added on, instead of being subtracted from his "amount due". Had the various figures on his bill been labelled, or had they been presented in explanatory statements, the bill could more readily have been questioned. As it was, figures materialised as if from nowhere.
- (iii) Several respondents wished to calculate the cheapest way to heat their homes. They were not able to find the unit costs - one of the pieces of information necessary to make this calculation - on their bill.

B Controls, including electricity meters, need improved design and labelling.

- (i) Controls intended for householder use should be labelled as such.
- (ii) The function of a control should be implicit in its design.
- (iii) Labelling should be an integral and permanent feature of switches.

C Two people were found using day-boost switches inappropriately, on Electricaire heating systems. It is possible to get into such severe financial difficulties through misuse of this switch that a case can be made for its total withdrawal.

- D Some switches seem designed for, rather than by, engineers. Switches intended for householder use should convey information relevant for the householder. Indicator lights should not glow "on" when systems are, from the consumer's point of view, "off".
- E Electrical appliances, including Electricaire storage heaters, need improved energy labelling. One respondent who owned two electric fires, was inadvertently using the one with the larger kilowatt rating.
- F People need more information about the cheapest way to operate their hot water systems.
- G Consumers will impose their own meanings, which may or may not be correct, on situations they do not fully understand. This can involve them in unnecessary energy expenditure.

CHAPTER FIVE

UNDERSTANDING ELECTRICITY BILLS

PART ONE

A report published by the Electricity Consumers' Council in 1979 revealed that 22 per cent of consumers, from varying income groups, find electricity bills hard to understand. The report did not state, however, what particular aspects of the bill were causing difficulties, and no changes in bill format arose as a result of the report.

In 1982, following claims by the National Association of Citizens' Advice Bureaux, that bills and consumer literature were still sometimes unintelligible to the average reader, the Electricity Council asked all Area Boards to examine the style and content of their literature with a view to making it more understandable (personal communication, Electricity Council, 1983). However, again, no specific difficulties were mentioned upon which improvements could be based.

Understanding bills is not a problem in the U.K. only. Gollin, Smith and Youtie (1976) established, through telephone interviews with 256 New Hampshire householders, that 16 per cent could not pick out the total kilowatt hours used on their monthly bill. However, since the interviewees were not being shown a bill at the time, and no example of a bill was provided in the report, this research did little to clarify misunderstandings.

The source of some difficulties in the U.K. was identified by Sewell (1981) during an investigation into adult numeracy. She gave a representative sample of 50 people a typical domestic electricity bill (a similar bill to the one used is shown in Illustration 5 : 1, page 136), and asked them how

they could use the information supplied on the bill to check the "units supplied" figure and also the "amount". Actual calculations were not called for, just the method. While no-one actually answered incorrectly, over a third of the sample could provide no answer at all to either question.

Had calculations been called for, as they would be for a real bill check, it is likely that many incorrect answers would have been recorded, for a report by the Advisory Council for Adult and Continuing Education (A.C.A.C.E.) (1982) showed that only 88 per cent of the population could handle simple addition, 74 per cent simple multiplication and 70 per cent simple subtraction, the three processes involved in bill checking.

Since a substantial proportion of consumers have difficulty with mathematics, an obvious improvement to bills would be to make the figures as meaningful as possible, by presenting them in the most informative way.

Illustration 5 : 1, page 136, shows a typical 1982-style Economy 7 bill,* and the following are some suggestions to ease the mathematics involved in Economy 7 bill checking. They are based on Sewell's and A.C.A.C.E.'s findings and actual consumer comments gathered throughout this research.

- (1) The method by which "units supplied" is calculated could be set out in 'sum' form thus:-

$$\begin{array}{r}
 14158 \text{ present meter reading for full rate units} \\
 - \underline{13505} \text{ previous meter reading for full rate units} \\
 \underline{\quad 653} \text{ full rate units supplied}
 \end{array}$$

*It should be noted that the format of Economy 7 bills changed slightly at the beginning of 1983, after the research described in this Chapter had been completed. Illustration 5 : 6 , page 170 shows an example of the new format. While it is an improvement on the 1982 version, it in no way renders any of the following pages irrelevant, and none of the recommendations need changing as a result.

A discussion of the new-style bill is provided on page 169.

- (2) The method by which the "amount" is calculated could be similarly set out in a multiplication sum form:-

$$\begin{array}{r}
 653 \quad \text{full rate units supplied} \\
 \times \underline{5p} \quad \text{each full rate unit costs 5p} \\
 \hline
 3265p = \text{£}32.65
 \end{array}$$

- (3) The "amount" for the full rate units (£32.65) should appear in the amount column, as does the amount for low rate.
- (4) The fixed charge should appear separately in the amount column.
- (5) The "@" and "p" symbols which appear three times in boxes below the heading "units and unit rates charged" should be removed as they are unnecessary.

Future research is necessary to establish the best way to present the figures, but that the information should be meaningful is essential.

The problems outlined in case studies which resulted in financial hardship [Mrs. McC. (Chapter Three, page 84); Mrs. L. (Chapter Four, page 109); Mrs. M. (Chapter Four, page 116); Mr. H. (Chapter Four, page 123); Mr. L. (Chapter Four, page 125)], did not arise out of a lack of mathematical ability, but because relevant information was either totally lacking on the bill, or presented in an obscure way.

- (1) Mrs. M. did not know of the existence of off-peak electricity, and she was unaware of the significance of small numbers of off-peak units on the bill.
- (2) Mrs. L. and Mr. H. had heard of off-peak electricity but did not know how much cheaper it was. Showing them a bill did not clarify their ideas.
- (3) Mrs. McC. and Mr. L. knew about off-peak electricity but were unaware that they were obtaining none. The significance of zero off-peak units was lost on them as was the significance of the two rows of figures on the bill.

Lack of information about off-peak electricity would appear to have been an important variable in every case.

Unless consumers are regular meter readers (during this entire research only three of these were found), the quarterly bill is the only feedback about energy use that they receive. It is important therefore that it should be understandable, and that the information it contains should be useful.

The Electricity Consumers' Council (1979) found what at first sight appeared to be an alarming rate of ignorance about tariffs among the 146 people they interviewed who were on off-peak tariffs. Only 50 per cent of them knew "what rate they were on". However, perhaps some of them did not understand the form of the question, and were in fact aware that they could receive 'cheap electricity' at particular times.

The finding that only one per cent knew they were on Economy 7 was not useful for the purpose of the present research as the report did not state how many were actually on this rate.

A study was undertaken to investigate the following questions.

- (a) Are people on Economy 7 generally aware that they can obtain cheap electricity at night?
- (b) Are they able to extract information about off-peak electricity from their bills?
- (c) Is a lack of knowledge about (a) and (b) ever associated with disproportionately low off-peak consumption and unnecessarily high bills?

If an understanding of bills were correlated with optimal fuel use, the obvious conclusion would be to make bills very much more comprehensible. But it was explained in Chapter Three that the causes of very large and, very small bills are many, and that even a lack of understanding can be associated with small bills if the heating and water systems are 'set up'

for economical use. So a straightforward correlation might not be obtainable. However, if it were found that particular individuals with little understanding also received large bills and used disproportionately low amounts of off-peak electricity, then it could well be inferred that in these cases the lack of understanding contributed to inappropriate energy use.

Thus, the purpose of the study was to gather numerical data so that a general picture of understanding Economy 7 would emerge, but also to look at any individual cases where a lack of understanding seemed to be the cause of inappropriate energy use.

THE PILOT STUDY

A fictitious bill was constructed (Appendix, page A17). An interview aimed at finding out whether people knew they could obtain cheap electricity at night, and whether they could extract information about off- and on-peak use from the bill was piloted on six people. (The form of the semi-structured interview appears on page A18 of the Appendix). A seventh pilot subject (Pilot Subject vii) did not answer all the questions but his comments were recorded as they indicated he misunderstood one aspect of his bill. His case is discussed on page 151.

One of the six pilot subjects (Pilot Subject vi) did not know that she had cheap electricity at night. She will be discussed on page 150.

Questions 6 and 7, asking subjects to indicate how many units had been used in the day and night time respectively, were answered correctly by only three of the six pilot subjects. This pointed to considerable ignorance about the figures on the bill.

When the responses to the pilot study were considered in depth it was felt that even the three subjects who answered Questions 6 and 7 correctly might not have spotted the significance of zero off-peak units, like those on Mrs. McC.'s and Mr. L.'s bills, or small numbers of off-peak units like those on Mrs. M.'s bill.

Knowing that a particular figure represented off-peak consumption does not necessarily indicate that suboptimal use would be spotted, or that zero units would be questioned. Case studies described in Chapters Three and Four showed that these aspects of bills were sometimes the cause of financial hardship. It was decided therefore that the interview proper should probe this aspect of bill understanding.

The Electricity Bill Interview

On the basis of the five case studies mentioned on page 137, it was decided to show householders on Economy 7 two electricity bills, one similar to Mrs. M.'s, with a small number of off-peak units supplied (Illustration 5 : 2, page 142), and the other similar to Mrs. McC.'s with zero off-peak units supplied (Illustration 5 : 3, page 143), and ask them

1. if they could tell why the bill in Illustration 5 : 2 was so big, or how it could have been reduced without the individual having to be cold,
2. if they could tell why the bill in Illustration 5 : 3 was so big,
3. if they had cheap electricity at night,
4. if they could tell from the bills how much the full price and cheap units of electricity cost.

The form of the semi-structured interview is presented on page A19 of the Appendix.

Yorkshire Electricity Board

PB XG2 Limewood Approach Leeds LS15 8TB

VAT. REGISTRATION NUMBER 238 5679 21

MR E Green
31 Exeter Ct
FRANSHOLME
HULL
NORTH HUMBERSIDE



please quote this reference when making enquiries

EP 475 239

meter reading date 28 MAR 1982 | tax point and date of issue 30 MAR 1982 |

meter readings		units supplied	units and unit rates charged				fixed charges	amount £	VAT
present	previous		z	p	z	p			
17621	15947	01674	1674	AT	5.00P	7.05	90.75	0.	
54377	53703	00674	674	AT	1.82P		12.27	0.	

Yorkshire Savings Bank
77 12 01
17 CHANCERY
HULL HU1 1ES

AMOUNT NOW DUE AND PAYABLE £ 103.02

E - estimated
R - customer's own reading IF ANY QUERY ON THIS BILL RING HULL 492211

Illustration 5 : 2. The specimen Economy 7 bill, with a small number of off-peak units, used in Question 1 of the Bill Interview.

Yorkshire Electricity Board

PB XG2 Limewood Approach Leeds LS15 8TB

VAT REGISTRATION NUMBER 238 5679 21

MR E Green
31 Exeter Cl
FRANSHOLME
HULL
NORTH HUMBERSIDE



please quote this reference
when making enquiries

EP 396 780

meter reading date 28 MAR 1982 tax point and date of issue 30 MAR 1982

meter readings		units supplied	units and unit rates charged				fixed charges	amount £	VAT
present	previous		£	p	p	p		£	
17621	15947	01674	1674	AT	5.00P	7.05	90.75	0	
53703	53703	00000	0000	AT	1.82P		00.00	0	

77 12 01
Savings Bank
HULL

AMOUNT NOW DUE AND PAYABLE £ 90.75

'E' - estimated

'R' - customer's own reading IF ANY QUERY ON THIS BILL RING HULL 492211

Illustration 5 : 3. The specimen Economy 7 bill, with zero off-peak units, used in Question 2 of the Bill Interview.

The Subjects and the Homes

Pensioners on Economy 7, from the same type of identical bungalows as those described in Chapter Three were chosen as subjects for the same reasons as those given earlier. The only difference was that, in this case, the person chosen to answer the questions was the person in the household responsible for looking at, and paying for, the bills.

Thirty four people were interviewed. Thirteen people declined the interview, saying that they understood their bills perfectly well. If they were right it is possible that subjects interviewed were the less well informed. A total of 46 people were out, so since subjects were obtained on a catch as catch can basis, it is possible that the sample is biased towards the more housebound pensioners.

The interviews were conducted in October 1982.

Y.E.B. Consumption Data

Permission for the Y.E.B. to supply consumption data was obtained from subjects.

It was decided that the consumption data for the quarter ending March 1982 should be used when comparing bill understanding with consumption because this provided winter data when off-peak use would be at its maximum.

Results and Discussion

Table 5 : 1 below summarizes the responses of the 34 public sector subjects to the electricity bill questions.

	No. of people giving correct answer	No. of people giving wrong answer or saying "Don't Know"
Q1. (few off-peak units)	2	32
Q2. (zero off-peak units)	5	29
Q3. (cheap electricity?)	27	7
Q4. (unit prices)	9	25

Table 5 : 1. A summary of the responses of the 34 public sector subjects to the electricity bill questions

It can be seen that some correct answers were recorded for each question, indicating that the questions were answerable. However, since only two people realized the significance of small numbers of off-peak units, and only five realized the significance of zero off-peak units, it could be argued that these questions were difficult.

But it must be borne in mind that the information on the bills which the subjects were given to look at was all that would have been provided

(a) had they been operating their system suboptimally

or

(b) if the Y.E.B. time-switch developed a fault.

The data show therefore that if either of the above had been true for the majority of the 34 subjects, they would probably have just continued paying up, putting the cost down to rising prices.

Seven people were completely unaware of the fact that they were able to obtain cheap electricity at night. The only information on the bill that suggests that electricity is cheap at night is the unit costs. However, only nine people could pick these out, and none of these included any of the seven people who were ignorant about cheap electricity. Indeed, even among people who knew they had cheap electricity at night there was considerable ignorance about the significance of the two figures. For many people then the unit prices, presumably intended to convey information, were meaningless.

The responses of two pilot subjects to the unit prices question drew attention to a different aspect of the uninformative way in which the prices are presented. They managed to pick out the two prices, but read them as £5.00 and £1.82.

Y.E.B. consumption data for March 1982 was available for only 28 subjects because six subjects had not lived in their homes for a year. All other results and discussion, therefore, concern the 28 subjects for whom data were available.

Columns A, B, C and D in Table 5 : 2 (page 147) and Table 5 : 3 (page 148) present individual subjects' responses to the bill questions, "1" representing a correct answer and "0" either an incorrect one or a response of "Don't know". Column E in both tables presents the total number of questions subjects answered correctly.

Column F in Table 5 : 2 (page 147) presents the proportion of off-peak electricity used in the quarter ending March 1982. The subjects have been arranged in rank order. In Column F of Table 5 : 3 (page 148) subjects' bills (low rate plus normal rate, to the nearest £) for the same quarter are arranged in rank order. Column I in both tables shows the number of people in each household. Mann-Whitney U Tests showed there were no significant differences between either the proportions of off-peak electricity

	A	B	C	D	E	F	I
S	Q1	Q2	Q3	Q4	Total questions correct	Rank-ordered proportions of off-peak electricity used %	No. in household
32	0	0	1	0	1	92	1
26	0	0	1	0	1	91	1
10	0	1	1	1	3	91	1
25	0	0	1	1	2	90	2
28	0	0	1	0	1	90	1
34	0	0	1	0	1	89	2
31	0	0	1	0	1	89	2
14	0	0	1	0	1	89	1
33	0	0	0	0	0	88	1
17	0	0	1	0	1	87	1
18	0	0	1	0	1	87	1
11	0	0	1	1	2	86	2
2	0	0	1	0	1	86	1
3	0	0	1	1	2	85	1
27	0	0	1	0	1	85	1
21	0	0	1	0	1	84	2
22	0	0	1	0	1	82	1
23	0	1	1	1	3	81	2
30	0	1	1	1	3	81	1
4	0	0	0	0	0	81	1
16	0	0	1	0	1	79	2
5	0	0	0	0	0	79	2
8	0	0	0	0	0	78	1
13	0	0	1	1	2	78	1
1	0	0	1	0	1	77	2
9	0	0	1	0	1	73	1
12	0	0	1	0	1	70	1
15	0	0	0	0	0	67	1

Table 5 : 2. Understanding and ranked consumption ratios
(public sector), March 1982

Columns A-D show subjects' responses to electricity bill questions ($\sqrt{x=1}$, $x=0$).

Column E shows subjects' total number of questions answered correctly.

Column F shows subjects' proportions (%) of off-peak electricity used during the quarter ending March 1982, placed in rank order.

Column I shows the number of people in the household.

	A	B	C	D	E	F	I
S	Q1	Q2	Q3	Q4	Total questions correct	Rank-ordered bills £	No. in household
13	0	0	1	1	2	59	1
26	0	0	1	0	1	68	1
14	0	0	1	0	1	69	1
10	0	1	1	1	3	74	1
30	0	1	1	1	3	79	1
2	0	0	1	0	1	79	1
21	0	0	1	0	1	82	2
3	0	0	1	1	2	84	1
32	0	0	1	0	1	87	1
17	0	0	1	0	1	88	1
28	0	0	1	0	1	88	1
12	0	0	1	0	1	90	1
22	0	0	1	0	1	92	1
25	0	0	1	1	2	94	2
18	0	0	1	0	1	96	1
34	0	0	1	0	1	100	2
31	0	0	1	0	1	102	2
27	0	0	1	0	1	102	1
1	0	0	1	0	1	103	2
5	0	0	0	0	0	103	2
33	0	0	0	0	0	104	1
16	0	0	1	0	1	105	2
11	0	0	1	1	2	109	2
15	0	0	0	0	0	119	1
23	0	1	1	1	3	121	2
9	0	0	1	0	1	136	1
4	0	0	0	0	0	138	1
8	0	0	0	0	0	141	1

Table 5 : 3. Understanding and ranked bills
(public sector), March 1982

Columns A-D show subjects' responses to electricity bill questions ($\sqrt{=1}$, $x=0$).

Column E shows subjects' total number of questions answered correctly.

Column F shows the bills, (to the nearest £) (low + normal rate) subjects received for quarter ending March 1982, placed in rank order.

Column I shows the number of people in the household.

used ($U = 82$) or the size of bills ($U = 52.5$) for one- and two-person households. It is for this reason that households of both sizes are included together in the two tables and are dealt with together in the correlations which follow.

In Chapter Three, page 87, it was explained that those people who use the largest proportions of off-peak electricity are obtaining the best value for money. It can be seen from Table 5 : 2 that Subject 32 was obtaining the best deal with 92 per cent of her consumption at the off-peak rate. At the other end of the scale, Subject 15 was getting the worst deal with only 67 per cent of her consumption at the cheap rate.

