Energy Projects in Milton Keynes: Energy Consultative Unit Progress Report 1976-1981

Other

ENERGY PROJECTS
IN MILTON KEYNES

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ENERGY CONSULTATIVE UNIT
PROGRESS REPORT 1976-1981

MILTON KEYNES DEVELOPMENT CORPORATION

1982

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1 INTRODUCTION

This report describes the work done on energy related projects in the new city of Milton Keynes over the period 1976-1981.

Milton Keynes is the largest of the twenty-eight UK new towns which have been planned as population and employment growth centres. The new city was designated in 1967 as a centre of urban growth and is now in the middle phase of its development. It is expected that eventually the population will be about 200,000.

The development programme provides real opportunities to examine how and to what degree long term energy problems can be either overcome or alleviated through new approaches to energy saving. This is particularly important in the UK at the present time because unless energy is conserved, there may well be a shortfall by the year 2000.

In view of this, in 1976 Milton Keynes Development Corporation, the government agency responsible for planning and developing the new city, established an Energy Consultative Unit. Working with members of the Development Corporation, the Unit draws on the research expertise of the Energy Research Group of the Open University (OU), the university located in Milton Keynes, and other research organisations, especially the Built Environment Research Group at the Polytechnic of Central London (PCL).

The Unit provides day to day advice on energy issues, investigating the effects of increasing fuel shortage on the development of Milton Keynes and reviewing current energy research to see what innovations are appropriate. It also undertakes its own research and develops projects which show the greatest opportunities for cost effective energy saving in the new city. The particular projects chosen for research and development are those which have a practical application and can be readily implemented, and where the experience gained can be continuously used as the city grows. In doing this it promotes experimental energy research projects, the results of which can be used throughout the UK.

In addition to its own research and development work, the Unit keeps in contact with research going on in the UK and with people who are working on their own energy projects in Milton Keynes. Also, increasingly, it uses the work that has been done to interest residents, encouraging them to be concerned with energy issues.

The Unit's first progress report was produced in 1976 and described eight projects, all of which are now completed or under way. Since the total fuel bill of Milton Keynes probably exceeds £10 million per annum, even a small percentage reduction would make significant savings. Already, the practical result of the eight projects is that there are likely to be fuel bill savings amounting to £150,000 per annum. If the lessons learnt in Milton Keynes can be shared, the potential of the projects nationally is considerable; if particular innovations were adopted throughout the UK there could well be energy savings amounting to many millions of tons of coal equivalent of fuel per annum.

Funding for the projects has come from the following organisations:

Milton Keynes Development Corporation

Energy Technology Support Unit, Department of Energy

Housing Development Directorate, Department of the Environment

Solid Fuel Advisory Service, National Coal Board

Energy Research Programme, European Economic Community

Southern Region, British Gas

Their support, and that of private housing developers and contractors involved in the building projects, has been greatly appreciated.

This second report describes the work that has been done since 1976. After a short explanation of how energy is used in the UK, the report introduces the Energy Consultative Unit projects and summarises the main conclusions drawn from the Unit's work. It then describes the projects on which the Unit has worked and summarises other energy projects under way in the new city. It does not go into the projects in detail, but there are a number of technical reports available for people who want to study them in more depth, and these are listed in the back of the report. The projects represent the work of a considerable number of people and a list of acknowledgements, indicating who should be contacted for further information, is also set out at the back of the report.

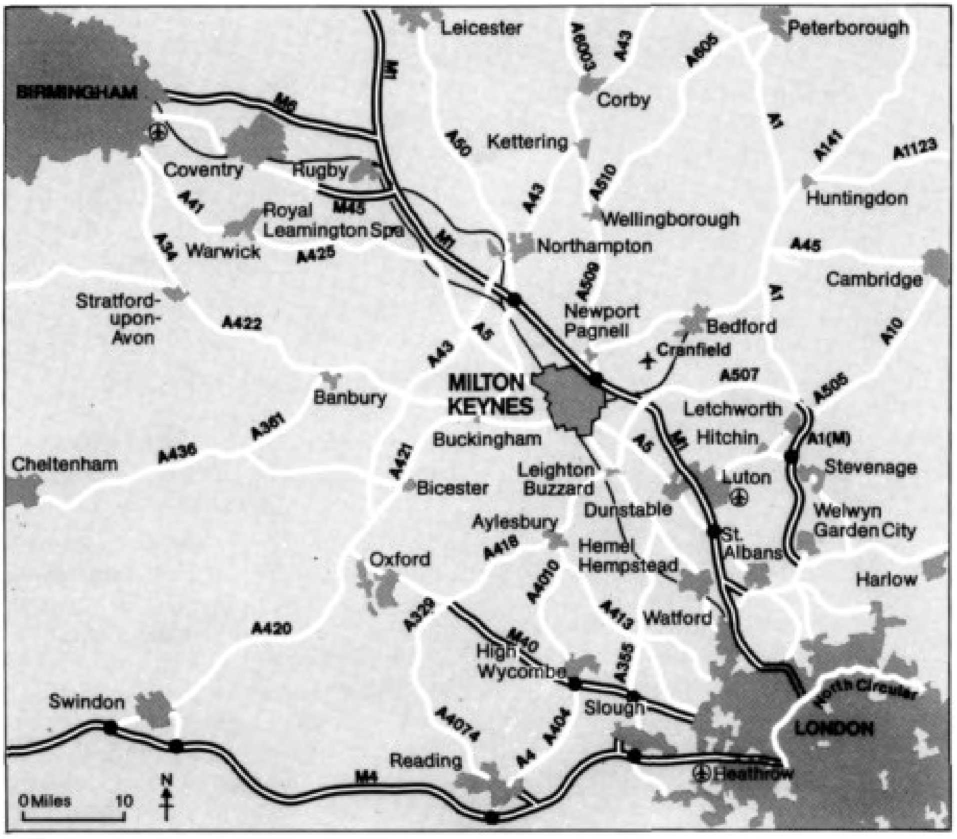


Fig. 1 Location of Milton Keynes

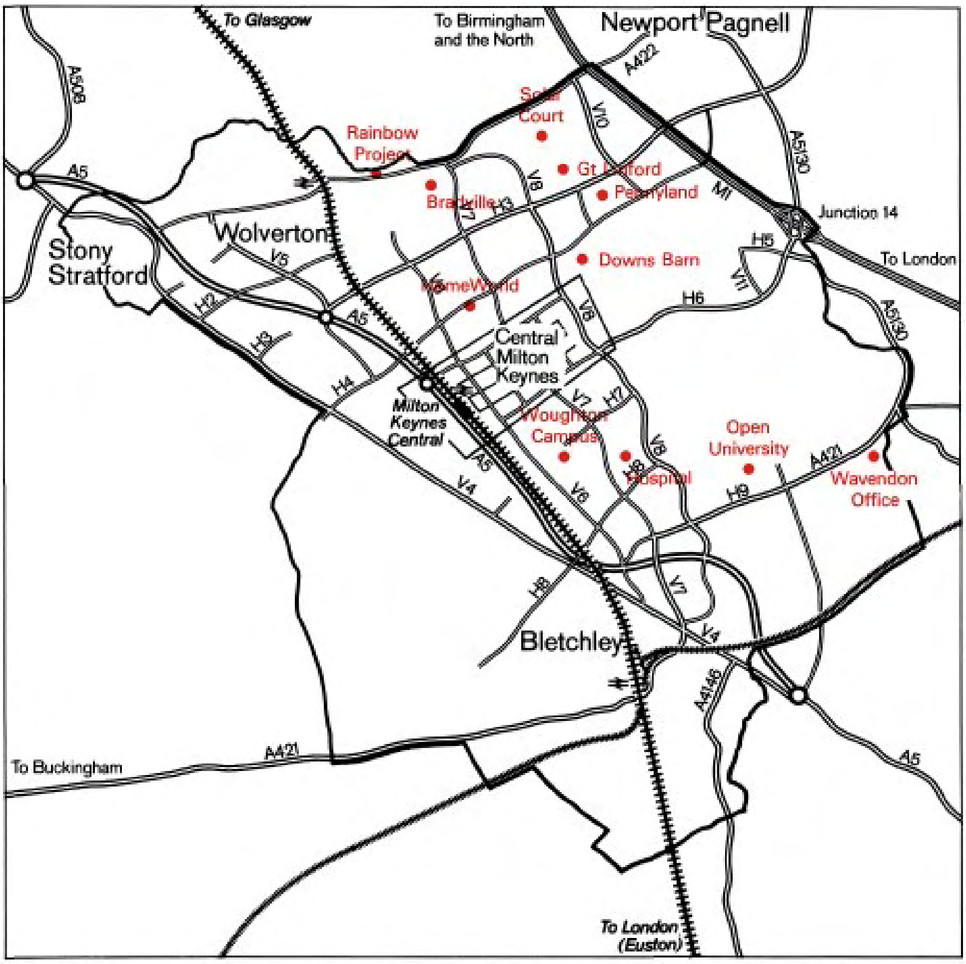
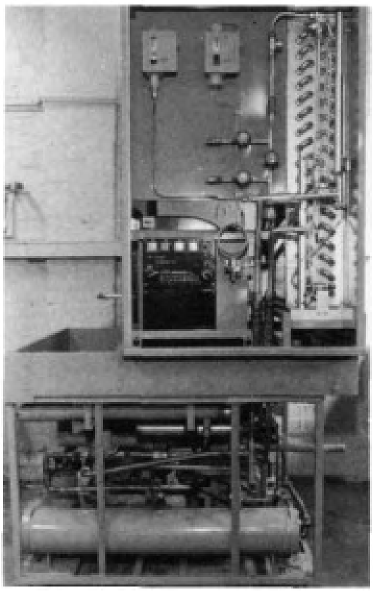


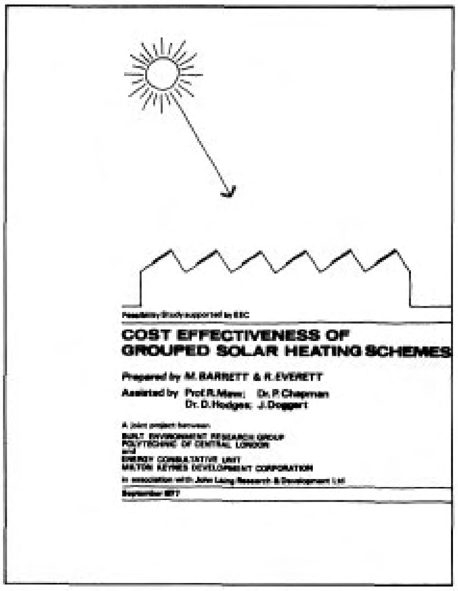
Fig. 2 Location of energy projects in Milton Keynes

Bradville solar house

Pennyland low energy and passive solar houses

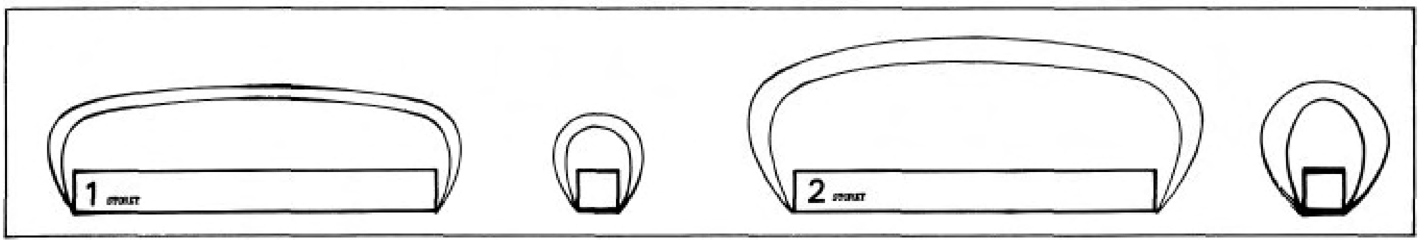


OU/LUCAS gas fuelled heat pump



Report on grouped solar heating schemes

Buy Insulation Cheap campaign



Solar shadow prints

Great Linford low energy and passive solar houses

Downsbarn coal fired houses

Fig. 3. The first eight projects

Energy Use in the UK

The way energy is used varies greatly between countries, it depends on the country's resources and sources of energy, its climatic and economic circumstances, and levels of demand.

In the UK, primary energy consumption currently runs at about 330 million tons of coal equivalent per year, or a national fuel bill of around £10,000 million a year; primary energy being defined as that energy which is extracted from the ground, including coal, oil, uranium and natural gas. The diagram 'UK Sources of Energy', shows that the majority of UK energy comes from coal and oil, although there is an increasing proportion of natural gas.

