THE HOUSEHOLDER AS ENERGY MANAGER: A SURVEY OF USER ATTITUDES IN LOW ENERGY HOUSING

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Introduction

The study aims to evaluate the response of householders in controlling and regulating energy use in 50 low energy houses built to passive solar design principles.

Predicted energy consumption for space heating is compared with actual fuel consumption as measured by regular meter readings of electricity and gas consumption. Interviews with all householders are analysed to identify householders' general perception of the thermal comfort and costs of heating, and to examine the behaviour of householders as energy managers.

Background

The 50 houses examined are part of the Solar Village (1) in Birmingham, UK, pioneered by The Bournville Village Trust and supported by the Commission of the European Communities. The Solar Village consists of a variety of housing provision targeted at different sections of the housing market. The buildings incorporate solar principles in the design to varying degrees. The 50 homes are all in the same location and were selected for this study from 90 similar buildings under continuous monitoring survey.

House description

The houses reported here are identical semi-detached buildings constructed in 1984. They were aimed at the first time buyer and sold under a shared ownerhip scheme, so are of a basic and uncomplicated design. The floor area is 80 m^2. There are three bedrooms and a bathroom upstairs; downstairs the kitchen is located to the north and a main room to the south.

The walls are built of 100 mm brick on the outside, 100 mm cavity filled with polystyrene granule insulating material and 100 mm high density concrete blocks on the inside to ensure heat retention.

There is 150 mm of roof insulation.

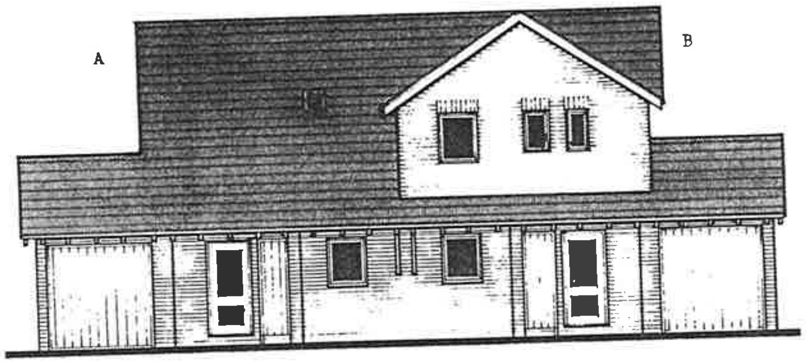

Fig. 1 North elevation: House B is the type discussed in this study

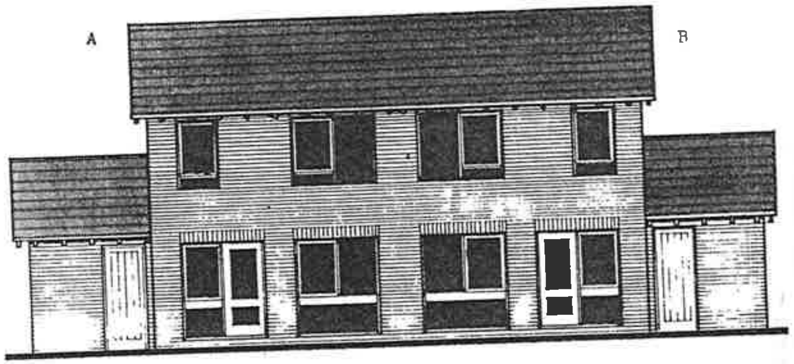

Fig. 2 South elevation: House B is the type discussed in this study

All windows in the houses are double glazed. The houses are all oriented north / south, with some variation to prevent monotony. The south side of the buildings have large windows: a total of 7.3 m^2 in each ground floor living room. The north windows are small: the downstairs kitchen window area is 0.7 m^2. All windows are fitted with roller blinds of a thermal insulating fabric which is reflective towards the outside.

To eliminate condensation the houses have trickle ventilators and humididty controlled fans in the kitchen and bathroom.

Space heating is by a programmable gas fired wet system. Water heating is also by gas with electric immersion heaters additionally provided.

Annual energy consumption for space heating: simulated and actual

The annual energy consumption for heating one of the houses described was predicted by using a TRNSYS simulation (2). The simulation was run for three different timer settings, with an assumed temperature requirement of 20°C during the day. Figure 3 illustrates the simulated monthly distribution of energy consumption for the three timer settings.