As predicted a lack of understanding about the tariff and the bill did not necessarily mean getting the worst value for money. Subject 33 scored zero on understanding but her proportion at the off-peak rate was above the median. Four others scoring zero however had proportions below the median.

A correlation between the total number of questions answered correctly (i.e. understanding) and proportion of use at the off-peak rate was not significant, but greater understanding was perhaps loosely associated with increased off-peak use in that the correlation was substantial ($r_s = 0.2366$).

Table 5 : 3 shows that Subject 13 had the smallest quarterly bill at £59 and Subject 8 had the largest one at £141. In this instance a correlation between understanding and size of bill showed that the people with the best understanding did indeed have the smallest bills ($r_s = 0.4603, p < 0.1$).

Despite the non-significant correlation between understanding and the proportion measure, comments made by some individuals with poor understanding indicated that their lack of understanding certainly was preventing them from getting better value for their money. In reply to Question 3, "Do you have cheap electricity at night?", Subjects 15 and 9 replied respectively,

"Of course electricity is cheap at night; you do not use any then."

and

"They say electricity is cheap at night but I don't use it".

These subjects' off-peak ratios are among the three lowest and their bills among the five highest. It was fortunate for them both (and indeed for all the people who did not know they had cheap electricity at night, and for whom consumption data were available) that either their water or their heating (or both) were 'set up' for some off-peak use, for part of their consumption was at the off-peak rate, (and more than the amount their fridges would have used in the cheap period). But the knowledge that they could obtain cheap electricity at night, together with an understandable bill, could well have resulted in a better deal for these subjects.

Subject 4 could answer none of the questions correctly. Her proportion measure was below the median, and she had the second largest bill. It turned out that she kept her hot water switch on "Day", and she stated with a logic that could not be faulted that she thought one only put the hot water switch to "Night" if one wanted hot water in the night. This finding illustrates the need for better designed controls. Perhaps the word "Day" could be accompanied by "Expensive" and "Night" by "Cheap".

Pilot Subject vi did not know she had cheap electricity at night; neither did she understand the concept of storage heating. Her proportion measure (79 per cent) was below the median, and her bill (£144) higher than any subject in the main study. It appeared she sometimes switched her storage unit off at night, using the switches shown in Illustration 4 : 9, page 118, if the house felt warm enough. She did not realise that this prevented heat from being stored. In any event she always switched the storage unit off in the mornings, if it had been on overnight, because, she maintained, it felt really warm then, and needed switching off. She did not realise that unless the day boost switch was operated, the storing process automatically ended in the morning.

If an individual does not understand the concept of storage heating, the above strategy makes sense. Again, more informative controls coupled with understandable feedback of energy use would help avoid the last mistake.

If Pilot Subject vi felt cold, she used a portable electric fire. Since she was partially sighted and could have tripped on the flex, it was felt relevant to ask her why she did not use the fitted fire on the wall. She replied that the portable fire used less electricity because the bar was shorter. In fact the bar was also fatter, and a check revealed that both bars were one-kilowatt. Illustration 5 : 4 (page 152) shows the two fires.

This incident illustrates the need for more obvious energy labelling of appliances.

A suggestion to this lady that she might save a little money if she kept her fan switch on "Low" rather than "High" was not received favourably. She maintained that the house felt warmer when the switch was set to "Low", therefore the "High" setting must be most economical. It could perhaps have been that the increased draught created by the high setting produced a greater sensation of cold. The words "economical setting" might usefully be added to the "Low" label.

Pilot Subject vii, when asked, "Do you have cheap electricity at night?" said "They say it's cheap at night, but my last off-peak total was only £2 less than my on-peak total." He was failing to grasp the fact that more units at the off-peak rate are supplied for the same money.

This man's proportion measure was below the median for the subjects in the main study, and his bill at £174 the highest of any subject in the entire study. Better labelling of the units supplied and the unit prices could have avoided his misunderstanding, but whether it would have resulted in a lower bill is questionable because he mentioned that the Social Security paid his bills so he could see no reason to economise. However, the fact that 105,180 households had their electricity supply disconnected in the



5.4 Two one-kilowatt fires

year ending 30th June, 1982 (Association of Metropolitan Authorities, 1982) is evidence that many people are responsible for paying their own bills, and it is possible that their thinking follows a similar line to that of Pilot Subject vii's above. Perhaps for them a more meaningful bill would result in 'a better deal'.

Conclusions

It can be concluded that for many people bills are uninformative.

- (1) Only 50 per cent of subjects in the pilot study knew which figures on the bill represented the off- and on-peak units used.
- (2) The significance of small numbers of off-peak units (Question 1 of the main study) was realized by only six per cent of the sample.
- (3) The significance of zero off-peak units (Question 2, main study) was realized by only 15 per cent of the sample.
- (4) Twenty one per cent of the sample were unaware that they obtained cheap electricity at night (Question 3, main study).
- (5) The unit prices, the only information on the bill which indicates that there are two different rates for electricity, were recognised correctly by only 26 per cent of the sample (Question 4, main interview).
- (6) The best understanding of Economy 7 and bills is correlated ($p < 0.1$) with receiving the smallest bills.
- (7) In individual cases it has been shown that ignorance of Economy 7 and inability to understand bills has contributed to consumers not obtaining the best value for money.

Recommendations

- A. Since the crucial factor is appreciating that electricity is cheap at night, this should be clearly stated on the bill, e.g. "You are on Economy 7 and you can obtain cheap electricity at night." An exhortation to "make the most of your storage heating which uses cheap electricity" would also be useful.
- B. The unit prices should be labelled so people know what they are, e.g. "Your full rate units cost 5p each". Prices like 1.82p should be explained, e.g. "Your cheap rate units cost 1.82p (that is, less than 2p)", so that the difference between the two costs is obvious to people who may not be familiar with decimals.
- C. The two rows of figures on the bill, which represent off- and on-peak use, should be labelled as such.
- D. The units supplied at each rate should be spelt out, e.g.

You have used 260 full rate units.

You have used 1670 cheap rate units.

An exhortation to try to use more cheap rate units than dear ones might help avoid the problems of suboptimal use and failure to realize the significance of zero off-peak units.

The above could be achieved easily at the cost of only a bottle of ink for every few thousand consumers.

UNDERSTANDING ELECTRICITY BILLS

PART TWO

The first part of this Chapter showed that a considerable proportion of pensioners on Economy 7 in the public sector

- (1) were unaware that they could obtain off-peak electricity at a cheap rate at night,
- (2) were unable to extract information about their energy use and tariff from the bill,
- (3) paid more than they need have for their electricity because of their failure to understand Economy 7 and their bill.

Reasons for using samples from the public sector were explained in Chapter Three. However there are those who maintain that some people will never learn however hard you try. A lack of understanding found among a better educated sample would be more powerful evidence that information is at present lacking on bills. It would better indicate that the proportion of the population who do not understand could be reduced, if provided with better information.

It was decided, therefore, to carry out another identical study with a sample of people drawn from the private sector. Finding homes on the Economy 7 tariff in the private sector did not prove easy. The homes exist, but naturally the Hull City Council was not in a position to supply relevant information in this instance. The Y.E.B. could not help either as it does not list consumers by tariff type, simply by address. The homes had to be found through personal enquiries.

As before, subjects were obtained by catch-as-catch-can. Eighty four calls were made to householders on Economy 7 before 30 suitable subjects were found. Among these were only two refusals. The remaining 54 people were either simply not in, or had only recently moved in, and thus appropriate consumption data would not have been available for them.

The interviews were carried out in late November and early December, 1982.

Because of the difficulty experienced in finding subjects it was not possible here, as it had been in the public sector, to control so many variables.

Thirteen of the homes were owner-occupied, and 17 privately rented. Although they were all flats they were not all identical. Household size varied from one to four. Occupancy patterns differed because some people were out at work each day, while others were retired people or housewives at home for most of the day. Some homes had Electricaire, some underfloor heating and others, storage heaters. The meters were not all read in the same month. Some of the occupants did not have time-switches on their hot water system and were therefore unable to take advantage of the cheap period unless they stayed up late till it began, or rose early before it finished and operated the hot water switch manually.

All these variables could explain differences in consumption patterns so a straight forward correlation between understanding and consumption would be less likely in this instance than it had been in the public sector. However, as before, individual cases could prove interesting.

Results and Discussion

Table 5 : 4 below presents the responses of the 30 private sector subjects to the electricity bill questions.

	No. of people giving correct answer	No. of people giving wrong answer or saying "Don't Know"
Q1. (small no.off-peak units)	4	26
Q2. (zero off-peak units)	20	10
Q3. (cheap electricity at night?)	30	0
Q4. (unit prices)	22	8

Table 5 : 4. A summary of the responses of the 30 private sector subjects to the electricity bill questions

It can be seen that the understanding here was better than in the public sector, but by no means perfect.

This time four people could answer Question 1 correctly. This was slightly better than in the public sector. Twenty people realized the significance of zero off-peak units. But even although this was a much larger number than in the public sector this still left ten people, a third of the sample, unaware of the significance of zero units.

Everyone in this sample was aware of the most important fact, that they could obtain cheap electricity at night.

More people in this sample could pick out the unit prices, but, even so, 27 per cent were unable to do so.

Columns A, B, C, D, E, F and I in Tables 5 : 5 and 5 : 6 (page 159 and 160), contain the same type of information as Tables 5 : 2 and 5 : 3 (page 147 and 148) but this time the information concerns the subjects from the private sector and the quarter ends in either February or March, 1982. The

	A	B	C	D	E	F	G	H	I
S	Q1	Q2	Q3	Q4	Total questions correct	Rank-ordered proportions of off-peak electricity used %	* indicates hot water system had no time-switch	occupancy	No. in household
28	1	1	1	1	4	91		Full	1
26	0	0	1	0	1	83		Full	1
18	1	1	1	1	4	83		part	1
27	0	1	1	1	3	82		Full	1
19	0	1	1	1	3	79		part	1
29	0	1	1	1	3	78		Full	1
24	0	0	1	0	1	78		Full	2
13	0	1	1	1	3	78	*	part	2
10	0	0	1	0	1	78	*	part	2
14	0	1	1	0	2	77	*	part	2
2	0	0	1	1	2	74	*	Full	2
16	0	0	1	0	1	68		part	1
1	0	0	1	1	2	65	*	part	1
30	0	1	1	1	3	64		Full	2
21	1	1	1	1	4	60		Full	1
25	0	0	1	0	1	60		Full	1
11	0	1	1	1	3	59	*	part	2
15	0	0	1	0	1	53	*	part	1
9	0	1	1	0	2	46	*	part	1
6	0	1	1	1	3	43		part	1
3	0	1	1	1	3	37		part	1
5	0	0	1	1	2	35		Full	4
4	0	1	1	1	3	29		part	2
7	0	1	1	1	3	21		Full	3
8	0	1	1	1	3	21		Full	2

Table 5 : 5. Understanding and ranked consumption ratios (private sector)
for quarter ending either February or March 1982

Columns A, B, C, D, E, F and I as in Table 5 : 2 (page 147) except this time the quarter ended either February or March 1982.

Column G An asterisk indicates that the hot water system had no time-switch.

Column H Occupancy patterns. Full = Full time: Part = house unoccupied for part of the day on a regular basis.

	A	B	C	D	E	F	G	H	I
S	Q1	Q2	Q3	Q4	Total no. of questions correct	Rank-ordered bills £	* indicates hot water system had no time- switch	occupancy	No. in household
19	0	1	1	1	3	44		part	1
18	1	1	1	1	4	47		part	1
9	0	1	1	0	2	49	*	part	1
16	0	0	1	0	1	64		part	1
15	0	0	1	0	1	71	*	part	1
27	0	1	1	1	3	74		Full	1
14	0	1	1	0	2	77	*	part	2
28	1	1	1	1	4	80		Full	1
25	0	0	1	0	1	87		Full	1
24	0	0	1	0	1	93		Full	2
4	0	1	1	1	3	93		part	2
11	0	1	1	1	3	99	*	part	2
8	0	1	1	1	3	100		Full	2
7	0	1	1	1	3	108		Full	3
29	0	1	1	1	3	109		Full	1
26	0	0	1	0	1	115		Full	1
30	0	1	1	1	3	119		Full	2
6	0	1	1	1	3	122		part	1
1	0	0	1	1	2	127	*	part	1
2	0	0	1	1	2	128	*	Full	2
21	1	1	1	1	4	138		Full	1
13	0	1	1	1	3	140	*	part	2
10	0	0	1	0	1	147	*	part	2
3	0	1	1	1	3	179		part	1
5	0	0	1	1	2	180		Full	4

Table 5 : 6. Understanding and ranked bills (private sector) for quarter ending either February or March 1982

Columns A, B, C, D, E, F and I as in Table 5 : 3 (page 148)(but quarter ended either February or March 1982).

Columns G and H as in Table 5 : 5 (page 159).

reason for the two dates is that when the consumption data was obtained from the Y.E.B. it became apparent that not all the homes had had their meters read in the same month. Some were read in March, 1982, others in February. However, it was decided to include these two groups together in the consumption analysis because, despite the fact that the weather conditions would not have been identical, the billing periods were both winter quarters.

Five subjects could not be included in Tables 5 : 5 and 5 :6, for the following reasons.

- (1) Subject 12 said he had lived in his flat for over a year, but there was a misunderstanding, for when his consumption data was consulted it appeared he had lived there for six months only, and therefore had no appropriate data.
- (2) Subject 17's meter reading in March, 1982 was for the preceding five months, instead of three.
- (3) Subjects 20, 22 and 23, although they had all lived in the same block of flats for over a year, had no consumption data for any time before April, 1982.

The reason for this was that in March, 1982, Subject 23 was unable to pay his bill and the Y.E.B. threatened disconnection of his supply. Upon consideration, this subject realized that he could not have used so much electricity as his meter readings suggested. He explained to the Y.E.B. that he was frequently out, and that a mistake must have been made. An investigation was undertaken which revealed that his meter was registering the energy use of the person in the flat opposite, and vice versa. It subsequently became apparent that the same was true for all eight people in the block. Thus, accurate billing for these people did not begin until April, 1982.

This story provides a nice illustration of the minimal feedback of energy use consumers receive. Had Subject 23 not found himself in financial difficulties, the eight occupants of these flats might have continued paying each other's bills for years. If a digital display of energy use were situated in a prominent position, people could observe the results of their energy use and this type of error might be less likely to occur.

It can be seen that the range in the bills was fairly similar to the public sector range, but the range in proportions was quite different. The lowest consumption ratio in the public sector was 67 per cent; here 13 people's proportion measures were below this figure, the lowest being 21 per cent.

Before performing the correlations it was decided to establish whether the main variables, which it had not been possible to control, exerted significant effects upon consumption. If particular variables were found to have significant effects, then dealing with all subjects together in the correlations would be inappropriate.

NO TIME-SWITCH ON HOT WATER SYSTEM

Subjects who had no time-switch on their hot water system are represented by an asterisk in Column G of Tables 5 : 5 and 5 : 6. A Mann-Whitney U Test showed no significant differences between the consumption ratios ($U = 67$) and the bills ($U = 61$) of people having, and not having, time-switches.

OCCUPANCY PATTERNS

Subjects' patterns of occupancy are shown in Column H of both tables. The results of Mann-Whitney U Tests here showed that neither the consumption ratio ($U = 71.5$) nor the bills ($U = 59.5$) were significantly affected by occupancy.

HOUSEHOLD SIZE

The number of people living in each household is given in Column I. Mann-Whitney U Tests showed there were no significant differences between either the proportion measures ($U = 51.5$) or the bills ($U = 40$) of the one- and two-person households.

Two subjects came from households with more than two people. In Subject 7's case the consumption ratio was significantly less than those from single and double households ($p < 0.1$). In Subject 5's case the bill was significantly more than those from single and double households ($p < 0.1$). For these two subjects then, size of household could partly account for consumption. It was decided, therefore, to exclude them from the correlations.

Neither the correlation between bill understanding and proportion of off-peak electricity used ($r_s = 0.039$) nor the one between understanding and size of bill ($r_s = -0.048$) was significant. Bearing in mind that everybody knew they had cheap electricity at night, this result was not surprising. Of all the questions, ignorance of this was likely to have an effect on consumption.

However, despite the lack of straightforward correlations, the following pages will show that the subjects with no time-switches on their hot water systems would (in all but Subject 12's case) have used increased amounts of off-peak electricity and have had smaller bills if they had possessed this feature, and that failure to grasp the need for the switch was based on a lack of understanding about Economy 7.

The missing time-switches were discovered by chance. It was only when several people had responded to the question "Do you have cheap electricity at night?" by saying, "Only for the Electricaire, not for the hot water", that suspicions were aroused. Subject 1 further remarked that he could not make sense of the advertisements for Economy 7 on the television, because

they showed a person waking up to a tankful of hot water, heated at the cheap rate, and he was not able to do this. Yet he had been told he was on Economy 7.

Investigations at Subject 1's home showed that the immersion heater was not fitted with a time-switch, and it later became apparent that the same was true for all the nine people interviewed from two particular blocks of flats.

Despite the fact that all these subjects knew they had cheap electricity at night, all but one of them (Subject 12), thought that only the Electricaire was fitted to use it. They believed this because they did not wake up to cylinders of hot water in the same way that they woke up to warm Electricaire units. It had not struck them that all that was missing was a time-switch; and nowhere had they read the information that ALL appliances used during the night are supplied at the cheap rate.

The strategy mostly adopted for heating water was to switch on in the daytime, when hot water was needed.

Subject 12 (who unfortunately has not been included in Tables 5 : 5, and 5 : 6, for the reason explained on page 161) actually understood and made use of the Economy 7 metering system, without the need for a time-switch. He was an early riser and heated his water between 6 and 7 a.m.

The Y.E.B. was contacted to find out whether it was possible for a system to be converted to Economy 7 (as these had been, for the flats were built before Economy 7 was introduced) without the additional fitting of a hot water time-switch. It was admitted that this was possible. They further stated that a reliable time-switch, which could not get out of phase with the cheap period, cost £55.