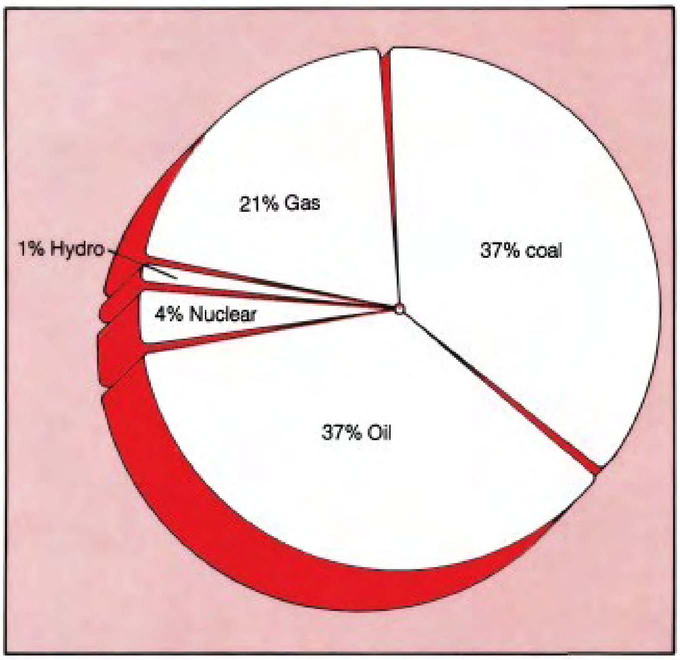


Fig. 4 UK sources of energy (1979)

The UK, unlike most other countries, is at present virtually energy self-sufficient, but this will change in the future with estimates indicating that there will be an energy shortfall by the year 2010 at the latest One can respond to this in the short term by promoting fuel saving measures but it also needs long term measures, the development of alternative sources of energy, replacing the use of fossil fuels such as oil with renewable supplies.

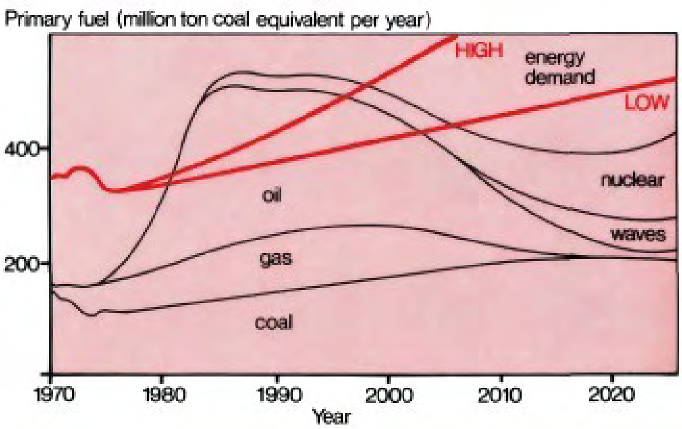


Fig. 5 UK energy supply and demand

Climatic factors are particularly important in determining the opportunities bolli for fuel conservation and the development of alternative sources since two significant factors in energy use in the UK are the amount of energy needed to heat buildings and the extent to which one can use solar energy as an alternative source.

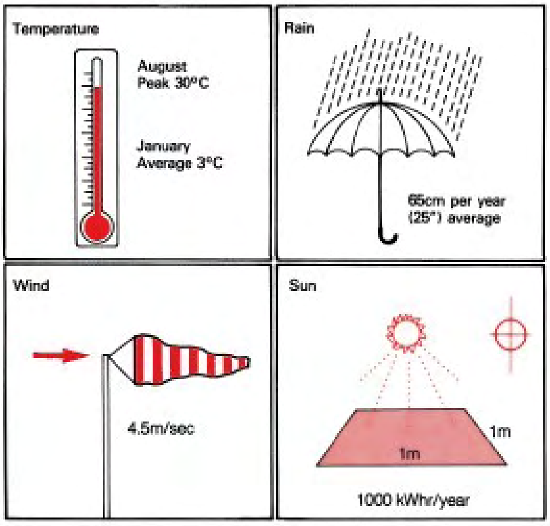


Fig. 6 Average UK climate

The UK has a temperate maritime climate. Winters are mild and although some insulation is used in buildings, levels are not as high as in some colder countries. Summer temperatures are not high enough for air conditioning to be needed in houses although it is often installed in new offices. Since the total annual solar radiation falling on the UK is eighty times as great as total UK primary consumption, researchers are increasingly examining the possibilities for using solar energy. There is considerable potential although it will not be as great as in some countries because the UK only receives about half the level of solar radiation received in Californian or Mediterranean climates. Since the highest levels of radiation in the UK are received in the summer months, its potential for use for space heating in buildings in winter is limited.

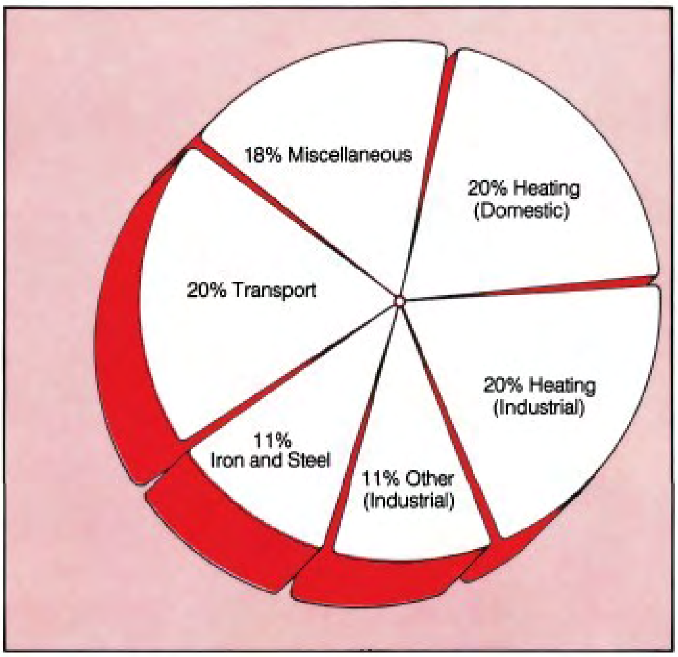


Fig. 7 UK primary energy use by sector (1979)

The significance of the need to heat buildings is shown in the diagram of 'UK Primary Energy Use by Sector'. 40% of all primary energy is used for this purpose, of which about half is used for heating houses; 22% of primary energy in the UK is used for industrial processes, and 20% is used for transport.

Energy Consultative Unit Projects

When the Unit was set up it looked at how energy was used in the UK and in Milton Keynes, how it would be used in the future, and the opportunities for energy savings. The areas where energy might well be saved appeared to be as follows:

1 Improving levels of insulation in new and existing buildings, particularly housing, and reducing energy losses in as many ways as possible.

2 Improving heating control systems in offices, factories and houses, and improving the efficiency of boilers.

3 Increasing the use of 'free' solar energy in buildings to substitute for energy that at the moment has to be bought

The Unit reviewed much of the work and looked at many of the projects that had been done already in the UK, but it was found that although some theories were quite well developed, very little applied research had been done. Milton Keynes is an excellent test bed for applied research and the Unit has been able to assist researchers and developers in undertaking projects within the new city. The main criteria in assessing what projects should be implemented was their cost effectiveness.

Analyses suggested that initially the best opportunities for cost effective energy savings were in the housing sector, and, consequently, projects have been concentrated there. Housing is a major energy user and, through the Development Corporation's housing programme for rent and sale, there have been real opportunities to develop energy saving projects relatively quickly.

Conclusions

There are a number of significant conclusions that can be drawn from the last five years research and development work, although the results from the two largest energy projects, the housing projects at Pennyland and Great Linford, are preliminary since monitoring has only recently begun. The main conclusions are that:

1 In the short term, there is not necessarily an energy crisis, but there is a problem of convincing people that proven energy saving measures are cost effective and should be put into practice.

2 Energy saving measures can be cost effective within short periods. This is illustrated in Figure 8 which shows that, for a typical three bedroom house, all the measures apart from the active solar heating systems have payback times of less than twenty years. Many have a payback time of less than five years.

3 Immediate energy saving can often be made simply by improving the levels of insulation and heating control systems in existing buildings.

4 Active solar heating systems for houses are not cost effective projects at the moment although both technical advances and the possibility of further increases in fuel costs suggest potential for the future.

The following payback times assume that energy costs will not rise in real terms. In practice, however, it is very likely that they will increase, so the payback times may well be reduced. As indicated, the times are calculated against current gas prices. If the measures adopted reduce consumption of electricity, the payback times could be further reduced, by up to as much as a half.

Measures	Cost/House 1981 prices	Payback time against 1981 gas prices
DOMESTIC		
Insulation Kits		
— Extra loft insulation (25mm increased to 80mm), extra water cylinder jacket, and draught stripping	£70	2-4 yrs
Pennyland*		
— 50mm (2") cavity wall insulation, — 75mm (3") loft insulation	£100	5-10 yrs
— 100mm (4") cavity wall insulation, — 150mm (6") loft insulation and double glazing throughout	£500	10-20 yrs
Active Solar Heating		
— 4m^2 Thermosyphon solar water heater installed by resident	£300	20-30 yrs
— (with labour cost)	£600	50-60 yrs
— 40m^2 solar water and space heating system	£3,000	50-60 yrs
Gas-Fuelled Heat Pump		
— 150kW heat pump shared between 20 houses	£300	5-10 yrs
Mini-CHP Scheme		
— 1 Totem shared between 3 houses	£500	10-12 yrs
*A normal Pennyland house has: — no cavity wall insulation; 50mm (2") loft insulation; no double glazing		
INDUSTRIAL		
Better heating system controls		1yr
Draughtstripping and extra insulation		2-5 yrs
Large-scale solar water heating		10 yrs
SWIMMING POOLS (INDOOR)		
Heat Recovery Units		1-2 yrs
Pool covers		5 yrs
Solar Water Heating		10 yrs

Fig. 8 Payback times for energy saving measures

5 Current research on passive solar housing projects indicates that considerable savings can again be made but final results will need to await completion of the monitoring programme at Pennyland and Great Linford.

6 The research work on both gas fuelled heat pumps and the Combined Heat and Power systems indicates sufficient potential for use in Milton Keynes to warrant further development work.

7 There is a continuing need for accurate information on the performance of new systems to enable architects to incorporate them into the designs for new buildings. Further work is needed therefore on the development of the monitoring techniques.

8 Many people are not aware of the energy saving opportunities available. If they are to make modifications in their houses, some residents may need both information and advice. Private developers may also be able to benefit from the research and development work that has been done.

Many different people and organisations may have the opportunity to implement energy savings measures; residents, office and factory managers, owners of existing buildings, and developers and designers of new buildings. The Development Corporation has been able to incorporate some measures in its projects, although like many organisations, it is subject to strong financial constraints.

The following sections of the report describe the individual research and development projects, beginning with the Housing Projects and continuing with Housing Layout and Planning Studies, work on Other Buildings, Technical Studies and Information and Advice.