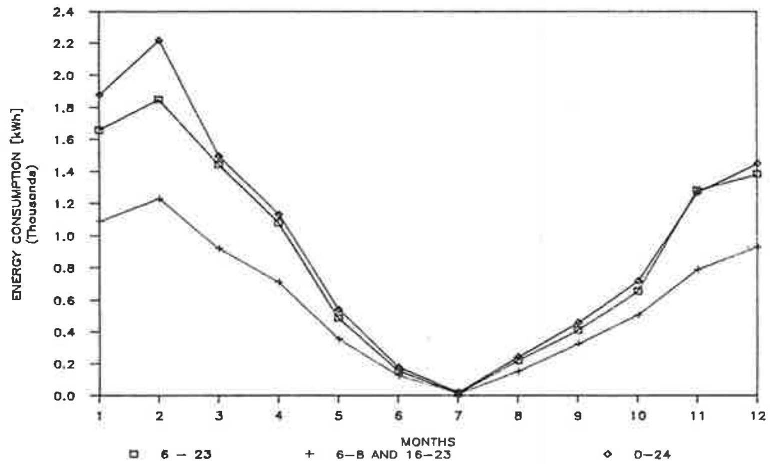

Fig. 3 Simulated monthly energy consumption for space heating

The actual energy consumption of all the houses was measured from February 1986 to January 1987 by four-weekly readings of electricity and gas meters. From these data average annual and four-weekly energy use were calculated for both electricity and gas consumption. Average four-weekly consumption of gas and electricity is illustrated in Figure 4.

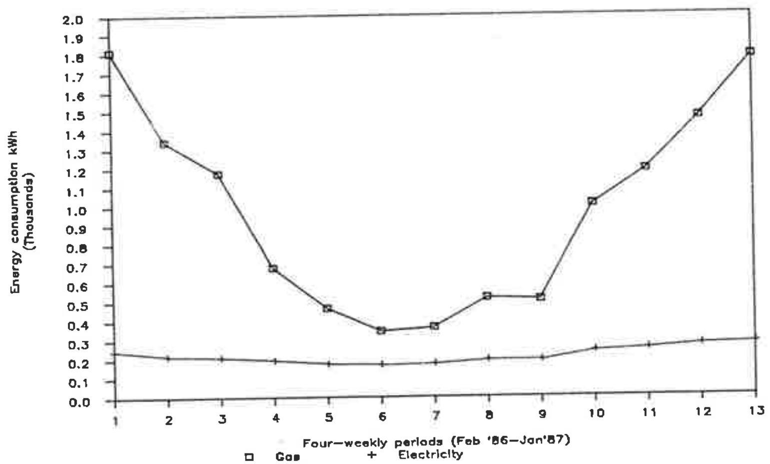

Fig. 4 Actual four-weekly consumption of gas and electricity (8 February '86 - 8 February '87)

Table 1 shows the actual average annual gas and electricity consumption and compares the actual energy consumption for space heating with the TRNSYS simulation results for three assumed timer settings. The division of gas consumption between space and water heating is based on figures provided by the Department of Energy (3) for a similar house.

It can be seen from Table 1. that actual consumption falls between predicted consumption for timer use 1. and 2. but is in fact much closer to the prediction for timer use 2.

ENERGY		kWh
Recorded Electricity		2778
Recorded Gas water heating		6107
Recorded Gas space heating		6892
Simulated Gas space heating, timer use	1. 0600-0800, 1600-2300	4921
	2. 0600-2300	7329
	3. 0000-2400	8174

Table 1 Recorded and simulated annual energy consumption

User response: interviews with householders

To assist in evaluating the results from the measured energy consumption householders in all 50 houses were individually interviewed in their own homes using a standard questionnaire. The purpose of this was to gain subjective opinions on design successes and problems and to investigate the awareness of householders in the energy management of their homes.

Householders' responses to a selection of questions are summarised in Table 2. These responses, together with general opinions recorded informally, are discussed below.

House heating

Householders were in general pleased with the energy efficiency of their homes and the implications for comfort and heating costs. Almost everyone said that their heating costs were lower than in their previous house and felt that in comparison with other houses their heating costs were below average for the size of their house.

Despite this fact, 50% of interviewees could not say that their house was always warm enough in winter. This was because of the frequent experience that one of the south facing rooms was cooler than the rest of the house. In some cases householders used an additional electric or portable gas fire in their main living room.

There was a division of opinion and experience about overheating in summer which the results do not reflect. Many householders felt that if the blinds and windows were properly used, over-heating did not occur. Some experienced overheating in south facing rooms in spite of their attempts to reduce it. Others did not wish to use the blinds to reduce overheating at the expense of losing sunlight.

Design

In general householders were happy with the design of their homes, and were particularly happy with their light south-facing living room. In spite of the size of the south windows, few people expressed concern about privacy. Where it had been a problem it was usually felt to be adequately solved by using plants or shelves as a screen or by hanging net curtains.

Most people were, however, dissatisfied with the natural lighting in the north facing rooms, particularly in the kitchen. Some claimed to use an electric light all day in the kitchen. The combination of the small window with the excessive roof-overhang was felt to intensify the problem.

Component problems

The main problems experienced with components were with the double-glazing units, cavity wall insualtion and thermal blinds.