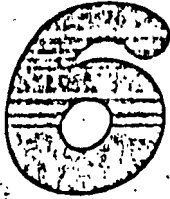
A possible explanation for the lack of time-switches is that these flats were privately rented with a fast occupant turn-over. Even supposing the people occupying the flats at the time of conversion were aware that the

system could be improved with an immersion time-switch they might not have considered them cost-effective to install, if they were planning a move shortly.

The interview with Subject 13 took place before it was realized that he did not have a time-switch. Despite the fact he stated he had never studied the details on his bill before, he answered Questions 2, 3 and 4 correctly. He maintained, however, as has been explained, that only the Electricaire was able to use off-peak electricity. The way in which Economy 7 worked was explained to him; but he was unconvinced.

A few days after the interviews had taken place, subjects in these blocks of flats were contacted again to inform them that it was likely they had no time-switches, and it could be to each person's advantage to obtain one. Subject 13 said that if this information were correct, this would explain a great deal, because he had just received his December, 1982 bill, and with it, an enclosure (Illustration 5 : 5, page 166) which implied that the information given to him during the Bill Interview, that all appliances operating during the night are obtained at the cheap rate, was correct. Because the interview had stimulated his interest, he had particularly noted his off-peak consumption, which amounted to only £1.98. As he had not yet switched on his Electricaire, this was a likely amount for his fridge to have used overnight for a quarter, but too small an amount to include hot water. Yet the enclosure mentioned hot water as being obtainable at the cheap rate. A missing time-switch, which he was now being informed of, and which was referred to later in the enclosure, would explain everything.

This subject was contacted again some months later. Since he is an early riser, he now heats his water in the early mornings before the cheap time finishes.



Fill in this coupon to find out just how YEB can help you with your electricity bills and send it to the address shown or hand it in at one of our shops.

Post to YEB FREEPOST, Scarcroft, Leeds LS14 1YY (no stamp required) or ring Freefone 5444.

NAME _____

ADDRESS _____

I am interested in INSULATION

ECONOMY 7 YEB BUDGET PLAN

NEW

HOME INSULATION

New! Bonded Bead - Dry cavity wall insulation.

SPECIAL WINTER OFFER

£30 OFF

Prices start from as little as £276.00.

LIST PRICES* Ring Freefone 5444

Thermafill Insulation service provided and guaranteed by MPI LTD. *OFFER ENDS 31.1.83.

What is...

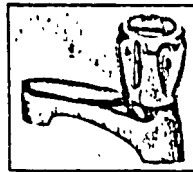
Economy 7 is 7 hours of night time electricity at less than half the standard price, which can be used for home heating and hot water and all other - appliances operating during the night period.

HEATING

The new 'Supa Slim' storage heaters give you the greatest possible efficiency and economy when combined with Economy 7 and they're very good looking too!

HOT WATER

Do you use normal price electricity to heat water? Have you an old inefficient hot water system? SWITCH TO



ECONOMY 7 HOT WATER. A simple time switch conversion for your immersion heater and cylinder will give you a tankfull of hot water every morning using LESS THAN HALF PRICE ELECTRICITY.

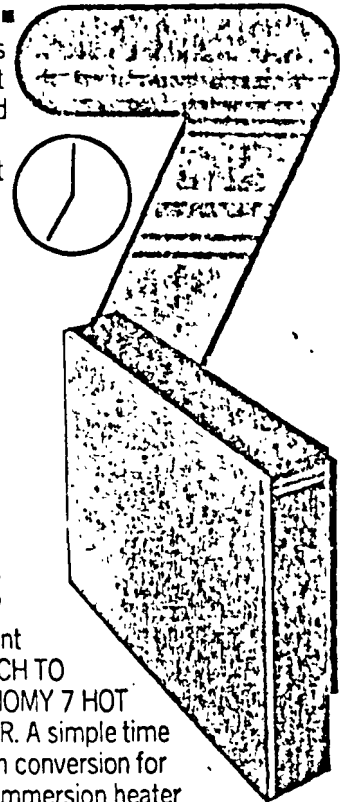


Illustration 5 : 5. The enclosure which accompanied Subject 13's December, 1982 bill.

Another "no time-switch" subject (Subject 14) had learned only one year previously, after living in his flat for a year, that he was able to obtain cheap electricity at night. Prior to that he did not make use of the Electricaire and left his hot water on all the time. He ran up a very large bill which he was unable to pay. This resulted in his supply being disconnected. When his supply was eventually reconnected he was informed that he received cheap electricity at night. He, like the others, assumed it was only for the Electricaire, which he began using. He changed to heating his water in the day, only when necessary. He remained unaware of the fact that he could heat his water cheaply at night, and that this could be easily achieved with a time-switch.

As things stand, households which remain disconnected for more than three months receive a visit from a Y.E.B. representative who offers certain advice. But consumers who somehow find or borrow the money to pay large bills promptly, or in less than three months, slip through the net. Since it is likely that people who have been disconnected could benefit from learning some economy measures, the Electricity Boards should provide such information as a matter of course in these cases.

It is not known how many other people are in the same situation as the subjects just discussed.

The fact that enclosures were received with the December, 1982 bills, coupled with recent Economy 7 advertisements on television specifically mentioning time-switches on immersion heaters, indicates that the Y.E.B. recognises the need to supply consumers with more information. However neither would have informed a person ignorant of the fact that he was on Economy 7 that this was his tariff, and that this meant he could receive cheap electricity at night, the most important piece of information of all.

Conclusion

The ability to extract information about energy use from bills was better in this sample than in the previous one, but by no means perfect. Still only 13 per cent of the sample realized the significance of small numbers of off-peak units. Still only 66 per cent realized the significance of zero off-peak units. Only 73 per cent could pick out the unit costs. These facts indicate that Economy 7 bills are unable to provide many consumers with any knowledge about their energy use.

At the time of the interview everyone in this sample knew that they obtained cheap electricity at night. But one person had only found out when his supply was disconnected, and the disconnection was due to his inability to pay a large bill which consisted mainly of units supplied at the dear rate.

Despite the fact that, overall, understanding the bill questions was not correlated with consumption, failure to understand one aspect of Economy 7, that all appliances operated during the night period are obtained at the cheap rate, was the cause of some subjects, who did not have time-switches on their immersion heaters, having unnecessarily high bills.

Perhaps then even better educated people need more information about the way in which Economy 7 works. Perhaps even they need bills with a clearer format if they are to have knowledge of the results of their energy use.

These facts serve to reinforce the recommendations made on page 155. To them should be added the recommendation that bills should contain the information that all appliances used during the night are obtained at the cheap rate, and the advice to check that the immersion heater is fitted with a time-switch.

Post Script: a discussion of the new format Economy 7 bill

During 1983 the format of the Y.E.B. Economy 7 bills changed slightly. An example of the revised format is shown in Illustration 5 : 6, page 170.

Without asking consumers directly what information they could obtain from this new-style bill, it is not possible to say, with certainty, that misunderstandings would still abound, but it is difficult to see how the new information would assist comprehension.

"D" and "N" presumably stand for "Day" and "Night" but no key is provided. "E7" is not explained. The advertisement "Less than half price electricity with Economy 7" (which appears on all bills, not just Economy 7 ones) is no replacement for the plain statement "You are on Economy 7 and you can obtain cheap electricity at night".

The bill states "See Enclosed". Illustration 5 : 7, page 171 provides a further example of a typical 'enclosure'. (An earlier example was shown in Illustration 5 : 5). Aside from the fact that it is not known how many people actually read enclosures, the item is, once again, merely an advertisement. There is nothing to tell the consumer that he is already receiving Economy 7.

The Head Office of the Y.E.B. in Leeds was approached and asked what the impetus had been for the format changes. The reply was that the changes were "internal decisions" only, and not based upon recommendations from outside bodies (e.g. The Electricity Consumers' Council) nor upon specific consumer misunderstandings.

It is unlikely then that the new format bill will have a dramatic effect in reducing misunderstandings.

Yorkshire Electricity Board

PB XG2 Littlewood Approach Leeds LS15 8TE
 V.A.T. REGISTRATION NUMBER 230 5079 21



HULL 492224
 quoting reference
 6 611

6 611

BRANSHOLME
 HULL
 NORTH HUMBERSIDE

Payment facilities - See overleaf			meter reading date	tax point end date of issue		4 JAN 1984			
Tariffs and meter readings ('E' - estimated, 'R' - customer's own reading)			units supplied	fixed charges £	amount £	VAT rate %			
present	previous								
21557	20777		780						
DOMESTIC E7 D			.780 @	5.34P	8.15	49.80	0		
69057	66058		2999						
DOMESTIC E7 N			2999 @	1.90P		56.98	0		
				3 0 0	REF 6611		106.78		
					CASH TEND		106.78		
					CHANGE		0.00		
					06/01/84 03782 653 614				
					YEE HULL AREA				

AMOUNT NOW DUE AND PAYABLE £ 106.78
 ANY QUERY, PLEASE TELEPHONE HULL 492224
 LESS THAN HALF PRICE ELECTRICITY WITH ECONOMY 7 -SEE ENCLOSED

Illustration 5 : 6. The new-format Economy 7 bill.



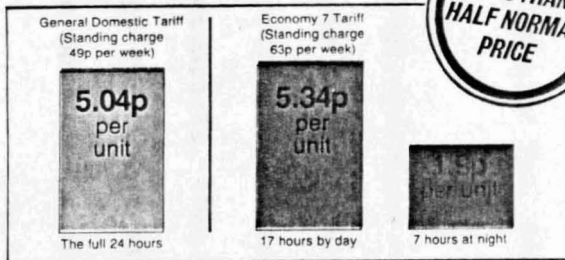
© Walt Disney Productions

What is **ECONOMY 7**?

During the night our industrious Economy 7 Dwarfs make less than 1/2 price electricity . . .

- The Economy 7 tariff guarantees 7 hours of cheap rate night time electricity at **LESS THAN HALF NORMAL PRICE**.

The chart shows the difference between the night rate of the Economy 7 tariff and the normal price for electricity. The big difference in the two prices means that the slightly higher standing charge and day unit rate of the Economy 7 tariff can soon be offset. Everything using electricity will cost a lot less to run at night, so, the more you use at night the more worthwhile it is to be on Economy 7.



Based on prices at 1st April 1983

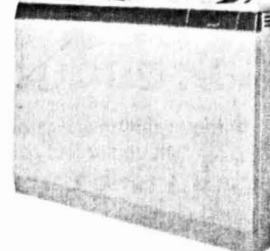
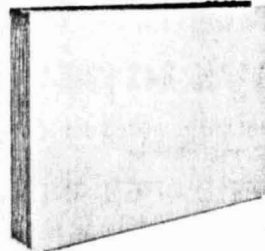
**LESS THAN
HALF NORMAL
PRICE**

Home heating costs less with **ECONOMY 7**

Electric heating on Economy 7 really is an economical form of home heating. Space age technology has provided a new range of heaters designed for the 1980's and 1990's.

- Slim stylish appearance
- Clean controllable warmth
- Simple economical installation - no boiler
- Attractive wall hung look
- Start with 1 heater - add on later
- No VAT to pay for first time installation

**Start From
£105.00**
excluding wiring
and VAT



Hot water costs less with **ECONOMY 7**

If you use an immersion heater to get hot water it makes sense to change to the Economy 7 package. A simple conversion for only £79.45 includes:-

- A new dual immersion heater
Two heating elements - one for cheap night time use, one for day time 'top-up'
- An Economy 7 controller
Automatically switches your immersion heater on during the cheap night rate of Economy 7 and off again at the end of the cheap period
- An 80mm lagging jacket

FAMILY SIZE & TYPICAL USAGE	2 PERSONS USING AROUND 100galls. per wk.	3 PERSONS USING AROUND 150galls. per wk.	4 PERSONS USING AROUND 200galls. per wk.
HOT WATER FOR LESS THAN £2.00 PER WEEK	£1.05	£1.50	£1.94

**Less than
£2.00**
per week
to run

A simple conversion from only **£79.45**



OFFER ENDS 17 JANUARY 1984

CHAPTER SIX

UNDERSTANDING THERMOSTATS

A review of the relevant research

Suboptimal operation of thermostats can result in either insufficient warmth, or unnecessary expenditure.

Misuse could result from ignorance. For instance, Mrs. L. (Chapter Four, page 109) was an example of a person who did not know the room-thermostat was there for her to use. In her case the setting of 65°F did not involve her in unnecessary expenditure, but it could be that some people, existing in a similar state of ignorance, have high settings on their thermostats.

Another example of ignorance was Mrs. M. (Chapter Four, page 116) who, whenever the Electricaire stopped blowing warm air, turned the thermostat up till it clicked.

Suboptimal use could also result from perversity. Conversations with some people who know quite well how thermostats function, indicate that if they are really cold, maximum settings are occasionally used to heat rooms quickly to average temperatures, because they like to feel they have done everything in their power to become warm.

If, in the population in general, suboptimal operation arose through ignorance, the implication for thermostats would be that they should be better designed and labelled so that their function would become obvious. If, on the other hand, misuse arose through perversity, then an argument could be made for lowering the maximum settings on thermostats, or removing the control altogether and replacing it with a more automatic form of control.

Sansam (1981) and Bagshaw (1981) found a tendency among their subjects to use the thermostat as an on/off switch. The reason for this is not specified; but it need not indicate either ignorance or perversity. It could mean simply that the thermostat was situated in a more convenient position than the central heating switch.

A finding (Sansam, 1981) that people who used their thermostats as on/off switches tended to alternate between extremely high and extremely low settings, and the findings (Sansam, 1981 and McGeevor, 1981) that people often used higher thermostat settings in cold weather, when the central heating took longer to warm the house, could imply that some subjects thought of thermostats as heat-output controls. But equally, since subjects were not actually asked if they knew how thermostats worked, the findings could indicate perversity.

Crawshaw and Dale (1980) asked 24 people from homes with Electricaire heating, "What happens if you turn the thermostat up?" Five people said they did not know, and one said it warmed the cupboard up. The fact that the remaining 18 people gave answers acceptable from the point of view of the study, i.e. "It makes the fan come on", or, "It makes the apartment warmer", does not clarify the issue as to whether they understood the principle on which thermostats work. These latter responses could have been provided equally well by people believing that thermostats were heat-output controls.

Formulating questions in an attempt to establish whether people understand the function of thermostats is not as easy as it might seem, as the next two studies will show.

Dale and Smith (1982) claim to have found that many sixth formers and university students think that thermostats regulate heat-output. This could be so; but the evidence from the study itself is not always

conclusive because sometimes the so-called "correct" answers to the questionnaire were not the only possible ones. For instance, the authors maintain that since only 65 of the 166 subjects gave the 'correct' answer of "Nothing" to the question "What will happen to the room temperature if a window is opened and it's cold outside?" this was evidence of misunderstanding. But the size, and degree of opening of the window were not specified, so the 99 people who said the room would go colder were not necessarily wrong.

However, even if there were misunderstandings among the sample, it must be asked whether school children's and university students' knowledge about thermostats is relevant. Granted, the parents of many of the young people had central heating. But it would be unreasonable to expect young people not owning cars to know how they function. So perhaps it is not unreasonable that misunderstanding about thermostats existed among a sample of people who had never had their own heating systems.

Conan (1982 page 83) reports that several of her 91 subjects from gas centrally heated council houses implied that they used the thermostat as if it regulated heat-output. But it is not the only conclusion that can be drawn from an actual question she later put to them (page 84) which was "If you want to get the front-room warm quickly, do you

- (a) turn room-thermostat up and turn it down later
- (b) turn room-thermostat up and leave it at that setting
- (c) turn the hot water thermostat up
- (d) check that the front-room window is closed
- (e) check that the vent in the front-room window is closed?"

Subjects could endorse any response category with "Yes" or "No".

Seventy one per cent answered "Yes" to (a) and 19 per cent answered "Yes" to (b). This implies, at first glance, that a total of 90 per cent of the subjects used their thermostats as heat-output controls. But Conan

had previously reported (page 80) that 13 people (14 per cent) never altered their room-thermostat at all. Since there was no response category for "never altering the thermostat" in (a) to (e) above, subjects might have been responding to leading questions in a way that did not reflect their actual behaviour.

Furthermore, Conan reported (page 76) that 23 per cent used their thermostats as on/off switches. Therefore subjects who reported they turned their thermostats up and left them at that setting, could have been implying, merely, that they "switched their thermostats on", a perfectly reasonable procedure from which misunderstanding regarding speed of heating a room need not be inferred.

Conan's subjects were unlikely to have been aware that responses (a) and (b) were trick ones. An individual who generally adopted the strategy of using an electric fire to heat the room quickly (for which there was no response category) might well have provided responses (a) or (b) in an effort to 'help' the interviewer. Misunderstandings about what a room-thermostat can and cannot do may have existed among Conan's subjects but responses to her question do not identify them.

Her study does show, however, that only 11 per cent of subjects turned up the boiler-thermostat in order to heat the room quickly, a strategy which would have achieved the intended aim. What is not clear, and the author points this out, was whether the people who did not turn up the boiler-thermostat did not perceive the relationship between hot water temperature and heat-output, or whether altering the boiler-thermostat was too much trouble.

The research on thermostats so far indicates that they are sometimes misused. Little is known about why. From a designer's point of view, providing a reason for misuse such as "insecurity" (McGeevor, 1981) is

not constructive. Two case studies, Mrs. M. (Chapter Four, page 116) and Mrs. J. (Chapter Four, page 121), did provide data upon which designers could build, however. For instance, if it were found that many people listened for clicks when setting their thermostats, then the clicks should be suppressed.

An investigation into consumer understanding of thermostats was proposed.

THERMOSTAT STUDY NUMBER ONE:

AN INVESTIGATION INTO HOUSEHOLDER UNDERSTANDING OF
THERMOSTATS IN GAS CENTRALLY HEATED HOMES

It was decided that subjects should be drawn from the public sector for the same reasons as those described in Chapter Three.

It was further decided that the homes should have three-thermostat-systems (boiler, room and cylinder) so that consideration could be given to thermostat interaction.

THE PURPOSE OF THE INVESTIGATION

Initially the purpose of the investigation was to provide answers to the following questions:

- (1) do people use their room-thermostats suboptimally?
- (2) what are the reasons for any suboptimal use?
- (3) do consumers know what their boiler-thermostat is for?
- (4) will the boiler-thermostat setting allow consumers to achieve the temperatures set on their room- and cylinder-thermostats?
- (5) is there a relationship between suboptimal thermostat strategies and fuel consumption?