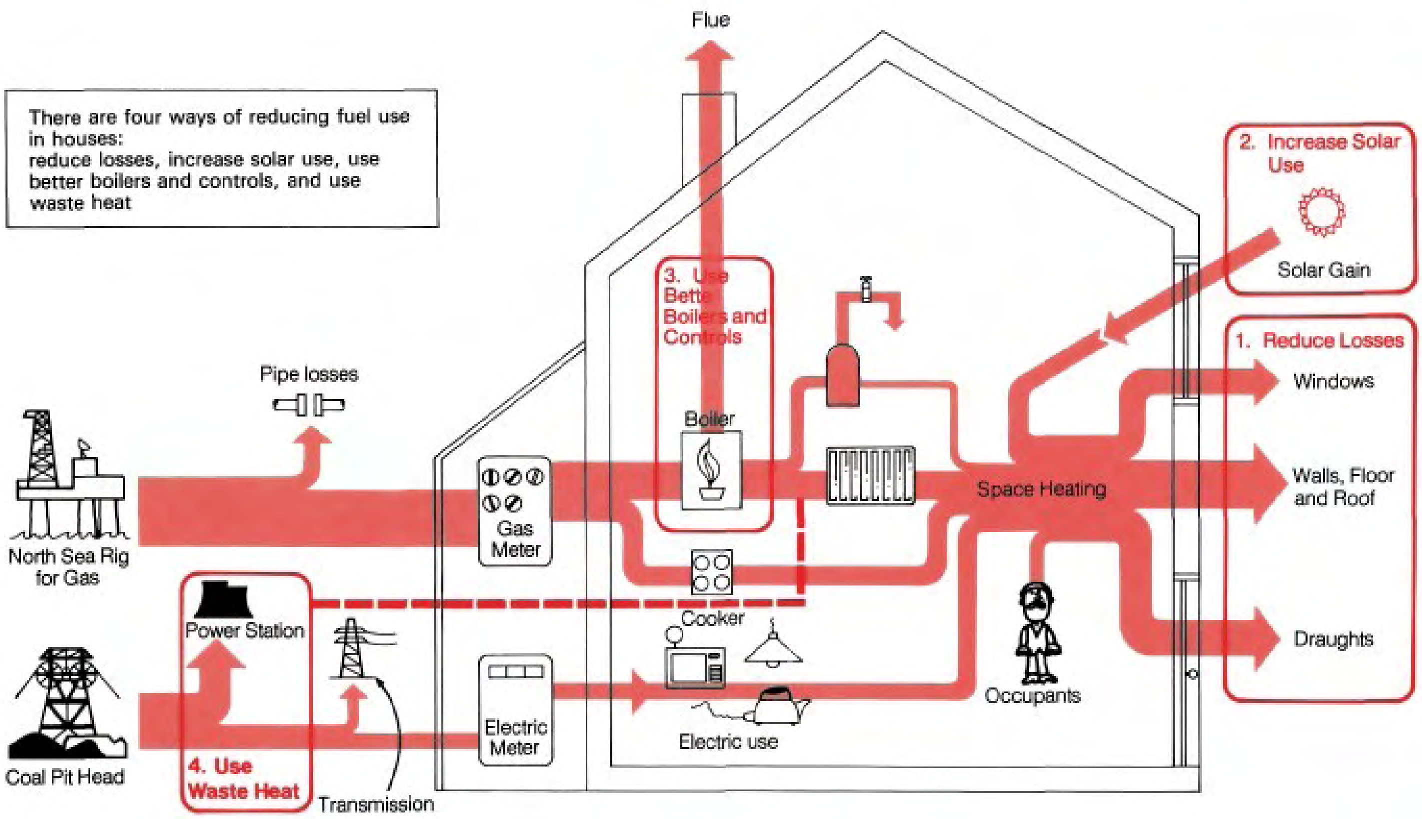


Fig. 9 Energy supply and use in an average house. Ways of reducing fuel use.

2 HOUSING PROJECTS

Priority has been given to housing projects because of the opportunities for cost effective energy saving. Studies have indicated that using current known technology, the UK's domestic space heating requirements could be halved by the year 2025.

In understanding how energy could be saved in housing it is first necessary to understand how and where it is used. The diagram shows how energy flows into, is used, and flows out of a typical three bedroom house, which is supplied with both gas and electricity and uses gas for heating.

With the electricity supply, the first point to note is that most of the primary energy that goes into the generation of electricity is lost at power stations. This means that electricity supply for housing can only be about 30% efficient, and this explains why on-peak electricity costs can be as much as three times the cost of gas or coal.

As regards the gas supply, a major source of energy loss can be due to the inefficiency of gas boilers. Most boilers only have an efficiency of about 60%, but this does greatly depend on the type of boiler and how it is used.

Within the house, heat is lost through the walls, roof, windows and floor, and much is lost through draughts. Heat also flows away with the waste water and escapes through the sides of hot water cylinders into the air. On the other hand, some heat can be gained by solar heating through windows and by the occupants generating heat themselves.

From analysis it appeared that there were four main areas of opportunity for a reduction in the use of energy:

1 Reduce the amount of heat escaping by improving insulation and preventing draughts.

2 Increase the use of solar energy when opportunities arise, thereby reducing the amount of gas or electricity householders need to buy.

3 Increase the efficiency of boilers and their controls or introduce more efficient systems such as heat pumps.

4 Introduce ways of using the heat that is wasted at power stations to provide energy for domestic use.

These energy saving opportunities were those that the Unit has concentrated on in its work on 'Insulation Kits', the 'Bradville Solar House', and the 'Group Solar Heating Feasibility Study'.

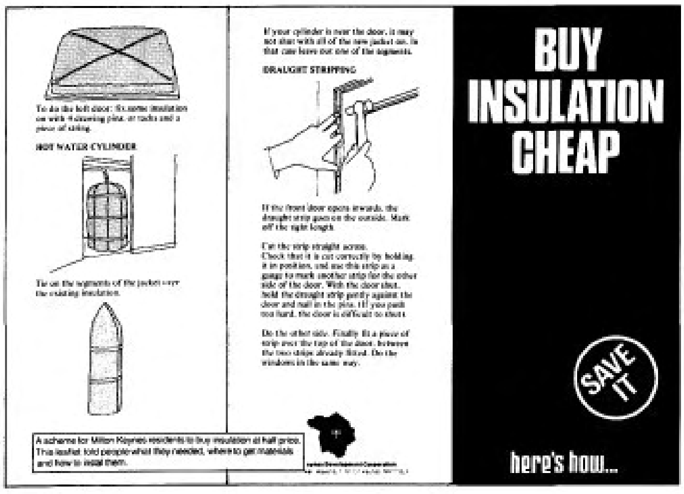


Fig. 10 Insulation kits brochure

Insulation Kits

The standard of insulation in older buildings is usually poor because when they were built fuel was relatively cheap and it would have been uneconomic to pay for high standards of insulation. However, since fuel prices have increased so fast in recent years, it is now economic to improve the level of insulation in existing buildings and provide much higher standards of insulation in new buildings. This was reflected in 1974 with an increase in the government building regulation standards for insulation.

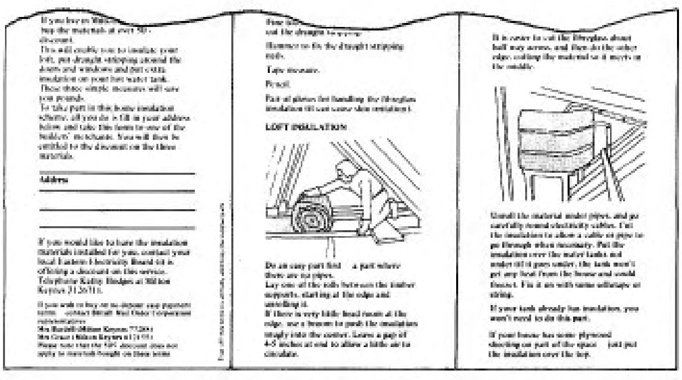
The Development Corporation introduced a scheme in 1976 to assist all existing householders in the new city to buy simple insulation materials at half the normal prices. The materials available included loft insulation, draught stripping, and insulation jackets for hot water cylinders. In installing the material themselves, householders were able to refer to a leaflet which was produced to show people what materials were needed, where to buy them and how to install them. Arrangements were made by the Development Corporation for local builders and builders merchants to purchase suitable materials in bulk and pass on the cost reduction to Milton Keynes residents, often at prices as much as 50% less than the recommended retail price. Estimates showed that the cost of the materials could be recouped through lower fuel bills within an average of a year.

Subsequently, old aged pensioners were provided with free materials which were installed free of charge, using grants from the Manpower Services Commission Job Creation scheme.

For householders in Corporation rented housing designed prior to 1974, materials were supplied and installed free of charge by private insulation contractors through grants made available by the Department of the Environment This brought the level of insulation in these houses up to new building regulation standards. Over 5,000 houses were improved in this way, the average cost of installation being £50 per house.

The fuel savings from these measures have been likely to amount to about £25 per year per house on average, or well over £100,000 per year over all the schemes. It should be stressed that these savings have been made by residents, reducing the amount they have to pay in running their homes.

The importance of providing increased insulation continues to be reflected in the improved specifications that the government introduces in the building regulations. Insulation standards for new houses were raised in 1976 and again in 1981.



Bradville Solar House

Interest in the opportunities provided by solar energy as a renewable energy resource have been increasing over the last decade, spurred on by the 1973 international oil crisis. Even though the climate in the UK is not as favourable for solar energy projects as some parts of the world, it is now recognised that solar energy could be feasible and economic in this country.

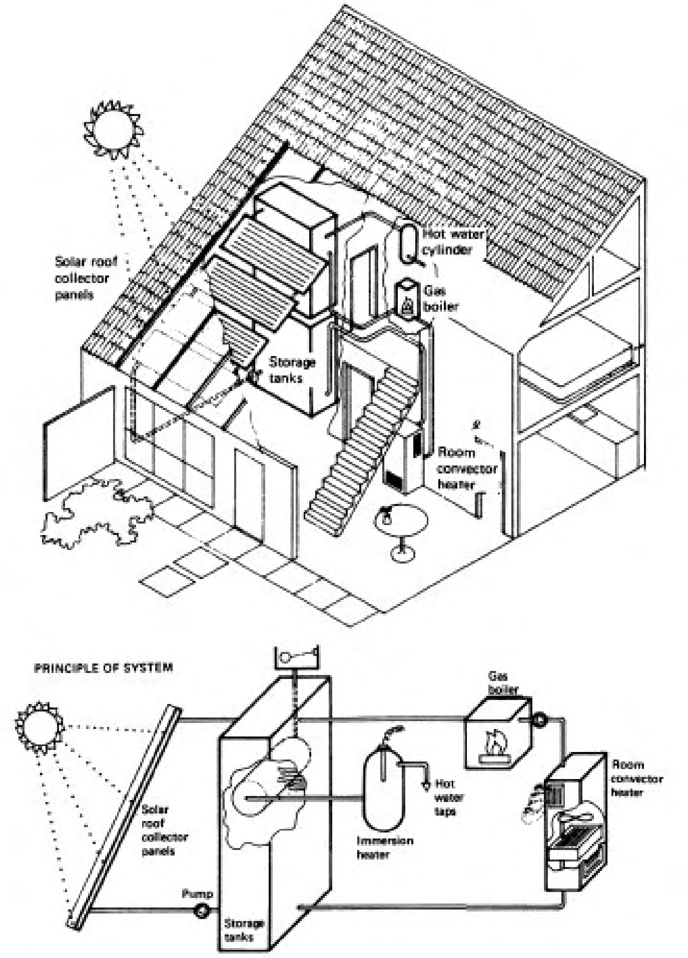


Fig. 11 The Bradville Solar House: The general arrangement of components.

The Bradville Solar House project started in 1972 when the Development Corporation were approached by Dr Szokolay of the Polytechnic of Central London (PCL) with proposals for developing housing with an active solar system. An active solar heating system uses solar panels, usually mounted on the roof, to collect the sun's heat This energy is then transferred to a separate insulated heat store before being used in the house. A special system was designed to adapt a standard Development Corporation rented house, built according to the standard building regulations. In 1974 this system was installed in a Corporation house for rent in the Bradville housing area The main aims of the project were to establish the design parameters of a system which could be developed for a mass market, to estimate the costs of such a system and to develop a computer simulation of its performance to be used for evaluation.

The system was designed to take advantage of the fact that the house that was being converted had a south-facing pitched roof which tilts at 30° to the horizontal. Aluminium rollbond solar collectors, 36m^2 in area, were fitted on the roof and water passing through the collectors fed two large storage tanks situated in the centre of the house. This hot water is used to preheat domestic hot water and provide some space heating. The original estimates of how the system would perform suggested that 60% of the total heating needs of the house could be supplied from solar energy.

The system has been monitored since 1975 by the Built Environment Research Group of the PCL and, following the first two years' results, it appeared that it would not meet this level of 60%. As a result, a number of modifications were made to the system and a few minor faults were corrected. These changes have now allowed the design performance to be achieved, the main modifications being first that the collector panels were coated with a good quality matt black paint to increase radiation absorption, second that more antifreeze was added to reduce the need to circulate warm water through the panels at night to prevent freezing, and third that the space heating control system was changed to make more effective use of low temperature water in the heat store.

The results are now much more satisfactory. In the year 1979/80, 71% of the hot water requirement and 47% of the space heating load were met by solar energy, giving an overall contribution of 56% towards the total heating needs of the house. As well as this, there may well be further savings to be made because computer simulations suggest that the performance could be further improved by:

1 Increasing insulation around the heat store.

2 Increasing the collector slope to about 60° to the horizontal.

3 Coating the collectors with a higher grade selective surface.

4 Making even better use of low temperature water in the heat store for space heating.

5 Supplying adjoining houses with excess hot water in summer.

The house monitoring has proved that the basic technology for active solar space and water heating is available.