Almost everyone had experienced problems with one or more of their double-glazing units. Within two years the seals of a large proportion

QUESTIONS ASKED DURING PERSONAL INTERVIEWS AND THE THREE CHOICES OF ANSWERS	ANSWERS (percentages)		
	A	B	C
House heating			
1 Heating costs: comparison with previous house A. Higher B. Similar C. Lower	5	0	95
2 Heating costs: perceived comparison with similarly sized houses A. Above average B. Similar C. Below average	0	10	90
3 Warmth of house in winter: warm enough A. Always B. Usually C. Not usually	46	42	12
4 Overheating in hot weather A. Often B. Sometimes C. Never	4	56	40
Design			
5 North facing windows: natural lighting provided A. Above average B. Adequate C. Less than adequate	4	22	74
6 South facing windows: privacy problems experienced A. Always B. Sometimes C. Never	6	26	68
7 Net curtains on south-facing windows are drawn A. Always B. Sometimes C. Never	28	4	68
Component problems			
8 Double glazing: condensation between panes A. None B. Some C. A lot	6	38	56
9 Cavity wall insulation: leakage of granules A. None B. Some C. A lot	30	54	16
10 Thermal blinds operate with A. No problems B. Some problems C. Many problems	38	50	12
11 Roof insulation presents A. No problems B. Some problems C. Many problems	94	6	0
12 Humidity controlled fan A. No problems B. Some problems C. Many problems	76	22	2
Energy management			
13 Use of central heating controls A. Timer & thermostat B. On/off & thermostat	84	16	
14 Usual weekday timer setting (in heating season) A. 24 hours B. All day C. Morning & evening	5	12	83
15 Usual weekend timer setting A. 24 hours B. All day C. Morning & evening	7	52	41
16 Experience of humidity controlled fan A. Very effective B. Reasonably effective C. Not effective	39	55	6
17 Perceived effect of net curtains on heat gain A. Improves B. Has no effect C. Reduces	6	52	42
18 Use of thermal blinds at night A. Usually all B. Usually some C. Never	57	43	0

Table 2: Summary of householders' experiences, opinions and behaviour

of the units had broken resulting in clouding from condensation. Replacement of faulty units had been arranged with the manufacturers.

Leakage of cavity wall insulation caused concern because of the annoyance of coping with the polystyrene beads and because of the implications for the reduced insulation level of the house resulting from the loss.

A variety of problems were reported for the thermal blinds including sticking, shooting up suddenly, staining and coming apart.

Energy management

The control of central heating was managed in a greater variety of ways than was anticipated, although the largest proportion of people used a morning and evening timer setting. Some preferred to use only the thermostat and an on/off switch, although only one couple admitted that this was because they did not know how to use the timer.

It became apparent after several interviews that some householders did not know how to operate the humidity controlled fans. Some were not aware of the humidostat control and were mystified by the seemingly erratic operation of the fan in response to the on/off switch. The location of the humidostat control near the ceiling was one reason for this.

The thermal blinds seemed to be well used and appreciated. Everyone claimed to use at least some of the thermal blinds at night, and a surprising number said they usually pulled down all the blinds in the house.

More than half of those interviewed did not realise that the use of net curtains on a window affects the heat gain of the house from the sun This knowledge would undoubtedly be useful in enabling householders to make use of solar radiation in the winter coolness and reduce summer over-heating in south-facing rooms.

Discussion of measured results and user response

Comparison of measured space heating energy consumption with simulations showed that measured annual consumption lay between the simulations for central heating in the morning and evening {1} and central heating on all day {2}.

From the interviews with householders reported below it was found that of the 86% who used the timer setting, 83% used setting {1} during the week, and 34% used it at weekends. It can be concluded from this that the actual energy consumption was somewhat higher than predicted. In general the thermal performance of the houses was nevertheless close to expectations. (4)

The interviews with householders help to reinforce and explain this result. Householders were on the whole pleased with their comfortable houses and reduced fuel costs but had some reservations about certain aspects of the buildings. It was clear that the thermal perfomance of the buildings would deviate from predictions because of irregularities in construction and energy management. Lowered insulation levels because of leakage and less than optimal energy control strategies explain a thermal performance which is slightly less than predicted.

Conclusions

The study highlights lessons to be learnt by architects, builders and householders.

Architects should beware of sacrificing natural light to reduce heat loss in northern windows. Solutions may include triple glazing or clerestory windows between rooms.

Good design is not the only criteria in producing a house which will run at optimum energy efficiency. It is vital that the components of the house are reliable and that their installation is properly executed.

A good communication between designer and user will ensure that the function of all the design elements and components will be appreceiated and used appropriately. This may involve simple explanations of how components work: this should ideally be verbal as well as written and should be flexible to accomodate various levels of understanding.

Investment in low energy housing should ideally be parallelled by investment in energy-use education of the occupants of those houses. Increased awareness of concepts behind heat loss and gain may help occupants to increase their comfort and control their houses in a way which optimises their thermal efficiency.

Acknowledgement

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