As a result of the preliminary phases of this research these questions were modified slightly (see page 184).

The Hull City Council was approached and asked where houses with gas central heating systems, fitted with three thermostats, could be found. The first housing estate suggested, known as The Quadrant, turned out to be a false start because the homes were, in fact, fitted with only two thermostats. But some interesting data were forthcoming none the less.

One man most certainly believed his room-thermostat was a heat-output control for this is what he said. "I have to have the thermostat set to

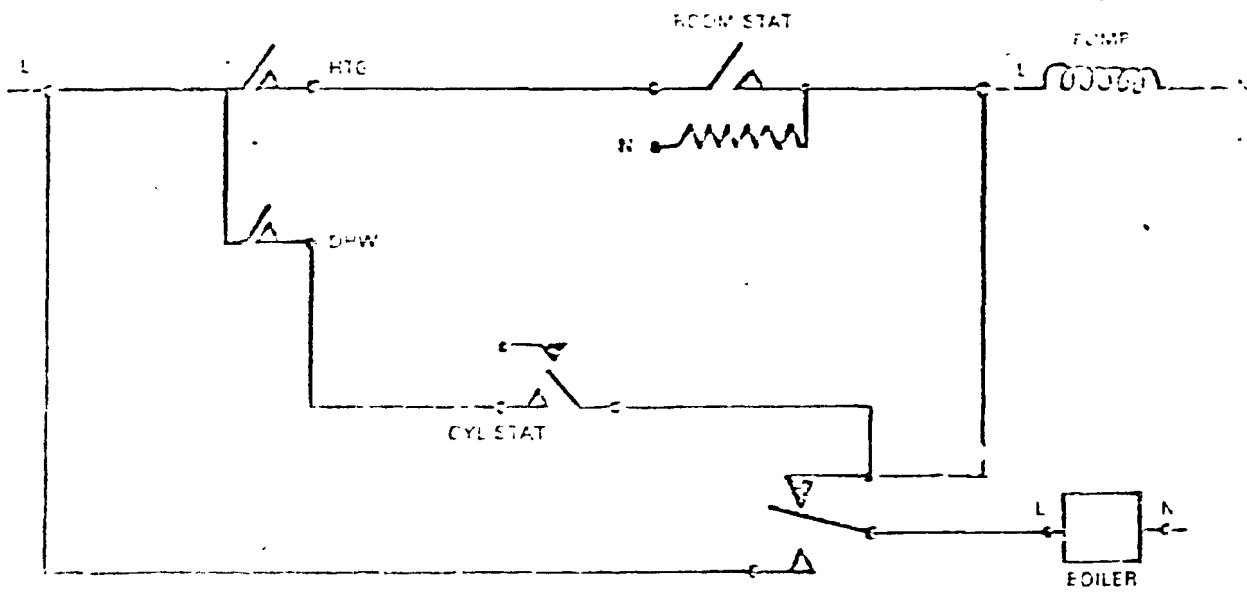


Illustration 6:6A Pumped Heating System with gravity hot water

HTG = Heating

DHW = Domestic hot water

It is apparent from the diagram that the cylinder thermostat controlled the temperature of the hot water only when either

- (a) the heating switch was off or
- (b) when the heating switch was on and the room thermostat was not calling for heat.

75°F. If I turned it down the radiators would only be lukewarm."

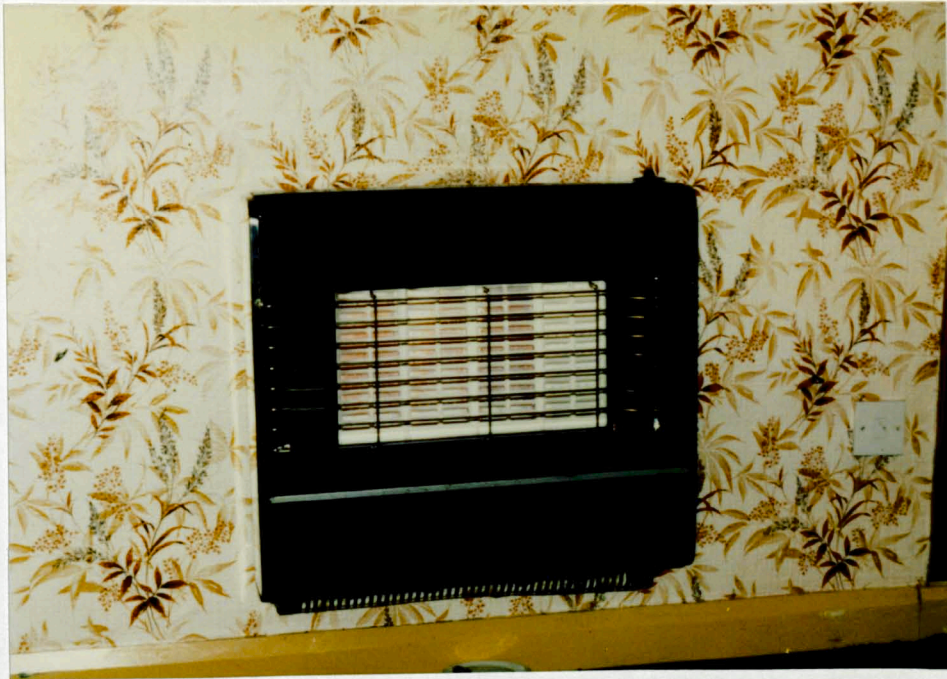
One subject said that her unlabelled boiler-thermostat was "... for the pump. If you turn it up the water is pumped round the system faster." Another subject said she did not have a boiler-thermostat at all. And indeed, it was positioned very unobtrusively. A final subject thought the boiler-thermostat was "for the pilot light".

The next housing estate suggested by the Council was fitted with the required three-thermostat system.

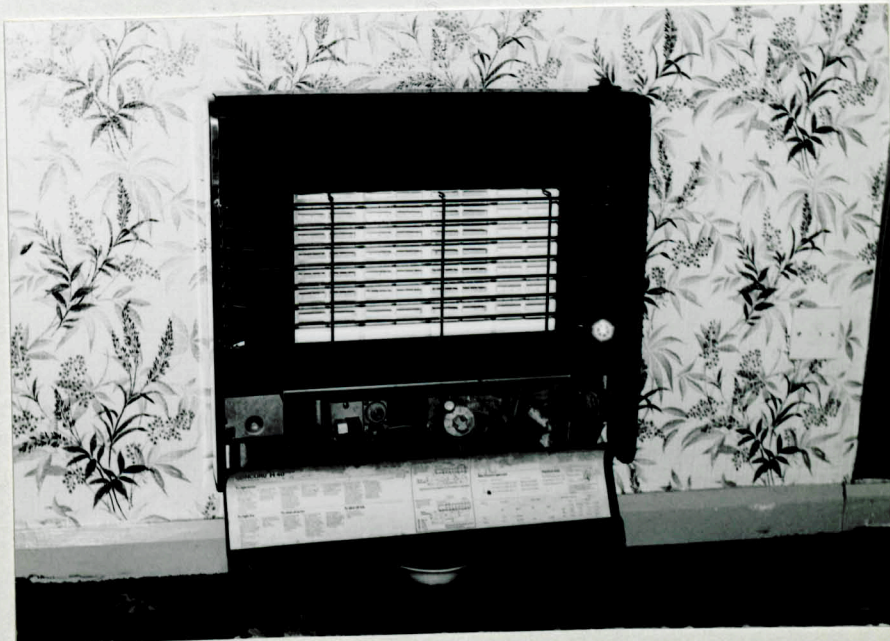
THE HOMES USED IN THE INVESTIGATION

The three-bedroomed terraced houses, situated in an area of Hull called Gipsyville, were pre-war. In 1979 they were converted from an open fire, with a back-boiler for hot water, to gas central heating, consisting of three downstairs radiators, heated by a Concorde H/45 gas fire with a back-boiler (Illustration 6 : 1, page 179). The boiler-thermostat was situated under the gas fire, behind an opening flap (Illustration 6 : 2, page 179). It was labelled with the figures 1 to 6, and in addition there was an "Off" position (Illustration 6 : 3, page 179). There were no instructions beside the control which indicated what its function might be. Instructions on the flap concerned the pilot light. The cylinder-thermostat, with possible settings from 30 to 90°C (Illustration 6 : 4, page 180) was positioned in an obvious way on the cylinder and not hidden by the insulating jacket (Illustration 6 : 5, page 180). The room-thermostat was situated on the wall of the lounge. The possible settings were from 10 to 30°C (Illustration 6 : 6, page 180).

Illustration 6:6A is a diagram of the heating system. It was a pumped system with gravity hot water which operated in the following way. In winter when the central heating was on, the cylinder temperature was dependent upon the boiler temperature; in summer when the heating was off, the cylinder thermostat controlled the temperature of the water.



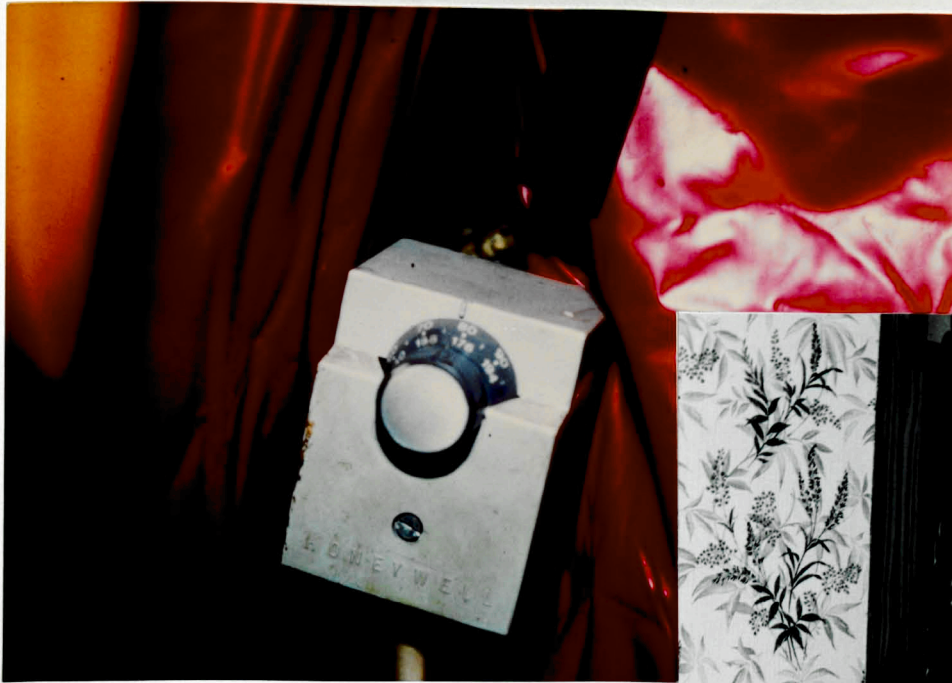
6:1 The gas fire/boiler



6:2 Flap beneath fire lowered to show boiler thermostat



6:3 The uninformatively labelled boiler thermostat



6:4 The cylinder thermostat



6:5 The position of the cylinder thermostat on the cylinder

6:6 The room thermostat in the gas homes



WHAT BOILER-THERMOSTAT SETTING IS NECESSARY FOR ACHIEVING VERY HIGH ROOM AND CYLINDER TEMPERATURES? 'EXPERTS'' ADVICE

A telephone call was made to Hull Council Gas Depot, to establish what boiler-thermostat settings were necessary to achieve very high room and cylinder temperatures. The depot representative, who was, in fact, the person responsible for giving advice to tenants, replied that the boiler-thermostat did not need to be raised to achieve either. He added that tenants were recommended to keep boiler-thermostats at 2, room-thermostats at 18°C and cylinder-thermostats at 60°C. He further added that they were recommended not to alter them.

A telephone call to Stelrad, the makers of the Concorde H/45 system, established that boiler-thermostats were simply a relic of the times before room- and cylinder-thermostats. If a system possessed the latter two controls then boilers were best kept at maximum settings. Rooms and cylinders should then be controlled simply with their own individual thermostats.

In addition, Stelrad supplied the information that the hot water temperatures achieved with the boiler at various settings were as follows:

<u>Boiler setting</u>	<u>Temperature of water (°C)</u>
1	54 - 57
2	60 - 63
3	66 - 69
4	71 - 74
5	77 - 80
6	82 - 85

Thus, if a temperature over 70°C were required in the cylinder, a setting of 4 would be necessary on the boiler.

The Stelrad representative could provide no exact figures for the boiler settings necessary for precise room temperatures, but he did state

that for maximum room temperatures and cylinder temperatures, the boiler had to be set to 6. He further added that he thought "common sense" would dictate to the consumer that this had to be the case.

The possibility that keeping the boiler on its maximum setting could have detrimental effects upon it was suggested to the representative. He stated that this was not the case; that, on the contrary, low settings were more inclined to have adverse effects, in that condensation could be created in the flue.

It seems then that the boiler setting of 2, recommended by the Gas Depot, would have produced their recommended cylinder temperature of 60°C and probably have achieved their recommended room temperature of 18°C. But the information that the boiler did not need to be raised for high room and cylinder temperatures was incorrect, and could have prevented people, seeking flexibility from their systems, from gaining their desired ends. Thus, if during the research people were found who were not achieving the temperatures they desired, incorrect information from the Gas Depot would need to be added to any other possible explanations. It was thus decided that the interview should contain a question on how subjects found out how to work their central heating, and one asking what settings had been recommended.

THE PILOT INTERVIEWS

Finding a satisfactory way of asking subjects if they knew how thermostats worked, took some time. The first pilot subject, when asked, "Do you know how a thermostat works?" replied "Yes". For research purposes this response was inadequate, yet, to have probed further seemed to be questioning her intelligence. It was therefore decided to ask subsequent pilot subjects, simply, if they ever altered their thermostats. It was

hoped that reasons for altering, or not altering, would emerge through conversation.

Ignorance concerning the existence of controls had not been expected initially, but since a subject from The Quadrant did not know she had a boiler-thermostat, it was decided to ask the direct questions, "Have you a control knob on your gas fire/boiler?" and also, "Have you a thermostat on your hot water cylinder?" The form of the semi-structured pilot interview appears on page A 20 of the Appendix.

SOME RESULTS FROM THE PILOT INTERVIEWS

Several points of interest emerged from the eighteen pilot interviews.

THE BOILER-THERMOSTAT

One subject did not know she had a boiler-thermostat and another was not sure whether she had one or not. Eight subjects did not know what it was for. Several said, "It makes the water hotter quicker".

The boiler-thermostat questions were satisfactory from the research point of view and did not need altering for the interview proper.

THE CYLINDER-THERMOSTAT

Two people were not sure if they had a cylinder-thermostat. Three people stated categorically that they did not have one. When the control was pointed out to one of these people, he claimed it was simply "for the electrics". On the basis of this last comment it was decided to include a question "What is the cylinder-thermostat for?" in the main interviews.

THE ROOM-THERMOSTAT

One subject said that she always turned it up when she wanted more hot water, but she had wondered why it did not seem to work. Another subject used Mrs. M.'s strategy exactly (Chapter Four, page 116); she regularly listened for the click. Her room-thermostat was set to 25°C. She said she did not worry that it was so high, because it put itself back after a bit. (It can only be assumed that another member of the family lowered it periodically). Lastly, one lady who said she never altered hers, because it was satisfactory, by chance added that when she first set it, when she moved into the house, she heard a click, and she had noticed that unless the setting was higher than the click the heating did not work. So she had left the thermostat at that original setting, just above the original click, ever since.

Because this last strategy could have important implications for the consumer, it was decided to incorporate a question on how the room-thermostat had been set in the first place, in the main interview. Moreover, finding out if people understood how room-thermostats worked was not proving possible without some sort of direct question. It was therefore decided to incorporate the question "How does the room-thermostat control your heating?" into the main interview.

As a result of the findings in the preliminary stages of this research the purpose of the investigation was now slightly altered. It was now designed to provide answers to the following questions:

- (1) are people aware of the existence of their boiler- and cylinder-thermostats?
- (2) do people know what their thermostats are for?
- (3) will the boiler-thermostat setting allow them to achieve the temperatures set on their room- and cylinder-thermostats?
- (4) is there any other suboptimal thermostat use?
- (5) what are the reasons for any suboptimal use?
- (6) is there a relationship between any suboptimal thermostat strategies and fuel consumption?

THE MAIN INTERVIEW ON HOUSEHOLDER UNDERSTANDING
OF THERMOSTATS IN GAS CENTRALLY HEATED HOMES

The form of the semi-structured interview appears on page A 22 of the Appendix.

The question "Have you lived here for a year?" was asked so that recent arrivals could be excluded from the survey, as they would have no consumption data from the previous winter.

Questions concerning use of the central heating, gas appliances owned, number in the family etc., were asked so that sense could be made of the consumption data. The question, "Are you satisfied with your central heating?" was asked in the hope that comments relevant to the research would be forthcoming. 'Actual' settings of thermostats were sought to see if they agreed with 'reported' settings.

The 31 interviews were conducted in late November 1982.

Permission for the North Eastern Gas Board to supply consumption data was obtained from subjects.

RESULTS AND DISCUSSION

DID SUBJECTS' BOILER-THERMOSTAT SETTINGS ALLOW
THEM TO ACHIEVE THE TEMPERATURES SET ON THEIR
ROOM AND CYLINDER THERMOSTATS?

Columns A, B, C, D, F and G in Table 6 : 1 page 187 show the reported and actual settings of subjects' boiler-, room- and cylinder-thermostats. It can be seen that many data are missing. In general people who felt they were sure of their settings could not be induced to check, or it would have appeared rude to have pressed them. People who genuinely did not know the settings frequently checked for themselves without being asked, except in the case of cylinder-thermostats. As these were upstairs, few people made the effort to go and look. A researcher wanting to gather this type of data in the future would need to explain exactly what he was after at the beginning of the interview. In the present case it was felt that making it clear from the start, that subjects were going to be checked-up on, might have had the effect of discouraging some people from agreeing to be interviewed. There are therefore no complete data for cylinder-thermostats. The boiler-thermostat data are complete in only eight cases. In two of these cases subjects were wrong in their reported settings. Room-thermostat data are complete for only six subjects and two of these reported settings turned out to be wrong. Thus the accuracy of the reported settings may not always be reliable; but in the absence of other data it will be considered.