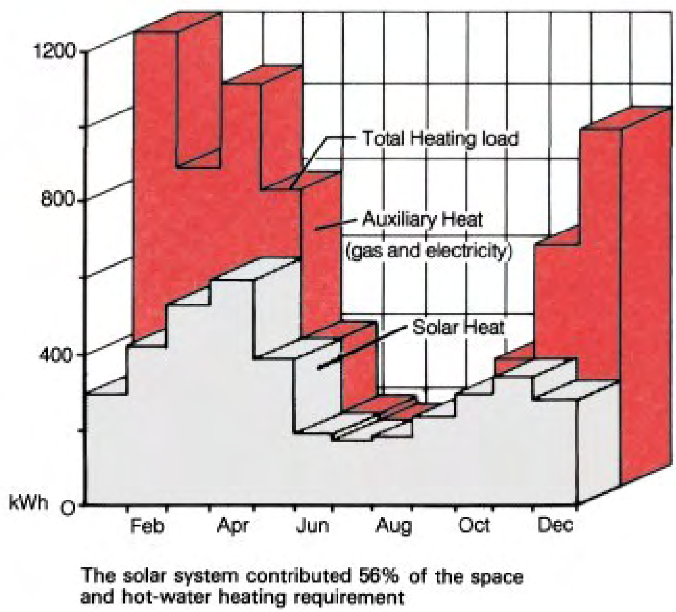


Fig. 12 Solar energy use at the Bradville Solar House, 1979/80

However, the system costs will have to be reduced to make the proposition cost-effective compared with gas heating.

PCL, with the assistance of the Unit, have therefore examined ways of reducing costs, and these are discussed in the detailed performance report. In summary they include using a cylindrical rather than a rectangular storage tank, using cheap agricultural glass and timber framing in the collectors, and simplifying the space heating system. If all these system improvements and ways of reducing costs were adopted, the system could be cost-effective compared with gas space heating and electric water heating, assuming reasonable energy price increases and a 20-year system life.

The Bradville house has been a particularly important project in Milton Keynes because it has provided measured data which have been invaluable for the validation of computer models of both solar heating systems and house thermal properties. The models have been used in much of the other work now going on in Milton Keynes, and have also contributed to work on other projects in Europe.

Coal Heated Houses at Downs Barn

The UK has very large resources of coal, enough to last for at least 150 years. It may be the only fuel freely available in the UK after the year 2050, and is likely to play an increasingly important part in supplying our energy needs before this date. The rising costs of fuel have made studies to improve the efficiency of the use of coal worthwhile and the Unit, working with the Solid Fuel Advisory Service, has been investigating the possible benefits of modern coal boilers in otherwise normal family housing for rent.

Fig. 13 Downs Barn coal heated houses

One way of using coal is to burn it in power stations, but this loses 70% of the energy through the cooling towers. Another way is to burn it directly in boilers in every house and in this case as little as only 25% may be wasted. However, open coal fires have traditionally been dirty and have needed constant stoking, and it is likely that an open fire's efficiency may be less than 40%.

Nevertheless, modern boilers and room heaters have reduced or eliminated most of those problems and higher efficiences can make coal costs competitive with gas. Also modern room fires with back boilers are simple to install, they can be controlled with room thermostats and clock programmers in the same way as gas heating and the use of an integral coal feed hopper can reduce the amount of coal carrying. Specially designed ash containers can also make disposal clean and simple.

Although it would seem that coal fires with back boilers could have an attractive future in domestic heating, many people may be unaware of these changes in heater design, and, even if they are, they may still be unwilling to trade off the appeal of a flame fire against the continuing needs to carry coal and clear the fire.

In order to test the performance of new equipment and people's attitudes to it, 22 new houses for rent at Downs Barn have been fitted with modern fires and boilers. After another winter's use, occupants will be asked for their opinions on the units. Also, comparison will be made of the cost of their coal bills with the gas bills of similar sized houses.

Grouped Solar Housing Feasibility Study

This feasibility study was started because it was thought that the high capital costs of active solar heating could potentially be reduced by having a system which is shared by a number of houses. Since there are so many related issues, the study did not only consider active solar energy, it also examined the potential for other energy saving measures as well and considered their cost effectiveness for a group system. The study was a joint project between the PCL, John Laing R & D Limited and the Development Corporation, with much of the work being carried out by members of the OU Energy Research Group.

The analysis involved selecting twenty different heating systems for single and groups of houses. These included normal heating using a standard boiler, a system using a higher efficiency boiler, electric heat pumps, gas fired heat pumps, solar heating systems, a solar heating system together with a heat pump, and all these at different levels of insulation.

The systems were all evaluated and costed against the heating demands for houses at three different levels of insulation, using the computer program developed to simulate the Bradville house. They were all compared in terms of cost effectiveness using a range of economic assumptions about future rates of fuel price rises and interest rates.

The conclusions were as follows:

1 The two most cost effective fuel conservation methods for the type of house considered are — increasing the levels of insulation, and improving gas boiler efficiency.

2 A significant cost advantage was found when houses were heated in groups of 20 rather than individually.

3 The most cost effective solar heating system is relatively small, probably only preheating hot water. This applies to both individual and group housing schemes.

4 Whereas electric heat pumps consistently were the least cost-effective, gas-fired pumps, if they became commercially available, could offer the most cost effective option.

5 Large scale water heat storage for solar heating, ie. storing heat generated in the summer through to the winter, is not cost effective, and would not become so until costs are dramatically reduced.

6 Large solar heating systems are not at present cost effective, but trends suggest that they could become so within the next twenty-five years. Since there may still be a real energy crisis with the costs of traditional fuels escalating or being unavailable, there is a real need for research to consider the use of solar heating systems for groups of houses.

3 HOUSING LAYOUT AND PLANNING STUDIES

By 1976 it was becoming clear that some forms of small solar heating systems could be cost effective. However, this conclusion was based on the requirement that, like the Bradville house, individual houses should face due south and not be in the shadow of another dwelling. Traditionally, however, houses do not face south, they are usually laid out in groups and are randomly orientated, and they are often overshaded. Since little research has been done on this subject, the Unit examined the issues in a 'Housing Layout Study'.

After examining the theoretical aspects of housing layout, the Unit has been able to test the layouts and their energy saving opportunities in its most extensive projects to date, the 'Pennyland' and 'Great Linford' housing projects, and these are described in this section.

It had become evident that immediate energy savings could be made by modifying housing and housing layout plans. Also there were possibilities to make energy savings if one considered modifying the relationships between the different land uses, the nature of the transport systems used and the density of development. Because of this the Unit took the opportunity to contribute to the planning of a new area of Milton Keynes with the 'East Flank Study'.

Development Corporation architects and planners now incorporate the proposed energy saving modifications wherever possible. This section summarises the research and development work that has been done to date on these four projects.

Housing Layout Study

Using funds provided by the Department of the Environment, the Unit studied the implications of the use of solar energy on the design of housing layouts, looking at whether or not solar energy considerations would present unacceptable constraints such as causing uneconomic low housing densities or unattractive layouts. The study examined the problems of house orientation and overshading, which were analysed for three basic types of solar heating system; active solar water heating, active solar water and space heating, and passive solar space heating.

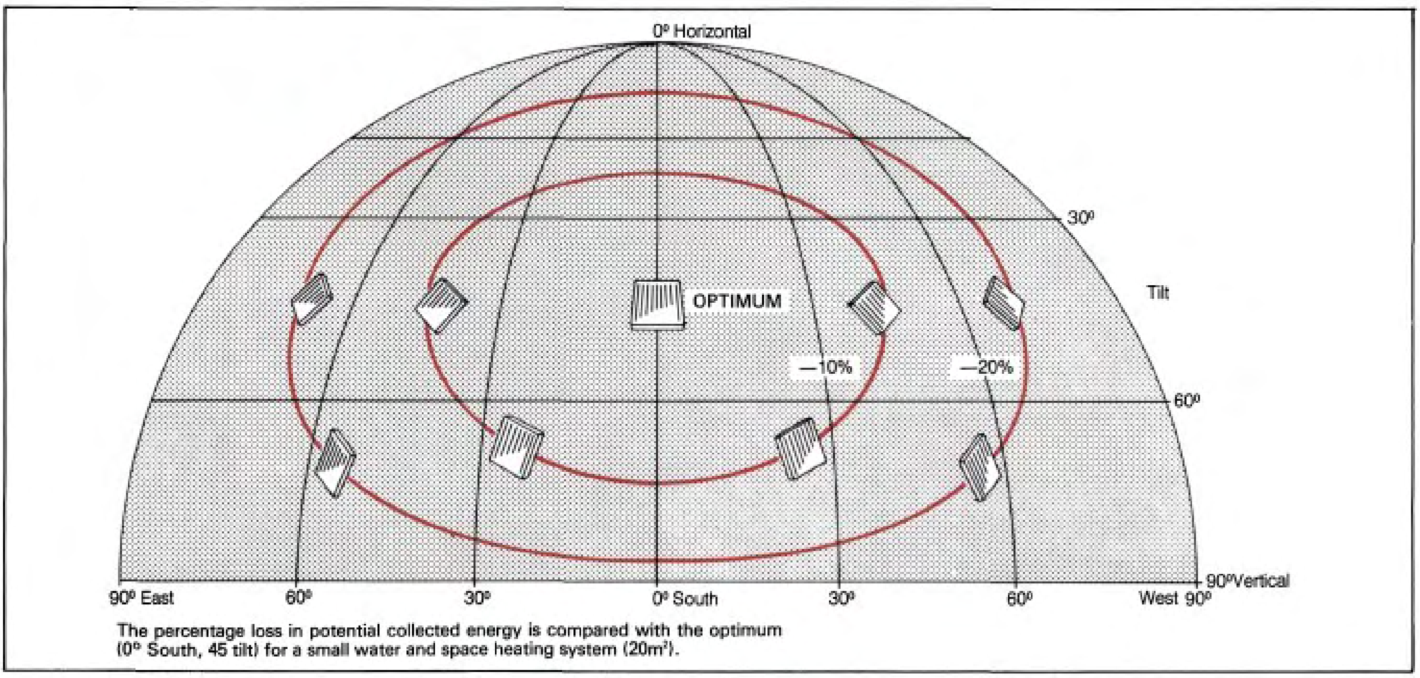


Fig. 14 Effect of orientation and tilt on a small water and space heating system

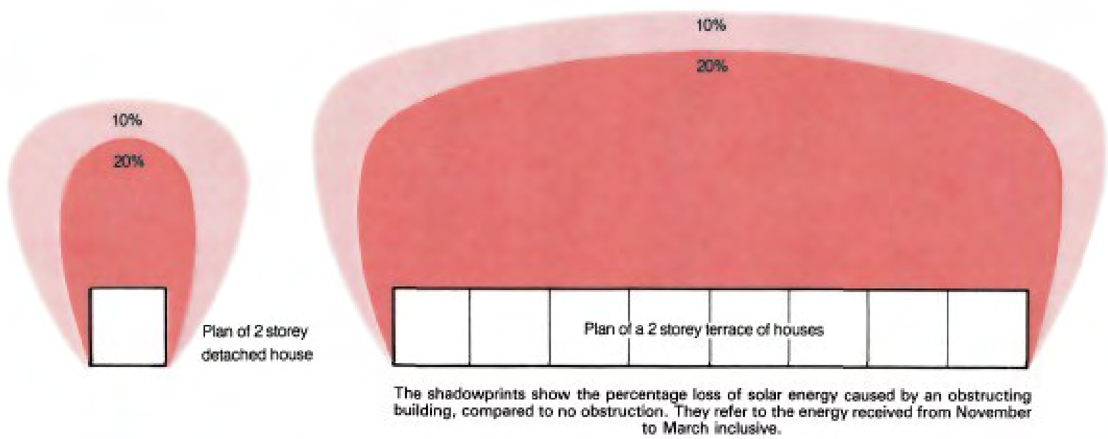


Fig. 15 Typical shadowprint

Active solar houses usually use roof mounted solar collectors to absorb the sun's heat, storing it in some form, usually in a central water store, before circulating it within the house. Bradville is a good example of a house using an active solar system. The effects of modifying housing layouts and orientation on active solar systems were studied using the computer simulation developed for the Bradville house. The basic conclusion was that for roof mounted solar collectors, orientation and overshading were unlikely to be a problem.

Passive solar houses usually use large south facing windows to collect the sun's radiation during the day and store it in some way, for instance in thermally massive walls of the house itself. The heat is then distributed within the house, which must be well insulated in order to stop the stored heat being lost For the passive solar systems orientation and layout are more significant. To study the issue, three sets of solar 'shadow prints' were drawn up showing the 'energy shadow' behind rows of houses. From these one could determine the effects of overshading on the reduction in solar radiation passing through a south-facing window during a heating season. These shadow-prints were then prepared as a set of overlay transparencies for use in designing housing layouts. They were produced for single houses and terraces of different heights and orientations and have been used subsequently to lay out the Pennyland housing area.