Columns E and H in Table 6 : 1 (page 187) indicate whether the subject's boiler-setting would have allowed him to achieve the temperatures set on his room- and cylinder-thermostats. In some instances it was not possible to be quite sure because Stelrad had not been able to supply the relevant figures.

Table 6 : 1. REPORTED AND ACTUAL THERMOSTAT SETTINGS AND WHETHER SUBJECTS WERE ACHIEVING TEMPERATURES SET ON THEIR ROOM AND CYLINDER THERMOSTATS

(p.187)

	A	B	C	D	E	F	G	H
S	BOILER		ROOM		Is subject achieving temp. on room 'stat?	CYLINDER		Is subject achieving temp. on cylinder 'stat?
	reported 'stat setting	actual 'stat setting	reported 'stat setting	actual 'stat setting		reported 'stat setting	actual 'stat setting	
10	1	D.Ch.	45 (not poss)	15	✓	70	D.Ch.	X
21	DK	1	12	D.Ch.	✓	DK	D.Ch.	?
2	3	5	15	16	✓	60	D.Ch.	✓
7	2	2	DK	20	?	50	D.Ch.	✓
27	2	D.Ch.	10-15	D.Ch.	✓	DK	D.Ch.	?
28	1	D.Ch.	10	D.Ch.	✓	10 (not poss)	D.Ch.	?
3	1	D.Ch.	DK	15	✓	DK	50	✓
13	2	D.Ch.	15	D.Ch.	✓	DK	D.Ch.	?
15	2	D.Ch.	DK	20	?	40	D.Ch.	✓
17	DK	2	DK	16	✓	DK	65	✓
8	2	D.Ch.	DK	25	X	DK	D.Ch.	?
11	4	D.Ch.	20	20	✓	Haven't got one		?
4	2	D.Ch.	16	25	X	DK	D.Ch.	?
31	4	D.Ch.	15	D.Ch.	✓	60	D.Ch.	✓
22	1	D.Ch.	15	D.Ch.	✓	Haven't got one		?
1	DK	3	20	D.Ch.	✓	60	D.Ch.	✓
6	2	D.Ch.	20	D.Ch.	?	55	D.Ch.	✓
24	DK	D.Ch.	16	D.Ch.	?	DK	D.Ch.	?
9	1	D.Ch.	30	D.Ch.	X	70	D.Ch.	X
25	2	2	15	15	✓	70	D.Ch.	X
19	3	D.Ch.	DK	14	✓	DK	70	✓
23	2	D.Ch.	15	D.Ch.	✓	DK	D.Ch.	?
12	1	D.Ch.	25	D.Ch.	X	40	D.Ch.	✓
30	2	D.Ch.	wherever it clicks	D.Ch.	?	DK	D.Ch.	?
18	4	4	20	D.Ch.	✓	40	D.Ch.	✓
26	6	2	30	D.Ch.	X	DK	D.Ch.	?
16	4	4	15	15	✓	65	D.Ch.	✓
14	4	4	25	D.Ch.	✓	60	D.Ch.	✓
29	2	D.Ch.	wherever it clicks	23	X	DK	40	✓
20	3	D.Ch.	15	D.Ch.	✓	DK	D.Ch.	?
5	2	2	15-20	D.Ch.	✓	50	D.Ch.	✓

DK = Do not know

D.Ch. = Subject did not check

But in six cases subjects were certainly not achieving room temperatures in accordance with the room-settings, and in three cases (and possibly more) subjects were not achieving cylinder temperatures in accordance with the cylinder-settings.

THE BOILER-THERMOSTAT

Table 6 : 2 page 189 presents subjects' responses to the boiler-thermostat questions.

Column A indicates whether people knew they had a control under their gas fire. Two people did not know they had one, and one person was not sure.

Column B presents the actual setting (*) where possible, or otherwise the reported setting. Twenty one people had settings of 1 or 2. Eight people had settings of 3 or 4. One person had a setting of 5 and one person did not check. There seemed therefore to be a preference for low boiler settings.

Column C shows that most people never altered their setting and eight people sometimes did.

Table 6 : 3 page 190 summarizes the responses (in Column D of Table 6 : 2) to the question, "What does altering the control under the fire do?" It can be seen that only five people provided satisfactory responses, (from the point of view of an engineer), indicating that they realised the room temperature would go up, or the radiators would get hotter.

Table 6 : 2. SUBJECTS' RESPONSES TO THE BOILER-THERMOSTAT QUESTIONS

	A	B	C	D	E	F
S	Have you a control under the fire?	Actual(*) or reported setting	Do you ever alter the boiler-'stat?	What does altering it do?	How did you find out how to work your central heating?	Recommended setting
10	Yes	1	never alters	It makes the water hotter	friend	1
21	Yes	1 *	never alters	D.K.	trial and error	none
2	Yes	5 *	never alters	correct	workman	can't remember
7	Yes	2 *	never alters	correct	workman	2
27	Yes	2	up, if I want hot water quickly	It makes your water hotter	workman	2
28	Yes	1	4 when we want hot water quickly	Hotter water quicker	workman	he said it was up to us
3	Yes	1	sometimes 2	correct	gasboard	1
13	Yes	2	never alters	You'd get hotter water quicker	trial and error	none
15	Yes	2	never alters	It alters the water in the tank	workman	4
17	I think so	2 *	never alters	It would reduce the heat of the fire I suppose	son-in-law	none
8	Yes	2	never alters	It would make my gas bill go up	trial and error	none
11	Yes	4	never alters	It's for the hot water	gasboard	3 or 4
4	Yes	2	6 when we want hot water	Hotter water	trial and error	none
31	Yes	4	never alters	More hot water quicker	trial and error	none
22	Yes	1	never alters	It's for the boiler	gasboard	1
1	D.K.	3 *	never alters	D.K.	gasboard	3
6	Yes	2	never alters	correct	workman	2
24	D.K.	did not check	never alters	D.K.	son-in-law	did not know I had one
9	Yes	1	6 for hot water quickly	Hot water quicker	friend	1
25	Yes	2 *	3 sometimes	It's for the pump	gasboard	2
19	Yes	3	never alters	Hotter water	trial and error	none
23	Yes	2	never alters	Boiling water	trial and error and still don't know	none
12	Yes	1	never alters	correct	friend	1
30	Yes	2	6 when we want lots of hot water	Hotter water	friend	2
18	Yes	4 *	never alters	It makes the pipes bang	trial and error	1
26	Yes	2 *	never alters	Hotter water	trial and error	none
16	Yes	4 *	sometimes 6 for hot water	Hotter water	friend	4
14	Yes	4 *	never alters	D.K.	trial and error	none
29	Yes	2	never alters	It would probably overheat	workman	3
20	Yes	3	never alters	It makes it blow up	trial and error	none
5	Yes	2 *	never alters	Quicker hot water	trial and error	none

Table 6 : 3. A SUMMARY OF SUBJECTS' RESPONSES TO THE QUESTION, "WHAT DOES ALTERING THE CONTROL UNDER THE FIRE DO?"

	No. of people
Don't Know	4
Correct from the point of view of the research	5
It makes the water in the taps hotter	9
It makes the tap water get hotter quicker	6
It's for the pump	1
It makes the gas fire burn more	1
It's for the boiler (correct but imprecise) -	1
It would overheat	1
It makes it blow up) possibly correct) but wrong from) the point of view) of the research
It would make the pipes bang	
It makes the bill go up	
	1
	1
	1

The 15 people who believed that turning the boiler-thermostat up would produce hotter water or hotter water "quicker", were questioned closely regarding their responses. Did they mean hotter water from the taps, or hotter water in the boiler? In all 15 cases the reply was "from the taps".

In winter they would have been correct. In summer they may not have been. However a closer look at the data revealed that for at least one subject the action was effective. Table 6 : 4 page 191 looks at the six subjects who sometimes altered their boiler settings in summer, in order to obtain hotter water from the taps.

It can be seen that Subject 9 was successful in his intention. Possibly others were as well, but since the cylinder-setting data is incomplete it is not always possible to say. Subject 16 was wrong. He apparently engaged in an activity which achieved nothing. Perhaps because certain people obtained hotter water from the taps, through turning up the boiler, a belief spread through the area that this was all one needed to do to obtain hotter water.

Table 6 : 4. THIS TABLE PROVIDES SOME ANSWERS TO THE QUESTION:
 WAS TURNING UP THE BOILER-THERMOSTAT AN EFFECTIVE
 STRATEGY FOR PRODUCING HOTTER WATER IN THE CYLINDER
 IN SUMMER?

S	A Actual (*) or reported boiler-'stat setting	B Reported cylinder-'stat setting	C Would turning up the boiler-'stat produce hotter water in cylinder in summer?
4	2	DK	?
9	1	70	Yes
16	4 *	65	No
27	2	DK	?
28	1	10 (not poss)	?
30	2	It's broken	?

Column A presents the actual (*) or reported boiler-thermostat setting.

Column B presents the reported cylinder-thermostat setting (where possible).

Column C indicates (where possible) whether turning the boiler-thermostat up was an effective strategy for producing hotter water in the cylinder in summer.

That there was ignorance in the sample concerning the boiler-thermostat is not surprising, for as has been mentioned before, it was not labelled, neither was its function implicit in its design. Moreover, from Column E in Table 6 : 2 page 189 it can be seen that no one had received any written instructions about how to operate the heating. Twelve people had tried to work it out through trial and error, one of these admitting that he still had no idea what he was doing. Seven people had had it explained by a friend or relative. Only twelve people seemed to have had it explained by someone at least partly official, although in the case of 'gasboard' explanations, the description provided by some subjects indicated that this was simply the person who came to connect the supply.

From Column F in Table 6 : 2 it can be seen that 2 was the setting mostly recommended by workmen and gasboard people, and never more than 4. This tallied with the information supplied by the Gas Depot representative (page 181). Stelrad's 'personally confided' recommendation, (not on general release), that the boiler should be kept at 6 (page 181), was nowhere in evidence.

THE ROOM-THERMOSTAT AND ITS USE IN
RELATION TO GAS CONSUMPTION

Column A in Table 6 : 5 (page 193) presents subjects' gas consumption in terms of hundreds of cubic feet, for the quarter ending February, 1982. The information contained in columns B, C and D is intended to help explain the consumption data. Many people, for instance, owned a gas cooker (C) (about 2000 cubic feet per quarter). One person owned a gas fridge (Fr) (about 900 cubic feet per quarter) or a gas fire (Fire) (about 10,000 cubic feet in a winter quarter), in addition to the main central heating gas fire. The appliances owned, apart from the main central heating system, are presented in Column B.

From the information presented in Column C it can be seen that subjects' use of the central heating system varied considerably. Some people hardly ever used it at all. Others used it for drying the clothes only. These have been classified as 'rare' users. Some people used only particular radiators and others used all three on a regular basis. The numbers in Column C represent the number of radiators used regularly.

Column D presents the number of people living in each house. The number varies from one to nine.

Table 6 : 5. SUBJECTS' RESPONSES TO THE ROOM-THERMOSTAT QUESTIONS AND THOSE CONCERNING HOW THEY LEARNED TO USE THE HEATING SYSTEM. Subjects are arranged in rank order according to their gas consumption. To help explain gas consumption, use of radiators, gas appliances owned, and number in household, are provided.

Ss rank ordered according to consumption	A Gas used cu.ft	B Gas appliances owned	C Use of radiators	D No. in h/h	E Actual(*) or reported setting	F How does the room-thermostat control the heating?	G Do you ever alter the room-thermostat?	H How did you set thermostat in the first place?	I How did you find out how to work the central heating?	J Rec. setting
10	191	C	2	5	15 *	D.K.	never alters	guessed	friend	15
21	206	C	1	3	12	D.K.	never alters	neighbours	trial and error	none
2	208	C	2-3	4	16 *	D.K.	never alters	heating people	workman	16
7	212	Zero	2	3	20 *	correct	Yes (sensible)	gasboard	workman	20
27	217	C	rare	3	10-15	D.K.	never alters	Thought low would be economical	workman	20
28	224	C	2	4	10	D.K.	never alters	workman	workman	10
3	247	C	3	4	15 *	heat output	Yes(heat output)	workman	gasboard	15
13	250	C	2	5	Just till it clicks 15	heat output	I listen for click freq. (heat output)	I always wait for the click	trial and error	none
15	250	C	2-3	2	20 *	correct	never alters	workman	workman	20
17	250	C	3	1	16 *	D.K.	never alters	son-in-law	son-in-law	16
8	252	C, Fr	3	3	25 *	heat output	Yes (heat output)	guessed	trial and error	none
11	261	C	2	5	Just till it clicks 20 *	heat output	I listen for click reg. (heat output)	I always wait for click	gasboard	none
4	263	C, Fire	rare	2	25 *	It's for the hot water	never alters	mate	trial and error	none
31	269	C	rare	5	15	D.K.	never alters	guessed	trial and error	none
22	272	C	rare	4	15	D.K.	never alters	guessed	gasboard	none
1	298	C, Fire	3	2	20	D.K.	never alters	gasboard	gasboard	20
6	321	C	3	2	20	D.K.	never alters	workman	workman	20
24	325	C	rare	3	16	correct	never alters	son-in-law	son-in-law	16
9	329	C	3	6	30	D.K.	never alters	Heard a click & set it above it	friend	can't remember
25	336	C	3	4	15 *	correct	Yes (sensible)	guessed	gasboard	none
19	338	C	rare	4	14 *	D.K.	never alters	Heard a click & set it above it	trial and error	none
23	344	C	2	5	15	D.K.	never alters	Heard a click & set it above it	trial and error, still don't know	none
12	357	C	rare	5	25	correct	never alters	Heard a click & set it above it	friend	none
30	364	C	2	9	Just till it clicks	D.K.	I listen for click freq.	I always listen for click	friend	none
18	417	C	rare	5	20	heat output	I listen for click freq. (heat output)	I always listen for click	trial and error	none
26	468	C	3	6	30	heat output	Yes (heat output)	guessed	trial and error	none
16	472	C	2	2	15 *	D.K.	never alters	guessed	friend	15
14	484	C	2	5	25	heat output	Yes (heat output)	I found that putting it at 25 got the rads. hot	trial and error	none
29	507	C	2	3	Just till it clicks 23 *	D.K.	I listen for click freq.	I always wait for the click	workman	none
20	522	C	3	4	15	heat output	Yes (heat output)	workman	trial and error	none
5	631	C	rare	3	15-20	heat output	never alters	neighbour	trial and error	none

During the planning stages of the research it was hoped that suboptimal thermostat strategies might show up in increased consumption. Due to the above variations between homes this was now unlikely. However the subjects in Table 6 :5 have been arranged in rank order, according to their gas consumption, so that individual cases can be considered.

Columns E, F, G and H in Table 6 : 5 present subjects' responses to the room-thermostat questions.

Column E presents the actual(*) setting where possible, or otherwise the reported setting.

Column F indicates whether the subject understood how the thermostat controlled the heating. Only five people provided satisfactory responses. Nine people believed it worked like a heat-output control. One person believed it produced hotter water in the cylinder. Sixteen people simply did not know (D.K.). Several people expressed considerable surprise when the principles were explained.

Column G concerns the question, "Do you ever alter your thermostat?" 'Sensible' means that any altering was of a sensible kind, for example, the requirement of a higher temperature in the evening, when sitting down. 'Heat-output' means that the way the subject described his altering of the thermostat implied that he thought of it as a heat-output control. "I listen for the click", means that the subject regularly fiddled with the thermostat, and set it just above the point where the click was detected.

Table 6 : 6 (page 195) summarizes the responses from Column G of Table 6 : 5 (page 193).

Table 6 : 6. A SUMMARY OF THE WAY PEOPLE USED THEIR ROOM-THERMOSTATS.
(The total exceeds 31 because 3 people belonged in both categories 3 and 4).

(1)	No. of people who never altered room-thermostat	19
(2)	" " " " altered room-thermostat sensibly	2
(3)	" " " " used thermostat as heat-output control	8
(4)	" " " " listened regularly for the click	5

The comments from the people who used their thermostats as heat-output controls included the following:

- (1) I turn the thermostat up if it's very cold weather.
- (2) I turn the thermostat down if it's very mild weather.
- (3) When the heating has been on for an hour and a half I turn it down.
- (4) I turn the thermostat down to 10 when the radiators are hot.
- (5) I found that putting it at 25°C got the radiators hot. If I change the thermostat the radiators are not warm.
- (6) If I put my thermostat below 20°C, it puts the heating off.

In none of the eight cases where thermostats were used as heat-output controls were people being simply perverse. When they were asked to explain how the room-thermostat controlled the heating, their responses (Column F, Table 6 : 5, page 193), in every case, implied that they thought they were, indeed, heat-output controls.

Using the room-thermostat in this way was not necessarily associated with high consumption. It can be seen that equal numbers of subjects were below and above the consumption median. However, in the case of Subjects 8, 14 and 26 the strategy did result in high room settings of 25, 25 and 30°C. In Subject 14's case the boiler setting was such that this temperature would most likely have been achieved. Her consumption was fourth largest. It

could be argued that an understanding of the room-thermostat, what it can and cannot do, could have saved her some money.

Subject 8 commented that she wished there were more radiators in the system. Had she understood that her boiler-thermostat should have been raised for her to achieve 25° she might have expressed more satisfaction with the system.

Five subjects (11, 13, 18, 29 and 30) listened regularly for 'the click' and set their thermostats just above that point. A possibility that this strategy could lead to high settings being adopted was confirmed by Subject 29's actual setting of 23°C, and indeed both subjects' consumption was considerably above the median. It is perhaps fortunate that Subject 29's boiler was set at 2 and never altered, so the high temperature was probably never reached. This latter fact did not appear to lead to dissatisfaction with the system, for his reply to the question concerning satisfaction was positive.

Subject 30 did not provide her room-setting, but it is likely that her regular 'click' strategy resulted in it being a high one. Since she frequently turned her boiler up from 2 to 6 for hotter water, she would have, at the same time, increased the heat to the radiators. As this was not intended, her ignorance could have been the cause of her high consumption. Hers was in the highest quartile. Alternatively, maybe it was only on these occasions that she felt comfortable, without knowing why.