The housing density implications of the work on passive solar collection have been analysed by the Martin Centre at Cambridge. They concluded that passive solar energy systems could be used at housing densities of up to 44 dwellings per hectare. As regards whether or not solar considerations caused any major design constraints, it was found that houses could be orientated south ± 40° and still take advantage of solar gains.

The Pennyland and Great Linford Projects are two major schemes where the principles developed in the Housing Layout Study have been implemented on a large scale.

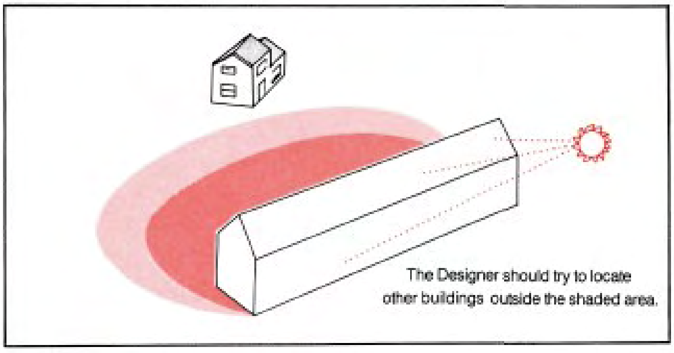


Fig. 16 Example of the use of shadowprints

Pennyland Project

The Pennyland housing area consists of 177 houses built by the Development Corporation for rent. It is being used to study the effects of different levels of insulation and passive solar energy techniques on domestic fuel consumption. The monitoring work is being carried out by the OU Energy Research Group and the project is being jointly funded by the Department of the Environment and the Department of Energy.

Housing Layout

The Pennyland houses were designed by the Development Corporation and laid out with passive solar collection in mind. As many houses as possible have been orientated to face south ± 45° and not be overshaded by the houses immediately to the south, the shadow prints developed in the Housing Layout Study being used as a design aid in the process.

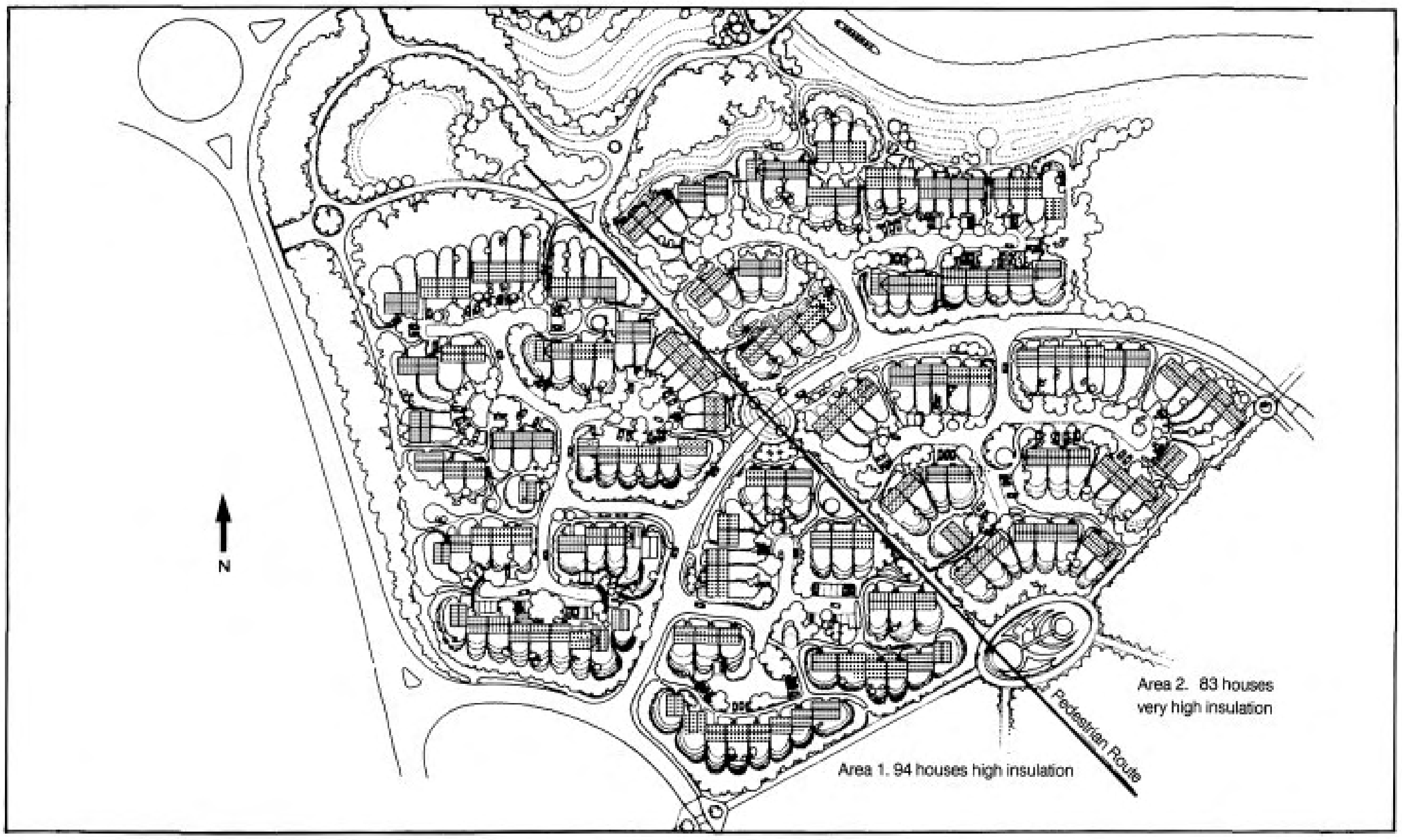


Fig. 17 Penny/and Housing Layout

House Design

Original ideas were for an all-out passive solar house, with thick insulation and 100% of the south face glazing. However the very large numbers of houses in Pennyland meant that extra costs had to be kept down to an absolute minimum and be justified as cost-effective. As a result, all the insulation measures were carefully costed and evaluated, and the relative effects of the glazing area and the house orientation were examined in detail. The house designs finally emerged as more general 'low energy houses' with only about 50% of the south face glazed, and lower insulation levels, but with other measures such as high-efficiency low thermal capacity gas boilers and good heating control for the central heating system. The houses also have thermally massive inner walls, in this case consisting of 100mm (4") dense concrete construction, poured on site, a standard feature of the Mowlem System Building Method used.

Insulation

Considerable research on alternative forms of insulation was done prior to recommending the techniques to be used for the project. The diagram shows the cost effectiveness of different insulation measures. The Pennyland housing area was split into two parts each with similar housing designs. Half the houses were built with 50mm (2") cavity wall insulation and 75mm (3") loft insulation, and the other half 100mm (4") cavity wall insulation and 150mm (6") loft insulation and double glazed throughout. Some of the houses were equipped with insulating window shutters as well. The fuel bills on half of the housing area are being compared to those of similar sized houses built to conventional insulation standards in other areas of Milton Keynes.

Passive Solar Techniques

Within each half of the housing area, there are different passive solar techniques used in the house designs. Two types of designs have been built, the first being single-aspect houses which have the main living room and glazing area (50% of the surface) concentrated on the south side, the second being dual-aspect houses which have the living room and glazing area located evenly on the north and south sides of the houses. The two designs are being compared with a selection of randomly orientated and overshaded houses on the nearby Neath Hill housing area.

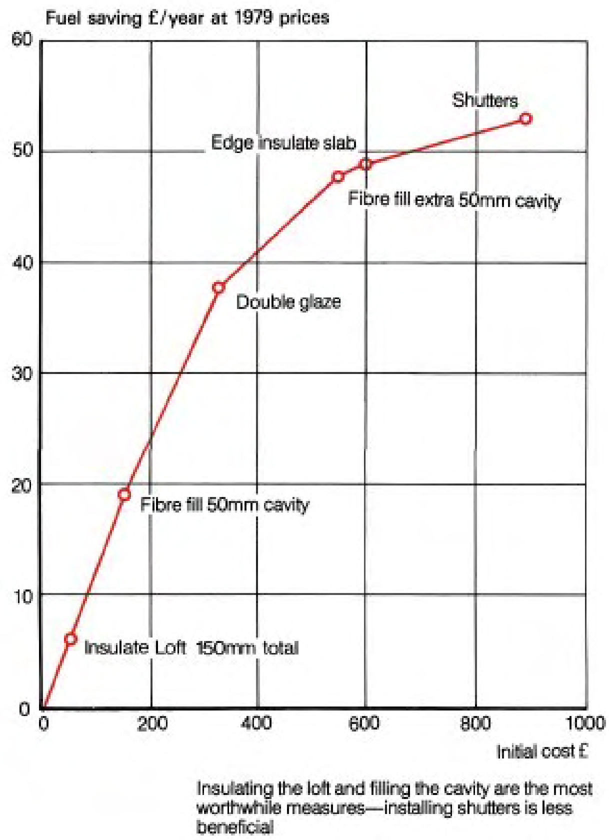


Fig. 18 Costs and benefits of fuel conserving measures

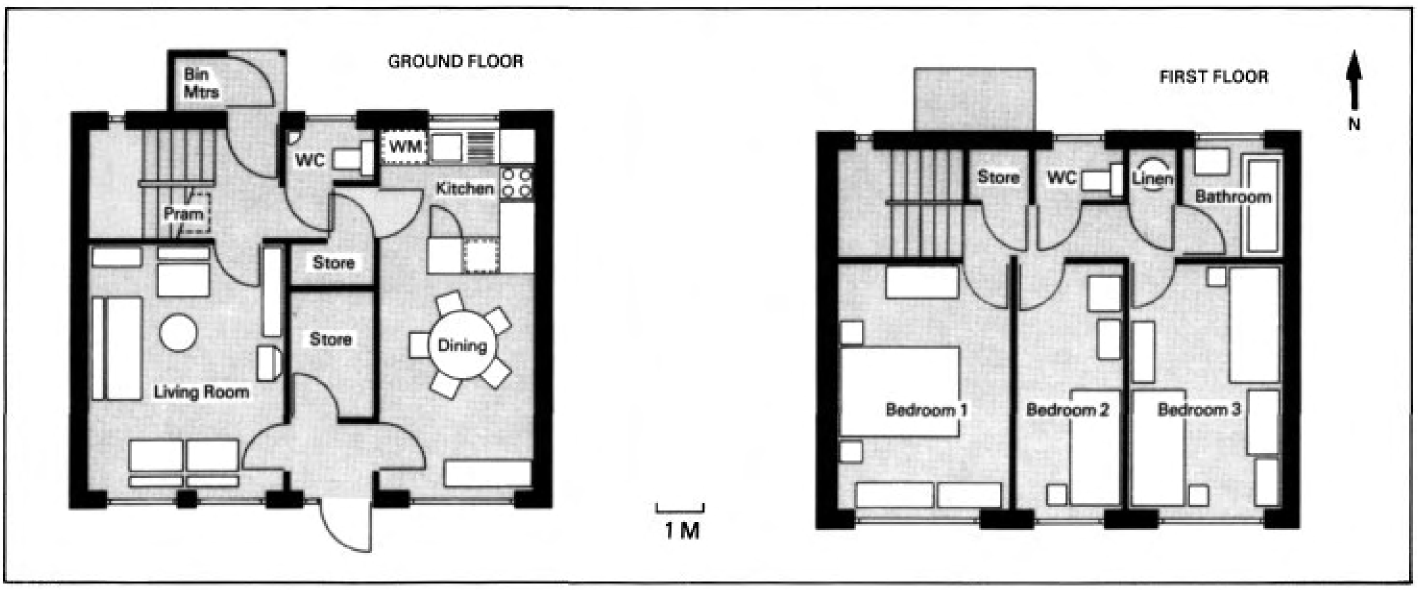


Fig. 19 Penny/and house plans

Fig. 20 Penny/and Single Aspect House: North (top) and South (above) elevations

Monitoring

In order to carry out comparisons, a total of 80 houses are being equipped with heat meters in the central heating systems to measure the amount of heat supplied to the radiators while Differential Temperature Integrators, a form of monitoring device described later in the report, measures house temperatures. These all can be read remotely in the house external meter cupboards once a week, along with the gas and electricity meters. One of the simple yardsticks that will be used to measure the effectiveness of the measures will be to see if the gas consumption of a three bedroom house can be halved, for an extra cost of about £500 per house. Measurements started in some houses in October 1980, but full measurements will not be taken until the winter of 1981/82. However, the limited results available so far are very encouraging.

The Great Linford Project

The Great Linford Summerhayes houses were built by a private developer, S & S Homes, for sale. Whereas the Pennyland project sets out to look at the overall effects of energy saving measures using a relatively large number of houses and simple monitoring techniques, the Great Linford Summerhayes project consists of eight highly monitored houses, seven of which will be occupied and one used as a research test house. The overall aim of the project is to develop a picture of energy flows within a low energy house and the way in which occupants interact with it so that future designs can be made more energy efficient

The project is being funded by the Department of Energy through the Energy Technology Support Unit and is being monitored by the OU Energy Research Group.

The houses, which were designed by Charter Building Design Group using an energy brief prepared by the Unit, are very similar to the Pennyland single-aspect houses. They are insulated to very high levels, ie. 100mm (4")insulation in the cavity walls, 150mm (6") in the roof, 25mm (1") perimeter insulation in the ground floor slab, and all the windows are double glazed. The houses have been built using a method of dense concrete blocks for the inner part of the external walls rather than the poured concrete method which was used on Pennyland. Like Pennyland, they have large south facing windows with those on the north side reduced in size.

In the houses each room is equipped with a temperature sensor and the walls, roof and floor are fitted with specially developed heat flux sensors to monitor heat flows. The double glazed windows and all the house doors are fitted with microswitches indicating whether or not they are open, and the central heating system is fitted with heat meters recording the heat flows. All this information is relayed back to Microdata M1600 Dataloggers which are located in the test house.

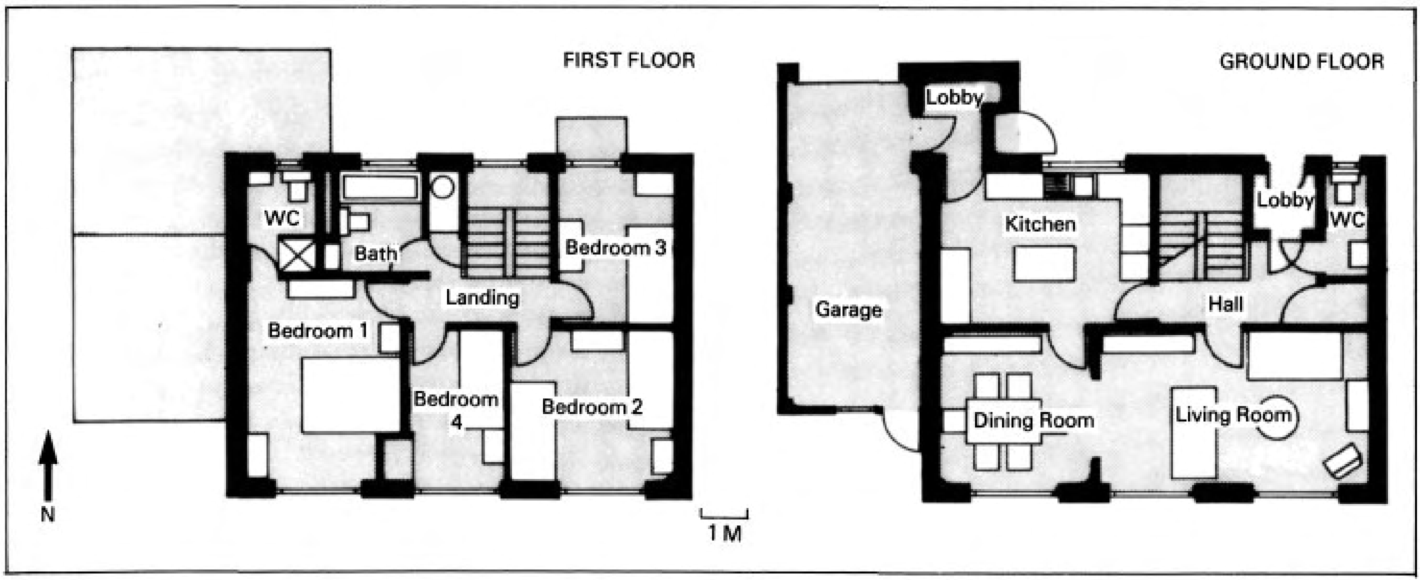


Fig. 21 Great Linford house plans

Specific studies will be made of the following particular issues:

The absorption of solar energy by the building

Window heat balance and window insulation

Potential problems of summer overheating

Ventilation rates

The practical in-situ insulation properties of walls

Validation of computer methods that are being used in the study

Potential condensation problems

The houses were completed in 1980 and the instrumentation and monitoring devices have now been installed so that the main monitoring period can start in the winter of 1981/82.

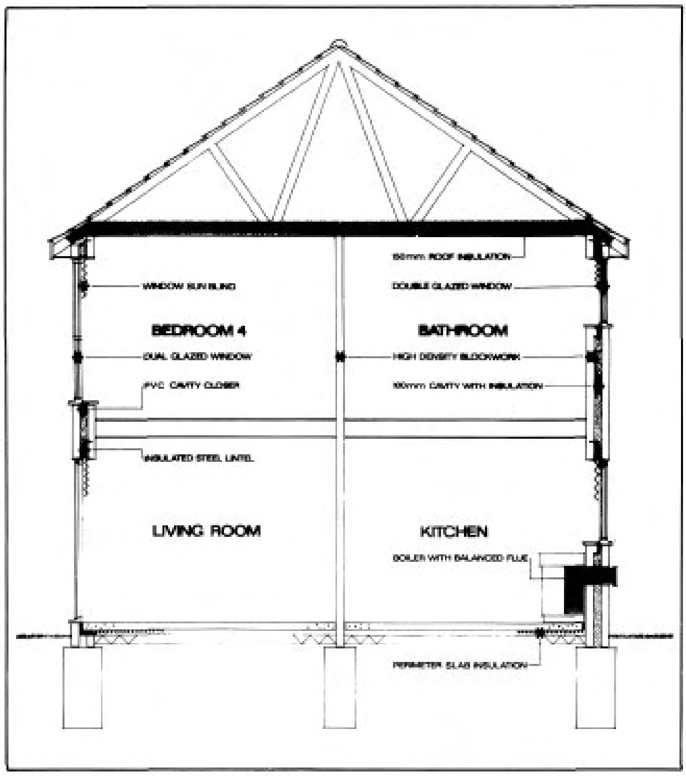


Fig. 22 Great Linford House Section

Fig. 23. Great Linford houses: North (top) and South (above) elevations

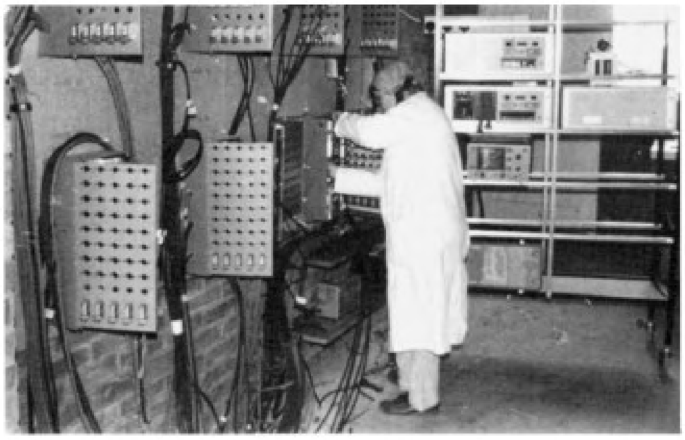


Fig. 24 Great Linford project: monitoring equipment

East Flank Study

In 1979 there was an opportunity for the Unit to examine the energy related issues involved in the planning work being prepared for one of the next major development areas of the new city, known as the East Flank. It is an area that could accommodate up to 35,000 people and will include housing, employment areas, commercial and community facilities. A study was done to provide the Development Corporation planners with information on the implications of alternative planning policies, and with the development proposals which would reduce energy consumption.

The study made a number of recommendations on how to make this area of the city more energy efficient The recommendations were:

1 Based on the work and knowledge gained from the Housing Layout Study, and the Great Linford and Pennyland projects, houses should face south ± 40°, be reasonably unshaded and have high insulation standards.

2 In order to take full advantage of passive solar energy, housing densities should not be higher than 44 dwellings per hectare; this meets current Corporation policy.

3 Feasibility studies should be done for the possible introduction of Combined Heat and Power Systems (CHP). A CHP system is one where power is generated locally at a small power station which would produce electricity to be distributed through the normal electricity board grid, while the wasted heat, normally lost through the cooling towers, would be distributed through insulated

pipes to individual houses and factories. In the past CHP systems have not been economic at low housing densities, but with the increase in fuel prices they might well now be more economic. Such a scheme could be financially feasible if buildings and other high energy users are concentrated along defined routes where the pipes can run, rather than dispersed throughout an area. The introduction of CHP would be a major change in planning policy in Milton Keynes and would need much more research before being considered for implementation.

4 Cycleways and footpaths should be made as attractive to users as possible. Since transport accounts for up to 20% of UK energy consumption, any contribution to making reductions is worthwhile, and significant savings can be made when people reduce their use of private cars and use buses, cycles or walk instead. The Corporation has already developed a city wide cycleway and footpath system.

5 Activities and any housing at higher densities should be concentrated along defined routes. Doing this should improve the economics of bus travel by increasing the potential number of passengers along bus routes. Proposals for this have been incorporated in the work done by the Development Corporation Urban Design Unit.

6 Residents should have easy access to allotments. About 15% of the country's primary energy is used in processing and distributing food. When people grow their own food this is bypassed and less energy is used. The Development Corporation and Milton Keynes Borough Council already operate a policy of distributing allotments throughout housing areas to a higher standard than is general throughout the rest of the country.

The study considered the physical implications of these conclusions and indicated in schematic form how the local planning in the East Flank area might be done to take energy saving more into consideration. One example was given of how the existing housing area at Neath Hill might have been modified to take such considerations into account. The 'before' and 'after' plan shows how land uses and buildings might have been rearranged to take account of the five main conclusions, ie. that a majority of houses be orientated towards south; that defined routes be planned for public transport and possible CHP systems; that attractive routes for cycleways and pathways be planned; that housing densities be less than 44 dwellings per hectare; and that allotments be located close to housing.

As well as endorsing existing policies, the study has contributed to recent planning and design work for the area which has incorporated some of the conclusions, particularly in concentrating activities and housing along defined local routes.

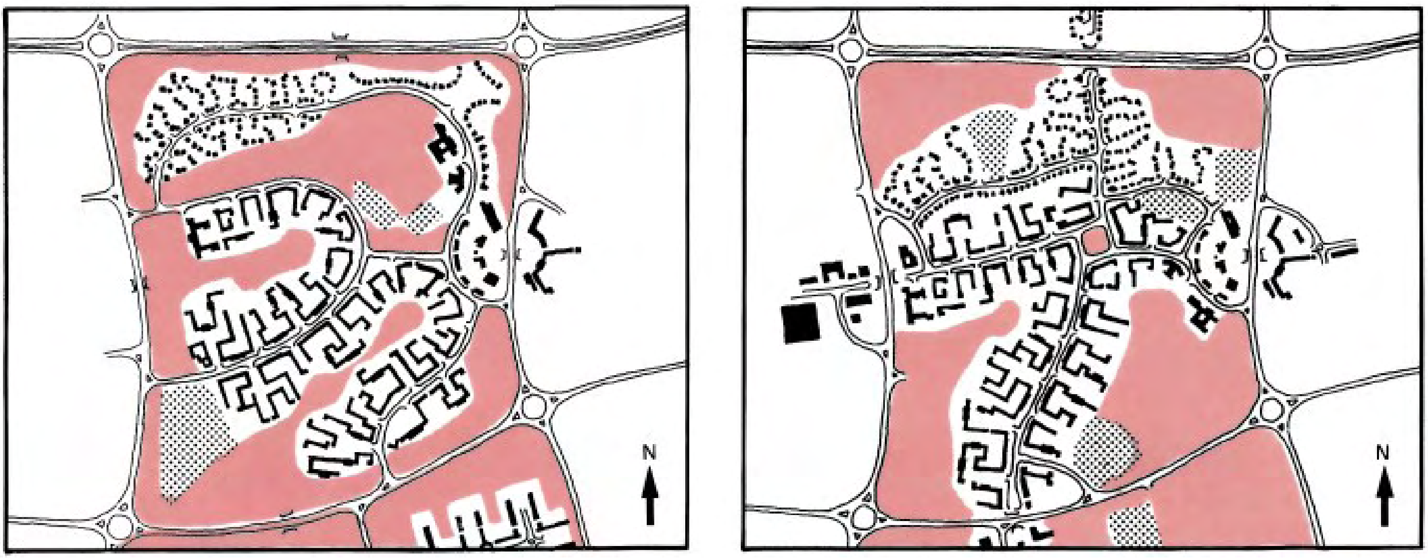


Fig. 25 Left: Neath Hill—Downsbarn housing area under construction, 1980. Right: Neath Hill-Downsbarn housing area reorganised on continous local routes.