Table 6 : 7 (page 197) presents the relevant data for all six subjects (including Subject 30) who turned up their boilers to obtain hotter water. It can be seen that in the cases of Subjects 4 and 9 the radiators would certainly have become hotter. It is unlikely that any of these six people were aware of this side effect, for they all thought the boiler-thermostat was for hotter water from the taps. Subject 4, however, used the central heating only rarely. Perhaps the reluctance to use it began when high bills were received, stemming from the above inappropriate strategy.

Table 6 : 7. ARE HOTTER RADIATORS A SIDE EFFECT OF TURNING UP THE BOILER TO OBTAIN HOTTER WATER FROM TAPS?

	A	B	C	D
S	Actual(*) or reported boiler setting	Actual(*) or reported room setting	Boiler setting when hotter water required	Would subjects' radiators also get hotter?
4	2	25 *	6	Yes
9	1	30	6	Yes
16	4 *	15 *	6	No
27	2	10-15	4	No
28	1	10	4	No
30	2	wherever it clicks	6	quite possibly

Columns A and B present actual(*) or reported boiler and room settings.

Column C presents the setting adopted when hotter water was required.

Column D indicates whether hotter radiators would also have resulted.

Subject 9 expressed some dissatisfaction with the system, saying that it was not really warm enough. An understanding of the function of the boiler-thermostat in relation to the room-thermostat would possibly have increased his satisfaction.

In neither case was consumption disproportionately large.

Never altering the room-thermostat can be a sensible strategy. However, consumers might just as well be provided with a non-adjustable thermostat, as provide them with one they do not understand and consequently never alter. Taking Columns F and G together (Table 6 : 5, page 193) it can be seen that of the 19 people who never altered their settings, only three of them understood the principles on which thermostats work.

Column H provides the information that 10 of the 19 had had the thermostat set for them by "the gasboard", "the heating people", "a friend", "a relative" or "a workman", apparently without explanation, and the fact they did not move it seemed to be due to ignorance rather than to an informed decision. Indeed, four of the 19 admitted they had guessed at a setting originally, and had hoped for the best.

Four people had found, on moving in, that the radiators did not begin to get warm unless they heard "a click". Ever since, their thermostats had remained at whatever setting that had been. In Subject 12's and Subject 9's cases this resulted in permanent settings of 25 and 30°C. In Subject 12's case this reflected a genuine desire for a high temperature, but he never achieved it for his boiler was set at 1. Subject 9's case has already been discussed on page

THE CYLINDER-THERMOSTAT

Table 6 : 8 (page 199) summarizes the responses to the cylinder-thermostat questions.

Two people did not know they had one, and one person was not sure. Eighteen people were correct about the function of this thermostat but ten people did not know what theirs was for. Most people never altered them. At least one person believed that they were not supposed to.

Table 6 : 8. SUBJECTS' RESPONSES TO THE CYLINDER-THERMOSTAT QUESTIONS

S	Have you got a 'stat on your hot water cylinder?	Actual(*) or reported setting	Do you ever alter it?	What does altering it do?
10	Yes	70	No	correct
21	Yes	DK	No	DK
2	Yes	60	No	correct
7	Yes	50	No	correct
27	Yes	DK	No	I <u>suppose</u> the water would get hotter
28	Yes	10	No	DK
3	Yes	50 *	No	correct
13	Yes	DK	No	DK
15	Yes	40	No	correct
17	Yes	65 *	No	DK
8	Yes	DK	No, The Y.E.B. told me not to	DK
11	No	not approp.	not approp.	not approp.
4	Yes	DK	No	correct
31	Yes	60	No	DK
22	No	not approp.	not approp.	not approp.
1	Yes	60	No	correct
6	Yes	55	No	correct
24	Yes	DK	No	correct
9	Yes	70	No	correct
25	Yes	70	sometimes 60	correct
19	Yes	70 *	No	correct
23	I <u>think</u> so	DK	No	DK
12	Yes	40	No	correct
30	Yes	DK	No	DK
18	Yes	40	No	correct
26	Yes	DK	No	correct
16	Yes	65	No	It would take longer for water to heat if you turned it down
14	Yes	60	No	It's something to do with the hot water
29	Yes	40 *	50 in summer	correct
20	Yes	DK	No	DK
5	Yes	50	No	DK

A SUMMARY OF THE MAIN FINDINGS, AND CONCLUSIONS
FROM THE INVESTIGATION INTO CONSUMER USE OF
THERMOSTATS IN GAS CENTRALLY HEATED HOUSES

At the outset of the investigation it was hoped to show a relationship between suboptimal thermostat use and energy consumption; unfortunately, a straightforward correlation between strategies and energy use was not possible because of the many other differences which existed between households. However in individual cases it was possible to point to thermostat use as being a probable cause of high consumption.

1. Boiler-Thermostats

(a) Ten per cent of the sample either did not know or were not sure whether they had a boiler-thermostat.

(b) Eighty four per cent of the sample were ignorant of the function of the boiler-thermostat, 58 per cent of these believing it controlled the temperature of the water from the taps.

(c) Ignorance of the function of the boiler-thermostat was the reason why at least 19 per cent of the sample were probably not achieving the temperature set on their room-thermostat, and why 10 per cent of the sample were probably not achieving the temperature set on their cylinder-thermostat.

(d) Ignorance of the function of the boiler-thermostat was the reason why at least six per cent of the sample inadvertently obtained additional heat from their radiators when they turned up their boiler-controls to obtain hotter water from their taps. It is not known whether this strategy resulted in 'wasted' heat or in greater satisfaction with the system, but none of the people who used this strategy had disproportionately large bills. However their ignorance created a situation where freedom of choice, to maintain or increase room temperatures, was removed.

2. Room-Thermostats

(a) Eighty four per cent of the sample were ignorant of the function of room-thermostats, 35 per cent of these believing they were heat-output controls.

(b) The belief that room-thermostats were heat-output controls was not necessarily associated with high bills, although it probably explained one subject's high consumption.

(c) Twenty nine per cent of the sample believed that the 'click' was an integral part of the setting-process for room-thermostats. In a third of these cases subjects were found to have very high room-thermostat settings and consumption above the median.

3. Cylinder-Thermostats

(a) Ten per cent of the sample either did not know or were not sure whether they had a cylinder-thermostat.

(b) Fifty per cent of the sample either did not know or were unsure about the function of cylinder-thermostats.

4. Some explanations for suboptimal thermostat use

At the beginning of this chapter two reasons were suggested which might cause people to misuse thermostats: ignorance and perversity. The findings in this chapter point to the former. The following are some reasons why many people in the sample interviewed were ignorant on the subject of their thermostats.

(a) Not one person in the entire sample had ever had an instruction leaflet about how to operate their heating.

(b) The labelling on the thermostats gave no indication about function or operation.

- (c) In the absence of precise instructions some people
 - (i) used the method of trial and error to find out about their heating system, and
 - (ii) relied on friends, workmen or gasboard personnel for information, whose advice may have been, but frequently was not, correct.

Both the above sometimes resulted in idiosyncratic meanings being imposed upon situations which were difficult to understand. For example, attention was paid to what should have been an irrelevant 'click'; and the boiler-thermostat control was designated the hot-water-from-the-taps control just because under certain circumstances this is what its operation produced.

RECOMMENDATIONS

The fact that many people followed the inappropriate advice they had been given, illustrates that people are willing to listen to, and follow, instructions. It therefore seems worthwhile to make the following recommendations.

- A Instruction leaflets should be provided with new heating systems. Should additional copies of the leaflet subsequently be required an appropriate address should be provided, prominently, somewhere on the heating system.
- B Manufacturers of boilers should consider producing one which operates at the maximum setting only, for use in three-thermostat systems.
- C When traditional boilers are fitted in three-thermostat systems the advice should be to keep it at its maximum setting and operate the room and cylinder controls only. This advice should appear prominently near the boiler-thermostat.
- D Room and cylinder thermostats should be clearly labelled "Room (or tap water) temperature required".
- E Irrelevant cues in thermostats, such as 'clicks', should be suppressed.

THERMOSTAT STUDY NUMBER TWO:
HOUSEHOLDER UNDERSTANDING OF THERMOSTATS IN
HOMES WITH ELECTRIC UNDERFLOOR HEATING

Thermostats controlling underfloor heating are, in fact, charge controls. Set high, they allow the concrete of the floor to store more heat than when they are set low. Once heat is stored in the floor there is no way that the thermostat can prevent it from being emitted. If a day turns out unexpectedly hot, consumers may find they have more heat than they need. It is therefore a form of heating with control problems, the ideal strategy being to listen to weather forecasts before charging-up times, and alter thermostats accordingly.

Case Study III (Chapter Four page 121) indicated that some people might be unaware of the 'ideal strategy'. Indeed a Y.E.B. booklet entitled "Operating The Underfloor Heating and Water Heating in Your Home", states that "Once set, the thermostats can be left to regulate the heating system throughout the heating season." (page 4).

The control problem and the inappropriate advice could have serious financial implications, especially since it has been noted (Hutton, 1981) that this form of heating is "commonly associated with low incomes".

It therefore seemed worthwhile to conduct an investigation into householder understanding of the function of thermostats in homes with underfloor heating.

THE SUBJECTS AND THE HOMES USED IN THE INVESTIGATION

Since much local authority housing has underfloor heating (Hutton, 1981) it seemed appropriate to use a sample from the public sector.

The area of Hull chosen for the investigation was part of a large local authority housing estate, called Bransholme.

The homes had underfloor heating in three areas on the ground floor: kitchens, halls and lounges, controlled by two, or in some cases three, thermostats (Illustration 6 : 7 page 206). Incorporated on the casing of the thermostat was also the ON/OFF switch, labelled "Auto" and "Off".

The homes were identical apart from one feature. Some were open plan, i.e. the hallway was not partitioned off from the kitchen ('open'), while others had an identical floor plan but the kitchen was separated from the hall ('closed').

They were on the tariff known as N.E.D.W., i.e. they received off-peak electricity at night (N), for part of the evening (E), for part of the afternoon (D [for Day]) and continuously at the weekends (W).

THE PILOT INTERVIEWS

The form of the semi-structured pilot interview appears on page A 24 of the Appendix. Its purpose was to ascertain whether householders altered their thermostats according to the weather conditions.

Subjects were obtained in the same way as before, each one being the person in the household mainly responsible for controlling the heating.

Seven pilot interviews were conducted.

Two pilot interviewees complained that because of the full availability of cheap electricity at the weekends, the house felt so warm then that windows had to be opened as a result. It was therefore decided to ask subjects in the main interview two separate questions on thermostat altering, one for during the week, and one for weekends, and in addition to ask them if they ever had to open their windows at weekends because they were too hot.



6:7 A thermostat controlling underfloor heating

From conversation with one pilot subject it emerged that he believed his heating felt hotter at weekends because the factories were "off" then and his electricity was therefore "stronger" at this time. He did not realise that he had full availability of the cheap electricity at that time. It was thus decided to ask all subjects in the main interview if they knew the times of availability, for without this knowledge, decisions regarding alteration of the thermostat are difficult to make.

It would not be surprising if uncertainties regarding times of availability were found, for nowhere in the Y.E.B. booklet, nor on the consumers' bills, are the times specified.

One pilot subject, with perfect understanding of the heating, described the way a neighbour of hers misused the system. The neighbour kept himself warm between storage times by using a paraffin heater. This had the unfortunate side effect of keeping the room temperature above that set on his thermostat, so when the off-peak periods began, no storage of heat took place, which further encouraged him to use his paraffin heater. It was therefore decided to ask subjects in the main interview if they ever used a fire between storage times, and if so, if they had noticed whether this made any difference to the underfloor heating, and if they could think what might account for any difference.

Since the subject in Chapter Four's case study (page 121) was under the impression that she had to fiddle with the thermostat until it clicked, before going to bed, it was decided to ask subjects in the main interview, specifically, if they too altered their thermostats before going to bed.

THE MAIN INVESTIGATION INTO HOUSEHOLDER UNDERSTANDING
OF THERMOSTATS IN HOMES WITH ELECTRIC UNDERFLOOR HEATING

The form of the main interview appears on page A 25 of the Appendix.

Thirty subjects were interviewed in early November 1982. All gave permission for consumption data to be supplied by the Y.E.B.

Items C, D and E and question 1 of the interview were asked to help explain the consumption data.

During the Main Interview several subjects volunteered the information that they were not going to use the underfloor heating anymore because it was too expensive. It was decided, later, to call again on the subjects who had not volunteered this information to ask them whether they intended to use the heating the following winter.

RESULTS AND DISCUSSION

The information presented in Tables 6 : 9 (page 210) and 6 : 10 (page 211) is for 29 subjects only because Subject 24 had not lived in her house for a year and therefore had no consumption data for the relevant winter quarter, ending March 1982.

Columns A - E present the subjects' responses to the thermostat questions. Column F presents subjects' total score for the questions.

Column G in both tables contains the consumption data. The first table presents the proportions of off-peak electricity subjects used in the quarter ending March 1982. The second table presents subjects' bills. In both tables subjects have been arranged in rank order according to consumption.

Columns I, J, K, L and M in both tables contain factors which, it was thought, might help explain variations in consumption. And indeed larger families were found to use greater proportions of off-peak electricity ($r_s = 0.42$ $p < 0.05$) and to receive larger bills ($r_s = 0.38$ $p < 0.1$) than smaller families. The only other significant finding was that 'closed' households used larger proportions of off-peak electricity than 'open' households ($U = 52$ $p < 0.05$). Perhaps people from open plan homes were conscious of the fact that their heating could be 'wasted' upstairs, and consequently used it less.

Because of the above significant findings it would not now be worthwhile to correlate thermostat understanding (Column F) with consumption. But, as was the case in the gas section of this Chapter, individual cases could still be considered.

What the consumption data did show however was that control problems clearly existed.

Table 6 : 9. UNDERSTANDING UNDERFLOOR THERMOSTATS, RANKED CONSUMPTION RATIOS AND SOME ADDITIONAL FACTORS WHICH COULD EXPLAIN CONSUMPTION

	A	B	C	D	E	F	G	H	I	J	K	L	M
S	Do you ever alter the 'stat during the week? No = 0 Yes = 1	Do you ever alter the 'stat at week-ends? No = 0 Yes = 1	Do you have to open your windows at week-ends? Yes = 0 No = 1	Do you know when your heating is on? No = 0 Yes = 1	Do you use a fire in same room as U.F. heating? Yes = 0 No = 1	Total score for five questions	Proportion of off-peak electricity used placed in rank order (%)	Are you going to use U.F. heating this winter?	No. of people in house-hold	Patterns of occupancy Full = full time Part = part time	No. of rooms where U.F. heating was on	Thermo-stat settings in those rooms	Type of house, open or closed plan O = open C = closed
3	0	0	1	1	1	3	95	Yes	1	Full	1	68	C
7	0	0	1	1	1	3	92	Yes	2	Full	2	65,70	C
10	0	0	1	1	1	3	92	Yes	4	Full	1	65	C
18	0	0	1	0	1	2	90	Yes	3	Part	2	65,65	C
6	0	0	1	1	1	3	90	Yes	2	Full	1	70	O
4	0	0	0	0	1	1	88	Yes	2	Full	1	68	C
9	0	0	1	1	0	2	87	Yes	2	Full	2	62,68	O
19	0	0	1	0	1	2	87	No	4	Full	1	70	C
26	0	0	0	0	1	1	87	Yes	4	Part	1	80	C
29	0	0	1	0	1	2	87	Yes	4	Full	1	70	C
11	0	1	1	1	0	3	86	Yes	3	Part	1	68	C
17	0	1	0	1	1	3	85	Yes	4	Full	2	62,66	C
13	0	0	1	0	1	2	85	Yes	2	Full	1	65	C
20	0	0	1	0	1	2	85	No	6	Part	1	65	O
8	0	0	1	0	1	2	84	Yes	3	Full	1	69	C
15	0	0	1	1	1	3	84	No	2	Full	1	70	O
16	0	0	1	0	1	2	82	Yes	5	Full	1	68	C
25	0	0	0	0	0	0	82	No	4	Full	1	70	C
5	0	0	0	1	1	2	80	Yes	6	Part	2	60,70	C
21	0	0	1	1	1	3	79	Yes	3	Part	1	63	C
22	0	0	1	0	1	2	78	Yes	3	Full	1	70	C
23	0	0	1	1	1	3	76	No	8	Full	3	65,60,55	O
30	0	0	0	0	0	0	76	No	5	Full	3	68,70,78	O
12	0	0	1	1	1	3	74	Yes	5	Full	1	68	C
2	1	0	1	1	1	4	73	Yes	5	Part	1	62	O
14	1	0	0	1	1	3	72	Yes	4	Part	1	65	O
27	0	0	0	0	1	1	62	No	3	Full	2	60,68	O
28	0	0	1	0	1	2	55	Yes	1	Full	1	65	C
1	0	0	0	1	0	1	55	Yes	6	Full	1	68	O

Table 6 : 10. UNDERSTANDING UNDERFLOOR THERMOSTATS, RANKED BILLS AND SOME ADDITIONAL FACTORS WHICH COULD EXPLAIN CONSUMPTION

	A	B	C	D	E	F	G	H	I	J	K	L	M
S	Do you ever alter the 'stat during the week? No = 0 Yes = 1	Do you ever alter the 'stat at week-ends? No = 0 Yes = 1	Do you have to open your windows at week-ends? Yes = 0 No = 1	Do you know when your heating is on? No = 0 Yes = 1	Do you use a fire in same room as U.F. heating? Yes = 0 No = 1	Total score for five questions	Bills placed in rank order (£)	Are you going to use U.F. heating this winter?	No. of people in house-hold	Patterns of occupancy Full = full time Part = part time	No. of rooms where U.F. heating was on	Thermo-stat settings in those rooms	Type of house, open or closed plan O = open C = closed
28	0	0	1	0	1	2	56	Yes	1	Full	1	65	C
5	0	0	0	1	1	2	73	Yes	6	Part	2	60,70	C
13	0	0	1	0	1	2	87	Yes	2	Full	1	65	C
6	0	0	1	1	1	3	96	Yes	2	Full	1	70	O
14	1	0	0	1	1	3	109	Yes	4	Part	1	65	O
4	0	0	0	0	1	1	114	Yes	2	Full	1	68	C
3	0	0	1	1	1	3	115	Yes	1	Full	1	68	C
2	1	0	1	1	1	4	115	Yes	5	Part	1	62	O
7	0	0	1	1	1	3	120	Yes	2	Full	2	65,70	C
9	0	0	1	1	0	2	122	Yes	2	Full	2	62,68	O
10	0	0	1	1	1	3	122	Yes	4	Full	1	65	C
29	0	0	1	0	1	2	123	Yes	4	Full	1	70	C
20	0	0	1	0	1	2	130	No	6	Part	1	65	O
11	0	1	1	1	0	3	135	Yes	3	Part	1	68	C
18	0	0	1	0	1	2	141	Yes	3	Part	2	65,65	C
19	0	0	1	0	1	2	142	No	4	Full	1	70	C
26	0	0	0	0	1	1	151	Yes	4	Part	1	80	C
8	0	0	1	0	1	2	153	Yes	3	Full	1	69	C
27	0	0	0	0	1	1	162	No	3	Full	2	60,68	O
25	0	0	0	0	0	0	163	No	4	Full	1	70	C
16	0	0	1	0	1	2	167	Yes	5	Full	1	68	C
1	0	0	0	1	0	1	171	Yes	6	Full	1	68	O
15	0	0	1	1	1	3	174	No	2	Full	1	70	O
17	0	1	0	1	1	3	175	Yes	4	Full	2	62,66	C
23	0	0	1	1	1	3	179	No	8	Full	3	65,60,55	O
30	0	0	0	0	0	0	191	No	5	Full	3	68,70,78	O
22	0	0	1	0	1	2	203	Yes	3	Full	1	70	C
21	0	0	1	1	1	3	207	Yes	3	Part	1	63	C
12	0	0	1	1	1	3	210	Yes	5	Full	1	68	C

According to page 2 of the Y.E.B. users' booklet for underfloor heating

"the usage of fuel in the average household is divided up in the following way:

$\frac{2}{3}$ for space heating

$\frac{1}{4}$ for water heating

$\frac{1}{12}$ for other uses."

If, therefore, subjects never used alternative forms of electric heating, by the above reckoning $\frac{11}{12}$ (or 91.6 per cent) of their consumption should have been at the off-peak rate, and $\frac{1}{12}$, (or 8.3 per cent) at the full rate. (Space heating and water both being on the off-peak rate).

From Column G in Table 6 : 9 (page 210) it can be seen that only three subjects achieved this, i.e. their ratio measures were greater than 91 per cent. Even if the criterion were doubled to 16.6 per cent at the full rate, only just over half the sample was successful.

Without even looking at the 'understanding' data (Columns A - F) it was clear that a control problem existed with this system of heating. And the control problem cost money for the consumers using the largest proportion of off-peak units also had the smallest bills ($U = 56.5, p < 0.05$).

In the absence of corroborating data, it is a suggestion only, that possibly, many subjects used alternative forms of electric heating (which had the effect of increasing their consumption at the full rate) in rooms where the heating was off; certainly from Column K (Table 6 : 9) it can be seen that a total of 21 subjects used the underfloor heating in one room only.

Since seven people were planning to stop using the central heating (Column H) for financial reasons, it is possible that those who opted for full rate additional heating in certain rooms, did so because they considered it more controllable, and therefore more cost effective.

It could be to an Electricity Board's advantage to make sure that consumers operate their underfloor heating optimally, for a significant difference was found between the bills of the people who intended to continue using, and stop using, the heating ($U = 40$ $p < 0.1$). Those people who planned to stop had larger bills, and it can be seen that they were not all from large households.

The semi-structured interview contained five main points concerning optimal strategies for operating the heating, and they were as follows:

- (1) did subjects alter their thermostats during the week?
- (2) did subjects alter their thermostats at the weekends?
- (3) did subjects have to open their windows because they were too hot at weekends?
- (4) did subjects know the times when their heating was on?
- (5) did subjects use fires in the same rooms as the underfloor heating?

The points will be dealt with in turn, below.

(1) WEEKDAY ALTERATION OF THE THERMOSTAT

Subjects' responses to this point are presented in Column A of the two tables.

People who never altered their thermostats during the week have been given a score of "0", others "1".

It can be seen that only two people ever did this. Subject 14 turned his living room thermostat up overnight, sometimes, "to air the washing". Presumably he did not do this often for his bill was less than the median. Subject 2 altered hers during the week because she had a morning job outside

the home. She turned the thermostat down overnight, then up again when she came in at lunchtime, ready for the afternoon boost. She rightly felt that she would not benefit from the night-stored heat. Presumably for this reason, her proportion measure was low, but so also was her bill, despite the fact her family size was slightly above average for the study.

It would have been to the advantage of other subjects, whose homes were occupied only part-time, to have adopted this strategy. However many subjects believed that it was not possible or sensible to turn the heating down once it was switched on for the heating season. Indeed the Y.E.B. instructions (page 3) specifically discourage this.

"It is wise not to switch off your heating system altogether except in summer. A low level of background heating costs little".

Generally then, people treated their thermostats as thermostats, and not as charge controls. This is not surprising, for the Y.E.B. leaflet (page 4) contains only one sentence which describes the true function of the underfloor thermostat, and it reads, "The amount of heat stored is regulated by the thermostats." However any understanding which could have resulted from presentation of this information is interfered with by contradictory statements like

- (i) thermostats "measure the temperature of the air immediately around them and automatically switch the heating system on and off to keep the room at the temperature to which the thermostat is set." (page 3).
- (ii) "Set the thermostat to a temperature that suits your requirements and let it control the heating system as it was designed to do. Don't simply use it as a switch by constantly turning it up and down." (page 3).
- (iii) "Once set, the thermostats can be left to regulate the heating system throughout the heating season." (page 4).

No one was found who turned the thermostat down "to cool the room", or who turned it up to "warm the room", which would have been inappropriate strategies (Questions 3,i,(a) and (b) in the interview). Neither were any subjects found who fiddled with their thermostats till they clicked, before going to bed, (Question 3,i,(c) in the interview).

(2) WEEKEND ALTERATION OF THE THERMOSTAT

Subjects' responses to this question are presented in Column B of the two tables. The scoring in this column is as for Column A. It can be seen that only two people ever altered their thermostats at weekends.

(3) WINDOW OPENING AT WEEKENDS

Since so few ever altered their thermostats, the chance that window-opening would occur at weekends was high; that is, given that subjects were warm enough in the first place; and thermostat settings indicate that they probably were (Column L).

Subjects' responses to the question are presented in Column C of both tables. In this case subjects who had to open their windows have been given a score of "0".

It can be seen that nine people found they were so hot at weekends that they had to open windows. Only one of the nine adjusted the thermostat at weekends.

(4) KNOWLEDGE OF STORAGE TIMES

The relevant responses are presented in Column D. People who had a rough idea of the weekday storage times, and a knowledge of weekend availability have been given a score of "1". All others have been given "0". It can be seen that 14 people, almost half the sample, are in the latter category. Many of these were unaware of the "full availability" at the

weekends although most had noticed it felt hotter then, without knowing the reason why. One person thought the heating worked continuously all week; another that it was on all day Sunday but not Saturday; and another believed that as electricity prices rose the times of availability at the weekends were shortened.

These beliefs, dreamed up to try to make sense of a complicated system where accurate information was lacking, probably just scratch the surface of myriad beliefs, many of which could result in suboptimal operation of the system.

Knowledge of heating-up times is not a prerequisite for adequate operation of the heating. But it is necessary for optimal operation. It can be seen that five of the nine people who opened windows had no knowledge of the heating-up times. These could easily be provided on the consumers' bills.

(5) THE USE OF A FIRE IN THE SAME ROOM AS UNDERFLOOR HEATING

The Y.E.B. booklet states that "The most economic way of using the system is to set the thermostats"[,]"to a suitable background temperature"[,]"and then to 'top-up' with extra heat from an electric fire for the short periods when you are sitting down on an evening." (page 4). It then goes on to say that "If you are having to use an electric fire more frequently, then the thermostat setting may be a little too low." It does not state that too much use of a fire can actually prevent storage of heat.

In view of the incompleteness of the above advice it was surprising that only five people were found to use fires in the same room as the heating. The relevant responses are presented in Column E. Those who used fires have scored "0". None of the five had any idea that the use of a fire could affect the heating.

Table 6 : 11 below summarizes the responses in Column F and presents the number of people who used particular numbers of optimal strategies while operating their underfloor heating.

<u>No. of people</u>	<u>No. of optimal strategies they used</u>
2	0
4	1
11	2
11	3
1	4
1	5

Table 6 : 11. THE NUMBER OF PEOPLE USING PARTICULAR NUMBERS OF OPTIMAL STRATEGIES IN THE OPERATION OF THEIR UNDERFLOOR HEATING

That there was considerable ignorance about the best way to operate underfloor heating is demonstrated by the fact that nobody used all five optimal strategies and two people used none at all.

It is likely that in every case money could have been saved through the use of more appropriate strategies.

CONCLUSIONS

Much ignorance was found in the sample about the optimal way to operate thermostats in homes with underfloor heating.

- (a) Only seven per cent of the sample ever altered their thermostats on weekdays.
- (b) Only (a different) seven per cent ever altered their thermostats before weekends when heat would be coming through continuously.
- (c) Thirty one per cent of the sample found that they were so hot at weekends that they had to open their windows.
- (d) Forty eight per cent of the sample were unaware of the storage times.
- (e) Seventeen per cent of the sample used a fire in the room where they used underfloor heating. None of this group of people was aware that the strategy could affect the operation of the underfloor heating.
- (f) That underfloor heating has control problems was corroborated indirectly by the fact that only ten per cent of the sample achieved the recommended consumption criterion (of 92 per cent at the off-peak rate).
- (g) The control problem cost money for it was found that people using the largest proportions of off-peak electricity had significantly smaller bills.
- (h) The control problem was probably responsible for twenty four per cent of the sample stating that they were not going to continue using underfloor heating, for it was found that people planning to change to another system of heating had significantly larger bills than those who were not planning a change.

RECOMMENDATIONS

- A Consumers with underfloor heating should be instructed that the control on the wall affects the amount of heat which is stored.
- B The control should be referred to as the storage control.
- C Consumers should be instructed to change the charge control according to weather conditions.
- D The charge control should be labelled like the ones on the Electricaire units, thus: "Set to weather conditions: mild, moderate, cold, very cold."
- E Irrelevant thermostat information should be omitted from the Y.E.B. booklet on underfloor heating.
- F Consumers should be informed of the times when their heating charges-up. This information could easily be provided on bills.
- G Consumers should be alerted to the fact that they may need to have their charge control set low at weekends, irrespective of weather conditions.
- H Consumers should be informed of the possible consequences of using a fire in conjunction with the underfloor heating.

CONCLUDING REMARKS

It was argued in the introduction that behaviour might more effectively be changed if it was first understood, that possibly people's intentions could be at variance with those of designers. Evidence for this has been found in abundance with the following being apt examples:

- (a) storage heaters switched off at night because electricity was considered dangerous;
- (b) failure to select "Night" on the "Day/Night" Economy 7 hot water control because hot water was never required during the night;
- (c) attention paid to inappropriate cues on thermostats.

That many subjects quickly adopted the 'correct' behaviours when provided with appropriate explanations is corroborating evidence for Bransford and McCarrel's (1977) suggestion that "Comprehension results only when the comprehender has sufficient cues".

The implications are that practical remedies have been suggested which, if implemented, would result in financial savings for individuals and energy conservation for posterity.

A theoretical basis for the present scheme of research is lacking. It is known now that people do have problems with their energy systems, but it is difficult to predict precisely what these will be, for they are multi-faceted, varying from linguistic comprehension of specialised words such as kilowatt hours to sociology and reasons for ventilation. It is likely that no one theory could explain concepts of such complexity, because we have no cognitive model of the consumer. For now it is enough if this research succeeds in awakening awareness to the importance of understanding consumers. Perhaps improved designs and instructions will result.

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THE SEMI-STRUCTURED INTERVIEW USED TO ASSESS KNOWLEDGE
OF THE RELATIVE RUNNING COSTS OF APPLIANCES

Would you like to take part in a survey about electricity? Are you the person in this house who is mainly responsible for making the energy-related decisions?

Show subject cards bearing the names of electrical appliances (excluding space heating, cooking, hot water and lighting).

- Q1. Which of these appliances do you own? They can all use up different amounts of electricity. Which one of them do you think uses up the most electricity in a year? Can you order all your appliances from the one which uses up the most electricity in a year to the one which uses the least?
- *Q2. (If subjects do not own spin drier, tumble drier or freezer give them these cards now). Where do you think these appliances would fit on your list if you were to buy them?
- Q3. (If a noisy appliance seems to have been overestimated)
How do you know that your noisy appliance uses up more electricity than your -----?
- Q4. (If colour television seems to have been overestimated)
How do you know that your colour television uses up more electricity than your -----?
- Q5. Do you like to have the television on in the daytime?
- Q6. Do you sometimes have the television on in the background even if you are not really watching it?
- Q7. For how many hours do you think your television is on each day?
- Q8. (Give subject card bearing the name 'cooking')
Where in the list will 'cooking' go do you think?
- Q9. Do you have a cooked breakfast?
- Q10. Do you generally cook your main meal for yourself, or do you quite often bring in something like fish and chips?
- Q11. Do you cook for yourself at the other time, or do you just have a sandwich?
- Q12. About how many times a week do you use your oven for cooking (meals and baking)?

*Responses to this question were not analysed.

- Q13. (Give subject card bearing the name 'lighting')
Where in the list will 'lighting' go do you think?
- Q14. How many lights do you generally have on in your living room in the evening?
- Q15. How often do you use your washing machine?
- Q16. For how many minutes in each hour do you think a fridge is actually running?
- Q17. (Give subject card bearing the name 'heating')
Where in the list will 'heating your home' go do you think (Electricaire and electric fires)?
- Q18. At the end of a year do you think you will have spent more on heating your home or on running all of the other appliances you have listed added together?
- Q19. (Give subject card bearing the name 'hot water')
Where about in the list will heating your water go do you think (including kettles for washing and washing-up)?
- Q19a. (If water appears to be misplaced)
Why do you think your water costs less in electricity than your -----?
- Q20. In the winter time, out of every pound you spend on electricity, how much of the pound goes on heating your home do you think (Electricaire and electric fires)?
- Q21. In the winter time, if you were feeling a bit cold, which would you be most likely to do
(a) turn up the central heating?
(b) put the electric fire on?
- Q22. In winter, at what time does your Electricaire start to blow out cold air?
- Q23. Do you put the electric fire on when the central heating goes cold?
- Q24. Do you prefer sitting by the fire to having your central heating on?
- Q25. Which windows do you open in winter?
- Q27. Do you think that opening windows makes much difference to your electricity bill?
- Q28. Do you heat your water up at night only or do you keep your immersion on all day and all night?
- Q29. (If yes to night time only for water)
Do you find that the water runs cold later in the day?

- Q30. About how many times a week do you use your day-time hot water switch?
- Q31. About how many times a week do you find you have to boil a kettle for things like washing and washing-up?
- Q32. Do you think it saves money to keep your immersion heater on all the time, so that the water stays hot, or to switch it off, let it cool down, and heat it up when you need it?
- Q33. Do you do anything to try to cut down on the amount of electricity you use?
- Q34. Your night time electricity is cheaper than your day time electricity, isn't it? How much cheaper is it do you think?
- Q35. If you discovered that you had no loft insulation would you try to get some do you think?
- Q36. How many people live in this house?

THE METHODS BY WHICH THE 'CORRECT' ANNUAL RUNNING
COSTS OF APPLIANCES WERE CALCULATED

To establish whether each subject's reported rankings were correct, some calculation had to be made of each subject's actual use of her appliances.

This section explains how from actual observations of wattage, and subjects' reported use, estimates were made of the correct cost of running appliances for different lengths of time and on different numbers of occasions.

All subjects were on the Economy 7 tariff, apart from Subject 14 who was on the Domestic White Meter. The way in which her data has been dealt with is explained on page 79 of the main text.

At the time the interviews took place full rate Economy 7 units cost 5p and off-peak ones 1.82p.

1. Spin driers The Electricity Council's booklet Home-Electric Information 1981 estimates that for a family, five weeks' washing can be spun for one unit at a cost of 52p per annum. This must be adjusted for pensioners. It was estimated that pensioners do about half an hour's spin drying a week. Since spin driers have a wattage rating of 300, the cost of running them has been estimated at 40p per annum.
2. Single tub washing machines (excluding the cost of water, since in most cases this was drawn from the tank and therefore heated at the economy rate. Washing machine heaters were not generally used). The wattage rating for the motor of a washing machine is roughly 300. On a normal washing day a machine runs for about an hour.

	<u>Estimated annual cost</u>
	(£)
A single tub used once a month	0.20
" " " " " a fortnight	0.40
" " " " " a week	0.80
A " " " " twice a week	1.60

3. Twin tubs (excluding the cost of water for the same reason as above).

The wattage rating for the motor of the washing machine is about 300, so the costs for washing are the same as for single tubs. The cost of spin driers has to be added. These tended to be used whenever spinning needed doing and not only when a large washing had been done so the running costs for spinners attached to twin tubs are roughly the same as for spinners by themselves.

	<u>Estimated annual cost</u>
	(£)
Twin tub, washer used once a fortnight, spinner frequently	0.80
" " " " " " week, " "	1.20
" " " " twice a week, " "	2.00

4. Vacuum cleaners The Electricity Council's booklet Home-Electric Information 1981 says that you can vacuum-clean for two hours for a unit of electricity. The wattage rating of most cleaners is around 500. If, as people indicated, they did not use their cleaners for more than an hour a week, this would have cost no more than £1.30 annually.

5. Irons The Home-Electric Information booklet says that you can do over two hours ironing for a unit of electricity. The wattage rating of the average iron is 1250, but since irons are thermostatically controlled, their

running costs are relatively small. The pensioners interviewed did not do more than one hour of ironing a week, so their ironing would have cost no more than £1.30 annually.