4 OTHER BUILDINGS

Although housing has been to date the Unit's highest priority, this does not mean that there are not considerable savings to be made in other sectors. The two examples described in this section, the 'Wavendon Tower Offices Energy Audit' and the 'Woughton Campus Swimming Pool Project', illustrate the potential savings very well.

Wavendon Tower Offices Energy Audit

Commercial buildings are another large energy using sector. This project shows that by improving insulation and using other conservation measures, one can make large and cost effective energy savings in existing office buildings.

In 1976 the Unit carried out an energy audit of the Development Corporation offices at Wavendon Tower, the audit comprising a detailed examination of fuel bills and an investigation of the heating system. This investigation revealed a number of weaknesses in the system; firstly, the pumps were circulating hot water from the boiler room continuously day and night, even when the building was empty; secondly, the space heating and water heating distribution circuits could not be controlled separately, and, thirdly, the space heating system was running when the building was empty, due to a faulty frost protection thermostat, even on fairly mild nights.

As a result of the energy audit £2,000 was spent on improving insulation and on making improvements to the control mechanisms, but the effectiveness of these measures had to be tested to see if the project was worthwhile.

In order to test the system performance and evaluate the fuel savings, the amount of fuel used during the winter of 1976/77, ie. before the energy saving measures were introduced, was compared with the amount used in the winter of 1977/78, ie. after the improvements had been made. The information used to plot the fuel use was drawn from fuel delivery records, and the temperature information was obtained from records from a local weather station and from the monitoring of the Bradville house.

The immediate conclusion was as one would expect, namely that the colder the outside temperature the more fuel that is used. If one examines the data on the diagram one can see that the weekly readings form a broad band as a straight line on the graph. There are readings that do not fit in with this but these are due to exceptional conditions, the points well above the line showing control malfunctions such as wrongly set time clocks, and the points below the line being mostly due to reductions in the temperature level in the office made to save oil during a fuel delivery strike. Taking into account these variations, the graph shows that considerable savings can be attributable to the improved measures, and it is possible from the data to calculate approximately these energy savings and apportion them over the year.

The overall conclusion of this work was that savings could be made; for an expenditure of £2,000, the Development

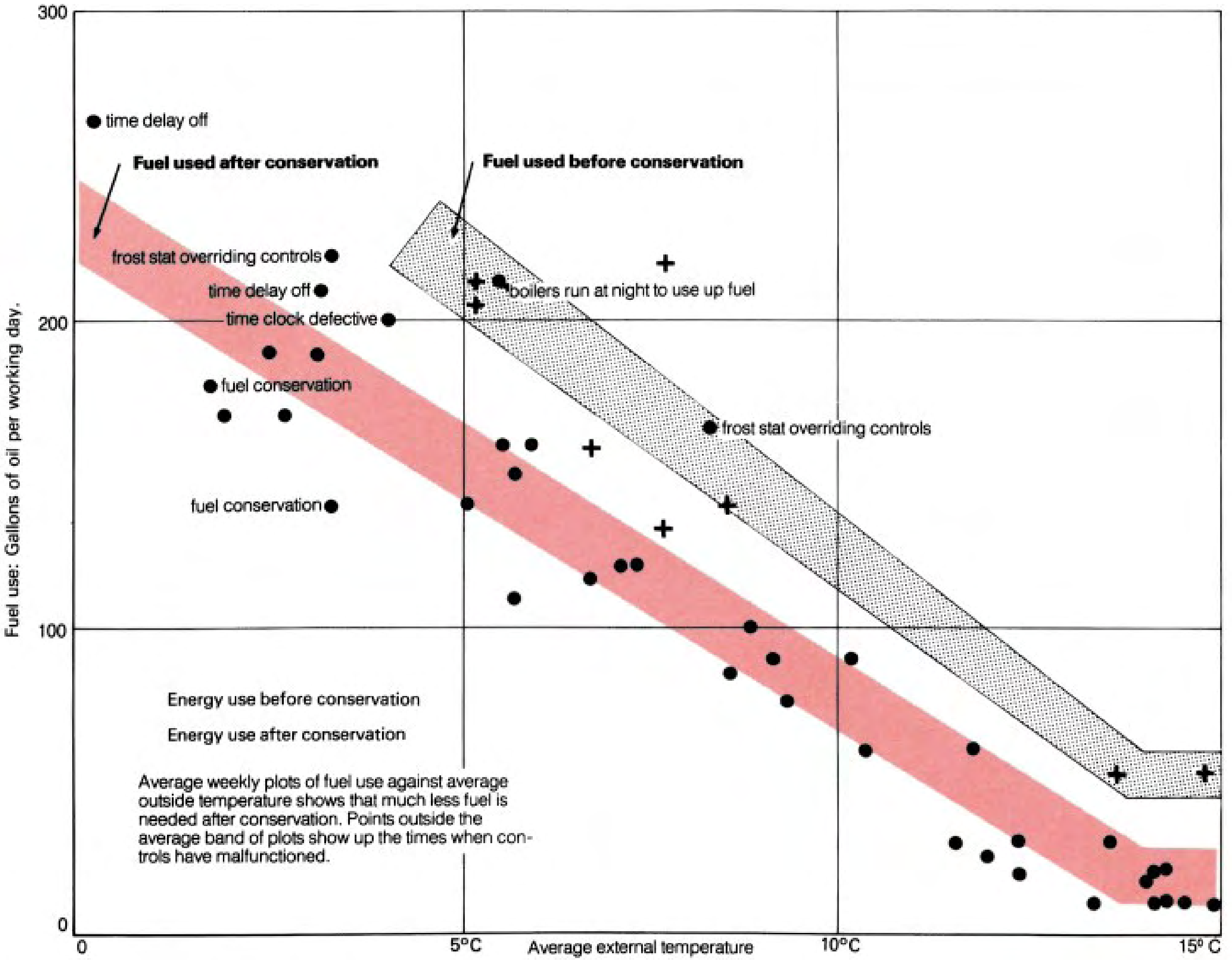


Fig. 26 Wavendon Tower offices energy audit

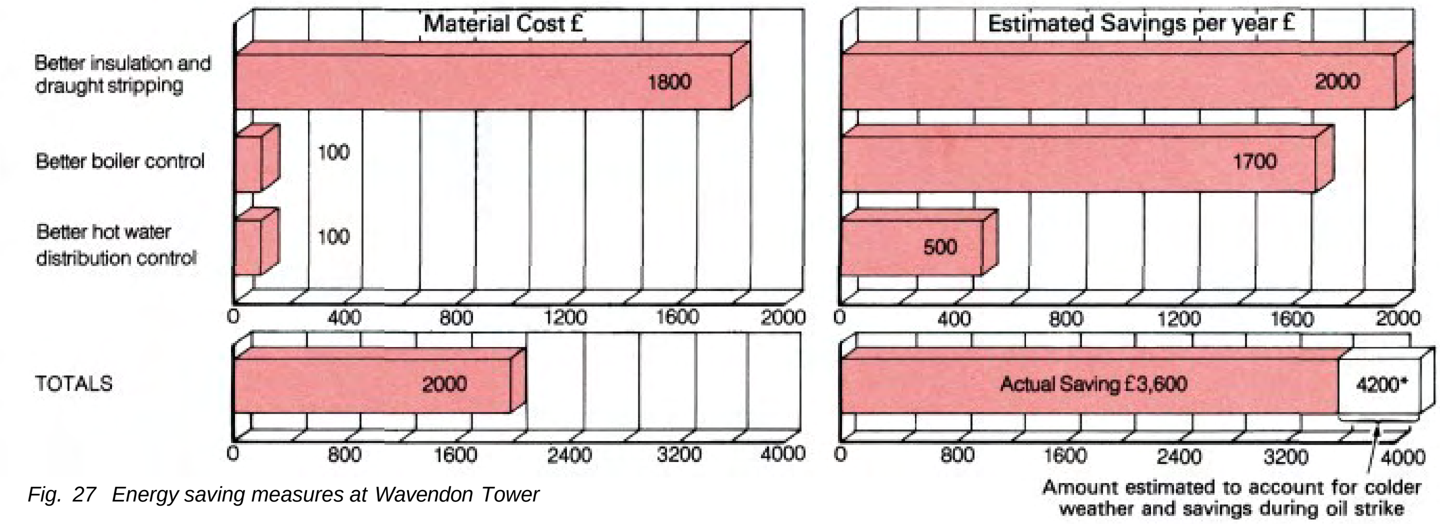


Fig. 27 Energy saving measures at Wavendon Tower

Corporation had saved an estimated £3,600 in the following year, representing about £8,000 at current oil prices. Even at the 1978 prices the investment had a payback time of less than seven months.

One of the most difficult areas to work on during the Energy Audit was found to be the collection of the temperature data, and this was one of the projects that further encouraged the Unit to study monitoring performance and develop monitoring devices like the Differential Temperature Integrator described later in this report.

Woughton Campus Swimming Pool Project

The energy used in heating indoor swimming pools is enormous, typically about 1 kW per square metre of pool, continuously day and night, which is equivalent to the energy used by over sixty houses. Because of the potential for savings, in 1978 the Unit carried out a brief study of the energy saving options for the swimming pool at the new Woughton Secondary School campus. This was done with the Buckinghamshire County Council architects.

It was found that there were three possible techniques for making energy savings, a heat recovery unit, already being considered, a pool cover and solar panels.

The heat recovery unit

In a heated indoor pool, water is continually evaporating from the surface. This means that the pool hall has to be heavily ventilated in order to keep the humidity down to bearable levels and this in turn causes enormous energy wastage as the warm moisture-laden air is extracted from the hall through vents. A heat recovery unit allows the hot outgoing air to heat up the cold incoming air, either by linked heat exchangers or by using a large rotating porous wheel. A heat recovery unit, as shown in the diagram, was in fact fitted and is now in operation at the pool. Estimated savings for the unit were as follows:

Estimated Capital Cost	-	£5,500 (1978 prices)
Estimated Fuel Savings	-	£4,100/yr
Payback time	-	1.3 years

Pool cover

A further way of reducing energy is to cover the pool at night with a thin sheet of plastic, thus preventing evaporation and allowing the ventilation to be reduced. Pool covers have been tried with success on indoor pools, but they tend to be bulky, and this causes problems of storing the cover during the day. Again considerable savings could be made if this problem was overcome, although the use of a cover would detract from some potential energy savings of the heat recovery unit. Estimated savings for the pool cover were as follows:

Estimated Capital Cost	-	£1,000 (1978 prices)
Estimated Fuel Savings	-	£800/yr
Payback Time	-	1.3 years

Solar panels

Swimming pool heating is an ideal application for solar panels because solar panel efficiency depends in part on the end use temperature, the lower the temperature at the point of use, the higher the collection efficiency. Swimming pools are an example of low temperature use, and outputs of 500kWhr/m^2/yr are therefore possible even from single unglazed panels. For this pool a collector area of 150m^2 of panels could have been installed and savings for the panels were estimated as follows:

Estimated Capital Cost	-	£4,000 (1978 prices)
Estimated Fuel Savings	-	£600/yr
Payback time	-	7 years

Although the final pool design did include the heat recovery unit as originally intended, the pool cover was not installed, largely on space considerations, neither were the solar collectors installed, since construction was too well advanced by the time the study was completed. Currently the heat recovery unit appears to be performing well, making an estimated savings of about £5,000 worth of fuel per year.

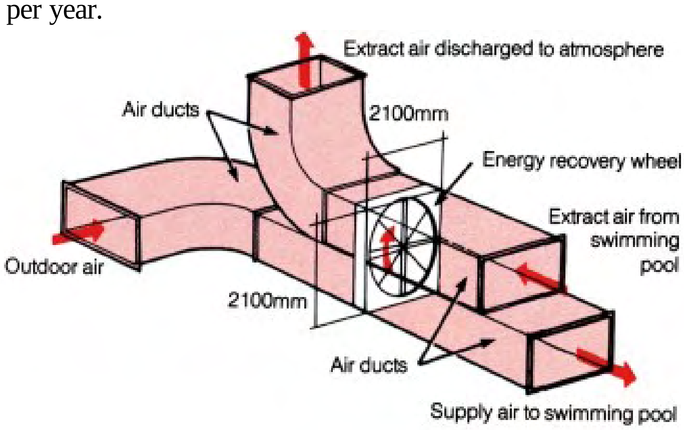


Fig. 28 Woughton Campus swimming pool: heat recovery wheel

5 TECHNICAL STUDIES

Since feasibility studies indicated that there was considerable scope for energy savings if new techniques were further developed, and since there were few technical studies available, specific technical projects were done on 'Heat Pumps' and 'Thermosyphon Solar Water Heaters'. In the course of its projects the Unit had found that if it were to convince people that energy conservation actually saved money, it needed more accurate monitoring equipment. Therefore it had to further develop devices such as the 'Differential Temperature Integrator'. These technical studies are summarised in this section.