6. Lighting It was estimated that lighting would be in use for eight hours for six months of the year, for four hours for three months of the year and for two hours for three months of the year. Since everyone interviewed said they were extremely careful to switch lights out in rooms they were not using, the living room lighting alone has been used to estimate running costs. The eight hour lighting period allowed for winter calculations takes into account the fact that the kitchen light would probably be on for a period while the evening meal was being prepared. Where two lights were alternated between, the mean wattage has been used. Where two lights were in use the combined wattage has been used. The following shows how the calculations were made for a person with a 60 watt bulb in their living room.

	<u>Annual Cost</u>
	(£)
60 w for 8 hrs for 6 months	4.36
60 w for 4 hrs for 3 months	1.09
60 w for 2 hrs for 3 months	<u>0.54</u>
	<u>5.99</u>
Total per annum	≈ £6.00

	<u>Approx. Annual Cost</u>
	(£)
Bulbs totalling 70 w in living room	7.00
100 w bulb in living room	10.00
Bulbs totalling 120 w in living room	12.00
150 w bulb in living room	15.00

7. Black and white televisions The Electricity Council states that nine hours viewing uses one unit of electricity. So viewing for one hour costs 0.5555p. The wattage ratings of black and white televisions vary greatly, but an average figure has been selected by the Electricity Council.

	<u>Annual Cost</u>
	(£)
View ½ hr. a day	1.01
" 1 " " "	2.02
" 2 hrs " "	4.05
" 3 " " "	6.08
" 3½ " " "	7.09
" 4 " " "	8.11
" 4½ " " "	9.12
" 5 " " "	10.13
" 5½ " " "	11.14
" 6 " " "	12.16
" 7 " " "	14.19
" 8 " " "	16.22
" 8½ " " "	17.23
" 9 " " "	18.24
" 9½ " " "	19.25
" 10 " " "	20.27
" 11 " " "	22.30
" 12 " " "	24.33
" 13 " " "	26.36
" 14 " " "	28.38

8. Colour televisions The Electricity Council says that six hours viewing uses a unit of electricity so viewing for one hour costs 0.83333p. The wattage ratings of colour televisions vary greatly. The average wattage was selected by the Electricity Council.

	<u>Annual Cost</u>
	(£)
View ½ hr. a day	1.52
" 1 " " "	3.04
" 2 hrs a day	6.08
" 3 " " "	9.12
" 3½ " " "	10.64
" 4 " " "	12.16
" 4½ " " "	13.68
" 5 " " "	15.20
" 6 " " "	18.24
" 7 " " "	21.29
" 8 " " "	24.33
" 9 " " "	27.37
" 10 " " "	30.41

9. Fridges The Electricity Council says that a small 4 cubic ft. fridge can run for a day on a unit of electricity. It has been assumed that pensioners have small fridges. The wattage rating of a fridge is about 100, but since they are thermostatically controlled they use less electricity than a 100w light bulb, burning continuously.

The calculations for the annual running cost of a fridge (apart from Subject 14 who was on the Domestic White Meter) take into account the fact that for seven hours of the day the units were at the Economy 7 rate.

For a fridge of this size running on daytime units only as in Subject 14's case the annual running costs are approximately £18.25. Taking into account the cheaper off-peak units, the annual running costs have been estimated at £15.

10. Fridge-freezers The Consumers' Association (1978) says that a fridge-freezer consumes 647 kWh per year. Taking into account that 7/24 of this was at the Economy 7 rate, the annual cost of running a fridge-freezer has been estimated at £26.34.

11. Water A representative from the Architect's Department in the Hull City Council provided the following information. The hot water tanks in the bungalows are all 25 gallon tanks. Each tank is provided with one 3 kW element at the bottom of the tank. The system where a day-time element is placed near the top of the tank is not used in these bungalows.

A representative from the Y.E.B. provided the information that it takes two and a half hours to heat the 25 gallons in the tank and to heat the entire tank at the economy rate, assuming that the water had run cold the previous day uses 7.5 units daily, with an annual cost of £50.00*. No allowance was made for standing losses since the tanks in the bungalows are exceedingly well lagged, in fact, insulated by the manufacturers.

For those people who occasionally used their day-time hot water switches the calculation is based on the day-time unit charge and the length of time for which the switch was 'on'; (no one operating their day-time switch occasionally left it on for more than two and a half hours).

Subject 2 was the only subject who kept her immersion heater on all the time, day and night. Her annual water costs are based on the full-rate, because her water use was in the day time, and following use it would have

*At a later date the units used over one night to heat a water tank from cold were recorded empirically. Eight units were used. To do this every night for a year costs £53.14 - a very similar amount to that estimated above.

reheated immediately at the day-time rate. She therefore gained no benefit from Economy 7 for her hot water. It has been assumed that she used a tankful a day. (7.5 units at the day-time rate.)

	<u>Annual Cost</u>
	(£)
Water heated all night, every night	50.00
" " 1½ hrs " "	29.89
" " 2 times a week at night	14.19
" " 3 " " " " "	21.28
" " in the day once a week, ½ hr	3.90
" " " " " " " 1 hr	7.80
" " " " " twice " " ½ hr	7.80
" " " " " 3 times a week, ½ hr	11.70
" " " " " " " " 1 hr	23.40
" " " " " once a fortnight, 1 hr	4.00
" " " " " all day and all night	137.00

The cost of boiling kettles for washing or washing-up assumes that people completely filled an average capacity (1.7 litres) electric kettle. Since to boil 0.56 litres (1 pint) in a kettle uses 0.16 units (Electricity Council, 1977), then to boil an average kettle uses 0.48 units, and these are all at the day-time rate.

	<u>Estimated Annual Cost</u>
	(£)
To boil 1 kettle a week	1.25
" " 2 kettles " "	2.50
" " 4 " " "	5.00
" " 2 " daily	17.50
" " 3 " "	26.28
" " 4 " "	35.00
" " 5 " "	43.80

12. Cooking (including kettles for tea and other hot drinks).

It has been assumed that seven kettles daily are boiled for cups of tea or other hot drinks, each kettle containing a pint of water. Since to boil a pint of water in a kettle uses 0.16 units, then kettles for one week use 7.84 units, and the annual cost for kettles for drinks is £20.38.

All the ladies interviewed cooked a full meal once a day. The cost of cooking boiled eggs for breakfast, as reported by two ladies, has been ignored. Some people reported occasionally doing a small amount of cooking for their tea, e.g. poached egg on toast, again this has been ignored. Most people reported eating a sandwich, or something cold, for their tea.

If ladies said they never used their ovens, then the cost of cooking their main meals has been calculated in terms of the cost of cooking those meals on the cooker rings. Examples of the units used to cook meals on rings are provided by the Electricity Council (1977). It is estimated here that the ladies might have eaten the equivalent of stew, boiled potatoes and peas (1.72 units) twice a week, the equivalent of lamb casserole, boiled potatoes and peas (1.36 units) twice a week, and the equivalent of fried sausages, boiled potatoes and peas, once a week (1.07 units). Meals cooked on the rings all week would use 7.23 units. If one ring meal was eaten each week the units used would therefore have been one seventh of 7.23 units.

	<u>Annual Cost</u>
	(£)
1 ring meal each week,	2.69
2 " meals " "	5.37
3 " " " "	8.06
4 " " " "	10.74
5 " " " "	13.43
6 " " " "	16.11
7 " " " "	18.80

If ladies reported using their oven once a week it has been assumed that this was for Sunday lunch. The Electricity Council (1980) has estimated that a Sunday lunch for four uses 2.56 units. This same figure has been used for the pensioners since the time the oven is actually on will not vary very much whether the cooking is for four or two. The annual cost of Sunday lunches is £6.66.

If ladies reported using their ovens twice a week, it has been assumed that the second time was for baking. The Electricity Council (1977) estimates that to cook 24 small buns uses 0.90 units. The annual cost of baking once a week is £2.34.

If ladies reported using their ovens more than twice a week, it has been assumed that the additional times were for cooking meals using the oven.

The costs of cooking a meal, using the oven has been based on the Electricity Council (1977) estimate that to cook chops in the oven uses 1.27 units. The cost of cooking carrots and peas together on a ring (0.53 units) and cooking potatoes on a ring (0.49 units) has been added.

<u>Oven meals</u>	<u>Units</u>	<u>Annual cost</u> (£)
1 oven meal per week	2.29	5.95
2 " meals " "	4.58	11.91
3 " " " "	6.87	17.86
4 " " " "	9.16	23.82
5 " " " "	11.45	29.77
6 " " " "	13.74	35.72
7 " " " "	16.03	41.68

This is how the annual cooking costs for Subject 4 were calculated. She reported using her oven three times a week, and she cooked one main meal a day.

	<u>Annual Cost</u> (£)
Kettles are always estimated as	20.38
Weekly Sunday lunches	6.66
1 baking each week	2.34
1 oven meal each week	5.95
5 ring meals each week	<u>13.43</u>
Total	48.76

Subject 7 reported never using her main oven at all. She owned a multi-purpose cooker, and always used this for oven-type meals. The Electricity Council (1980) states that cooking lamb casserole in a multi-purpose cooker uses about the same amount of electricity as if it was cooked on a boiling ring. For this reason the costs of Subject 7's cooking assume she cooked all her meals on the boiling rings.

13. Space heating The Electricity Council (1977) states that Electricaire consumption can vary, but the average yearly consumption is approximately 1700 units for every kilowatt of the calculated heat requirement. A 5 kW requirement, for example, will result in a consumption of approximately 8,500 units in a well insulated house, during a 32 week heating season.

The Architect's Department provided the information that the Electricaire systems in the bungalows were called AB8/54. This means that they were 8 kW systems and could store 54 kW of heat on the maximum setting.

A representative of Creda, the manufacturers of Electricaire, supplied the information that on a mild setting the AB8/54 would take approximately 40% of its full charge.

Assuming that out of a 32 week heating season, 10 weeks were on the maximum charge, using all 8 kW, and 22 weeks were on the mild charge, using about 3.2 kW (this averages out to the 5 kW requirement figure used by the Electricity Council), then the cost of heating the home is £155 and by far the most expensive item on the electricity bill. (The cost is based on the Economy 7 low-rate tariff and excludes any possible use of day-boost switches or electric fires).

It was because space heating was by far the most expensive appliance that no attempt was made to calculate each individual's 'correct' heating costs. Heating was just accepted as being the most expensive appliance.

Questions 22 and 23 in the interview were asked to establish whether householders actually used their Electricaire system.

Table A.: 1. THE 'CORRECT' RUNNING COSTS OF APPLIANCES (costs calculated according to method on page 77 of the main text and pages A4 to A14 in the Appendix)

A15

S	(£)												Total annual electricity cost (£)	
	Heating	Water	Cooking	Fridge Freezer	Fridge	Colour T.V.	B & W T.V.	Twin Tub	Single Tub	Lighting	Vacuum	Iron		Spin drier
1	155.00	32.40	39.18		15.00	12.00			0.80	6.00	1.30	1.30	0.40	263.38
2		137.00	52.03		15.00	12.00		1.20		10.00	1.30	1.30		384.83
3		89.00	40.35		15.00		12.16		0.40	10.00	1.30	1.30	0.40	324.91
4		95.59	48.76	26.34		6.00		2.00		12.00	1.30	1.30		348.29
5		52.50	52.03				28.38	1.20		15.00	1.30	1.30		306.71
6		50.00	48.76	26.34		21.00		1.20		6.00	1.30	1.30		310.90
7		50.00	39.18	26.34			20.27	2.00		10.00	1.30	1.30		305.39
8		50.00	45.49		15.00		9.12	1.20		6.00	1.30	1.30		284.41
9		50.00	55.30		15.00	12.00			0.40	10.00	1.30	1.30	0.40	300.70
11		40.47	45.49				17.23			7.00	1.30	1.30	0.40	268.19
12		40.47	61.84	26.34			7.09		1.60	4.00	1.30	1.30	0.40	299.34
13		53.90	39.18		15.00	30.00			0.40	10.00	1.30	1.30	0.40	306.48
14		50.00	55.30		18.25		10.13	1.20		20.00	1.30	1.30		312.48
16		50.00	61.84		15.00		8.11			7.00	1.30	1.30	0.40	299.95
17		55.00	45.49	26.34		15.00		1.20		20.00	1.30	1.30		320.63
19		73.40	43.15				18.24			8.00		1.30	0.40	299.49
20		55.19	58.57	26.34		18.00		1.20		8.00	1.30	1.30		324.90
22		50.00	45.49		15.00	30.00				16.00	1.30	1.30		314.09
23		50.00	45.49	26.34		15.00	* 0.28			15.00	1.30	1.30	0.40	310.11
25		50.00	43.15		15.00	16.50		1.20		14.00	1.30	1.30		297.45
26		50.00	61.84	26.34		19.50		1.20		15.00	1.30	1.30		331.48
27		51.25	58.57	26.34		15.00			0.40	30.00	1.30	1.30	0.40	339.56
28		38.78	39.18		15.00		9.12			6.00	1.30	1.30		265.68
29		50.00	52.03		15.00	18.00				15.00	1.30	1.30		307.63
30	↓	50.00	61.84		15.00		10.13		0.20	6.00	1.30	1.30	0.40	301.17
Median	155.00	50.00	48.76	26.34	15.00	15.75	10.13	1.20	0.40	10.00	1.30	1.30	0.40	306.71

* indicates the cost of a 'second' T.V. set which was watched infrequently. It is included in the subject's total electricity cost, but excluded from the median figure for B & W T.Vs.



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Electricity Consumption Survey

To: The Manager,
Hull Area,
Yorkshire Electricity Board,
Ferensway,
Hull, HU1 3UL.

I, _____ (Name, capitals)

of _____ (Address, capitals)

am willing to let the records of my household's
electricity consumption be made available to Hull
University for research purposes.

I understand the aims of the survey, and that all
information will be treated as confidential.

_____ (Signed)

_____ (Date)

Illustration A : 1. An example of the form granting permission
for consumption data to be supplied by the Y.E.B.

PILOT ELECTRICITY BILL QUESTIONS

Are you the person in the house who is responsible for looking at and paying for the bills?

1. Do you know if you have cheaper electricity at night?
2. Do you know when the cheap time starts and finishes?
3. Do you know what the Electricity Board calls your system of cheaper night-time electricity?
4. Can you tell from the bill how much each night-time unit of electricity costs?
5. How much is a full price day-time unit of electricity?
6. How many units did this person use in the day-time?
7. How many units has this person used during the cheap time at night?
8. Which is the cheapest, ten units of night-time electricity or ten units of day-time electricity?

THE ELECTRICITY BILL QUESTIONS USED IN THE MAIN STUDY

Are you the person in the house who is responsible for looking at, and paying for the bills?

1. Show subject the bill like Mrs. M.'s with a small number of off-peak units.

If this were your bill would there be any way that you could save money but still keep warm?

2. Show subject the bill like Mrs. McC.'s with zero off-peak units.

If this were your bill, would you know what was going wrong?

3. Do you have cheap electricity at night?

4. Can you tell from the bill, how much the full price and cheap units of electricity cost?

Other details.

Number in household.

THE FORM OF THE SEMI-STRUCTURED PILOT INTERVIEW ON
UNDERSTANDING THERMOSTATS IN GAS CENTRALLY-HEATED HOUSES

Are you the person in the household responsible for using the central heating?

1. Name
2. Address
3. Have you lived here for a year?
4. Have you ever used your central heating?
5. Is it on at the moment?
6. Are you planning to use it this winter?
7. (If not) What will you use then?
8. What is the name of your system?
9. How many are there in your family?
10. Do you use a gas cooker?
11. Have you got any other gas appliances?
12. Do you use all your radiators?
13. Are you satisfied with your central heating?
14. What is your wall-thermostat set to?
15. Actual setting.
16. Do you ever alter it?
17. Have you got a control knob on your gas fire/boiler?
18. What have you got it set to?
19. Actual setting.
20. Do you ever alter it?
21. What does altering it do?
22. Have you got a thermostat on your hot water cylinder?
23. What is it set to?
24. Actual setting.
25. Do you ever alter it?

26. How did you find out how to work your central heating?
- (a) leaflet (b) person from the gasboard (c) person from council (d) friend/relative (e) trial and error (f) still don't know.
27. (If (a) (b) (c) or (d)), What were you told to do by these instructions/people?

Boiler-'stat ____; Wall-'stat ____: Cylinder-'stat ____.

26. How did you find out how to your central heating?
(a) leaflet (b) person from the gasboard (c) person
from the council (d) friend/relative (e) trial and error
(f) still don't know.

27. (If (a) (b) (c) (d)) What were you told to do by these
instructions/people?

Boiler-'stat ____; Wall-'stat ____; Cylinder-'stat ____.

28. Central heating before?

THE PILOT INTERVIEW FOR THE INVESTIGATION INTO HOUSEHOLDER
UNDERSTANDING OF THERMOSTATS IN HOMES
WITH ELECTRIC UNDERFLOOR HEATING

1. Name.
2. Address.
3. Do you use the underfloor heating?
4. Open or closed plan house.
5. Number of bedrooms.
6. Number of people in house.
7. What are your thermostats set to?
 Kitchen _____; Living-room _____; Hall _____.
8. Do you ever alter your thermostats?

THE MAIN INTERVIEW FOR THE INVESTIGATION INTO HOUSEHOLDERUNDERSTANDING OF THERMOSTATS IN HOMESWITH ELECTRIC UNDERFLOOR HEATING

- A Are you the person in the house responsible for operating the underfloor heating?
- B Have you lived here for at least a year?
- C How many people live in this house?
- D Is there someone at home most of the time?
- E Open or closed plan house?
1. What are your thermostats set to?
Kitchen _____; Living-room _____; Hall _____.
2. Do you ever alter your thermostats?
- 3(i) (If 'yes' to Q2) Why?
- (a) to cool the room quickly
 - (b) to heat the room quickly
 - (c) because you are going to bed
 - (d) weekends
 - (e) other reasons.
- 3(ii) Are you ever so hot at the weekends you open windows?
4. Do you know the times when your heating is actually warming up?
5. Do you ever use a fire of any sort during the times when your heating is off?
6. (If 'yes' to Q5) Have you noticed whether using a fire makes any difference to your underfloor heating?
7. (If 'yes' to Q6) What is the cause of it do you think?
8. (Additional Question asked on a subsequent occasion) Are you planning to use the underfloor heating this winter?