Heat Pumps

A heat pump is a machine that is fitted to buildings to extract heat from the outside, from the air, the ground or from water, and transfer the heat to be dispersed inside. They work rather like an air conditioner in reverse or like a refrigerator, which extracts heat from the food compartment to cool it down and disperses it through a radiator at the back.

Simply, heat pumps work as follows. A refrigerant fluid is circulated by a compressor through an outside coil of tubes, the evaporator, and an inside coil, the condenser. The fluid in the evaporator coil draws in the heat from outside, evaporating the fluid, which then passes in gas form through the compressor to the inside coil where it condenses, giving up heat at a higher temperature to provide warm air to the inside of the building.

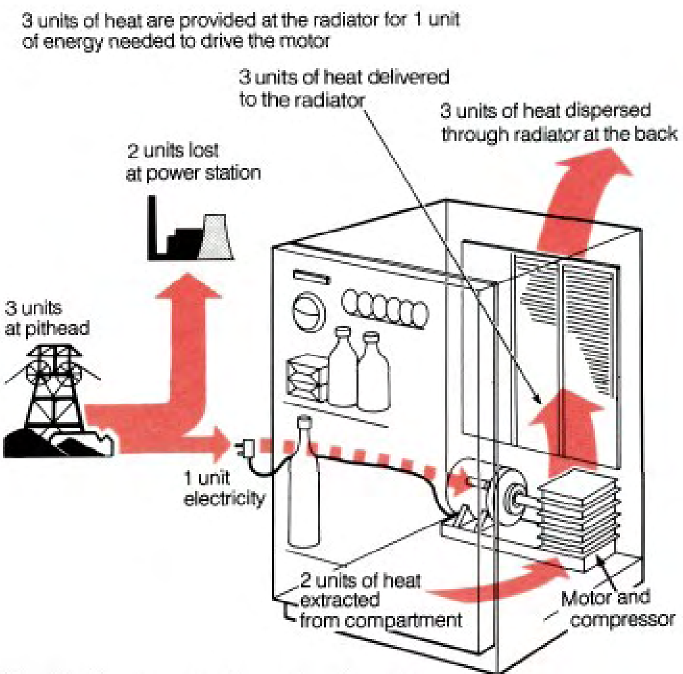


Fig. 29 Heat transfer through a refrigerator

The compressors, which are powered by electric motors or gas motors, use energy. Generally, for every unit of energy going into driving the compressor, about three units of heat can be delivered to the building interior. Since it takes 3-4 energy units of coal at power stations to produce one unit of electricity, an electric heat pump which uses one unit of energy in its compressor is only turning it back into three units of heat. Consequently, electric heat pumps using on-peak electricity are not very economic. However, they can be relatively economic if they use off peak electricity and are used for air conditioning as well as space heating. Also they can be relatively easy to install, and they have been installed in a number of shops and offices. However, electrically driven heat pumps do not have the same energy saving potential as gas fired heat pumps.

Because of this potential, particularly for housing, the Energy Research Group has been carrying out research on gas fired heat pumps, examining the use of gas fired internal combustion engines rather than electric motors. With gas fired heat pumps, primary energy in the form of gas is transmitted directly to the home without being turned into electricity at a power station with the consequent loss of energy.

At present, in houses that have gas fired heating, much of the heat generated is lost either up flues or chimneys. Heat pumps offer the opportunity of providing the same level of heat as a conventional gas boiler using approximately half the energy. Although at present a typical internal combustion engine is generally only 30% efficient, the other 70% of heat can also be used by tapping the engine cooling water and hot exhaust gases. These factors considered, a gas fired heat pump could theoretically be built that is equivalent to a gas boiler with an efficiency of 140%.

The conclusion of this work was that there was considerable potential in the use of gas fired heat pumps to the extent that it warranted further research, particularly in their application for use in housing projects.

The Experimental Gas Fuelled Heat Pump Project

Because little research had been done on the practical application of gas fired heat pumps to domestic uses, in 1977 the Open University Energy Research Group started collaboration with Lucas Aerospace on the design and construction of a prototype machine. This was the first gas-fuelled engine driven heat pump to be built in the UK, the Lucas involvement being a result of trade union interest in such projects. It used a single cylinder motor boat engine converted to run on gas and was capable of providing about 15kW of heat output, enough to heat two or three houses.

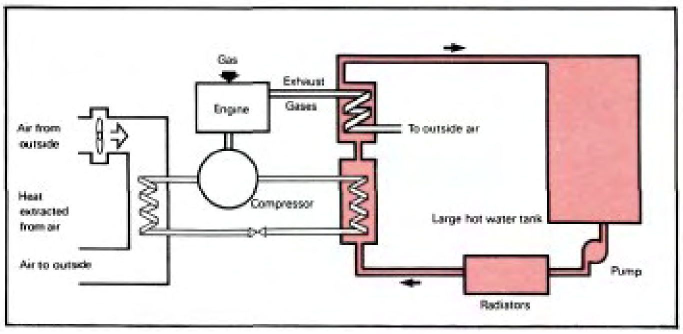


Fig. 30 General arrangement of a gas fuelled heat pump

The heat pump was originally to be installed in a small house at Fishermead in Milton Keynes. Indeed two special hot water storage tanks were built and the heating system of the house was modified to use larger radiators to cope with lower temperature hot water that the heat pump would produce. However, when the machine was delivered, it was found to be more experimental than was originally envisaged, so a programme of extensive laboratory testing replaced the direct practical application of installation in the house. The laboratory tests were completed at the Open University and the machine was transferred to the University of Warwick for a further research programme. This has now been finished and the machine is scheduled to be transferred to Cranfield Institute of Technology for further work.

Fig. 31 OU/Lucas experimental gas fuelled heat pump

The main conclusions of the tests at the Open University were that the engine did achieve its theoretical performance, but that the reliable starting of a single cylinder engine presented a major problem. A more reliable unit would probably use a four or six cylinder car engine which could heat perhaps ten houses, and such units are now becoming commercially available. Although the particular machine examined did not have direct practical application, if, as is likely, a reliable engine system does soon become available, there would be opportunities for a practical demonstration project in the city, either with a large commercial heat pump heating a factory unit, school or group of houses or with newly developed pumps for individual homes.

Thermospyphon Solar Water Heater

Energy used in heating domestic hot water can be high; indeed in a very well insulated house it can be as much as the energy used for space heating. It is therefore equally important to look at ways of reducing hot water energy use as it is for ways of space heating.

One way of achieving savings is to use solar panels to heat or preheat the hot water and so provide some of the needed energy, and well designed conventional solar water heating panels of about 4-5m^2 area can contribute about 30% of the annual hot water requirement of an average house. Unfortunately, the capital costs are too high to make them really economically viable at present. Because of these high capital costs, in 1978 the Unit decided to explore the possibilities of cheaper designs and examined what are known as Thermosyphon Systems.

A conventional pumped solar water heater uses glazed water-filled panels, usually mounted on the roof. When the solar radiation is favourable, the hot water is pumped from the panels to a storage tank in the loft. The pump is turned on by an electronic controller, but both these components, the controller and the pump, are expensive and unreliable and they consume valuable electricity.

A thermosyphon system uses the natural convection of hot water to transfer the collected energy from the panels to the tank. This avoids the need for controller and pump, but it does mean that the panels have to be mounted below the storage tank. This can cause siting problems and overshading problems if the panels are significantly below the roof lines of surrounding houses.

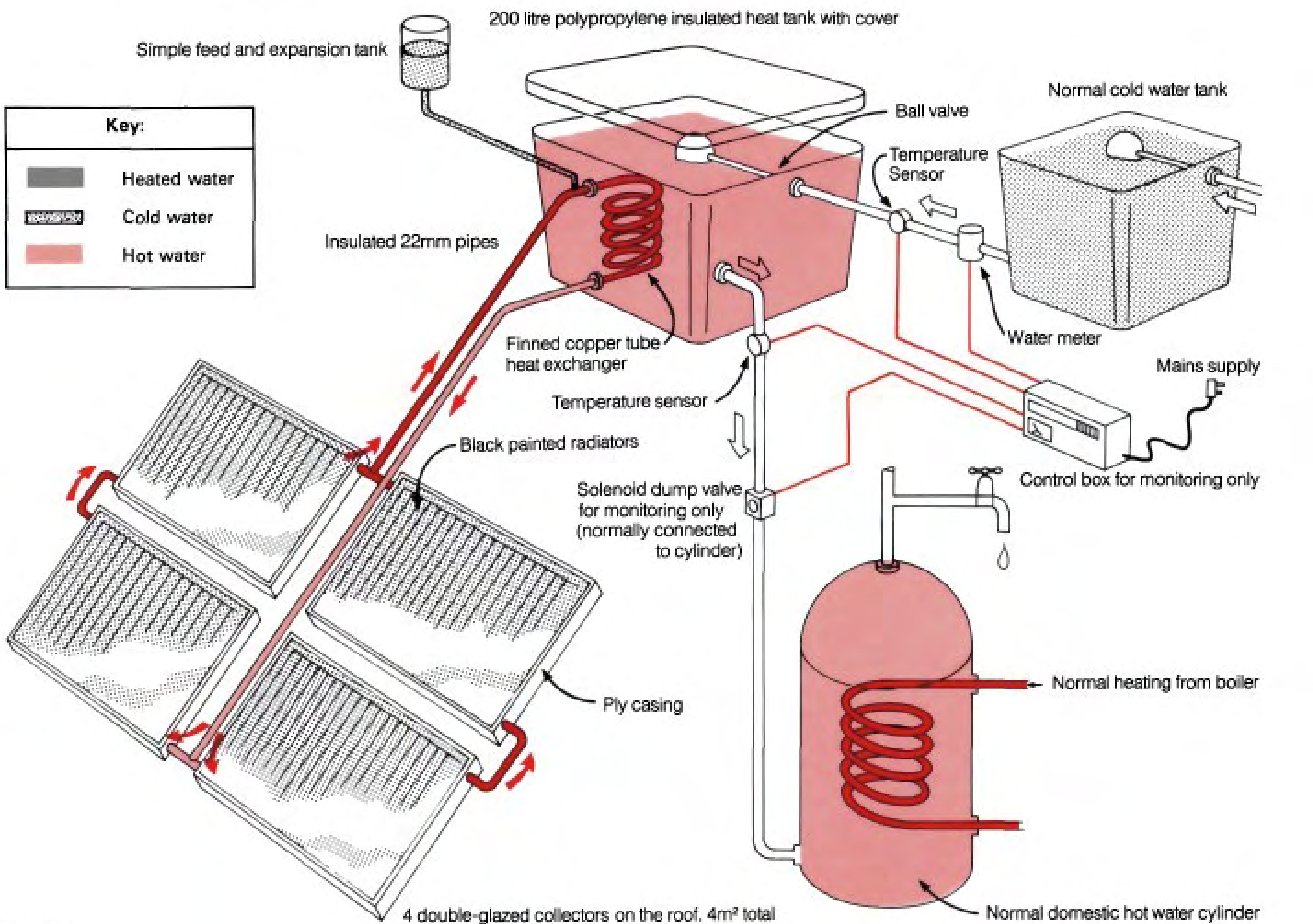


Fig. 32 A thermosyphon system

Since in 1978 there were no published data on the measured performance of thermosyphon systems, the Unit designed and constructed a small $4m^2$ system, such as might be used on a typical house. In order to keep the costs to an absolute minimum, it was made from cheap, normally available materials. The total material cost was about £200 (1978 price).

The system was an indirect one, using a heat exchanger in the storage tank. This allowed the collector to be filled with an antifreeze solution so that it would not have to be drained down in cold weather. It was erected on a house in Stony Stratford in July 1978 and ran until November, when it unfortunately had to be dismantled.

Monitoring was carried out by using a specially designed monitoring/control device which automatically bled off 160 litres of water a day to simulate normal use. The device calculated the energy output of the system from the water temperatures. The measured energy outputs were compared with a computer model of an equivalent sized pumped system, using local weather data. The constructed system seemed to have a measured output consistently about 20% less than that of the computer model, a finding in fair agreement with other research. Using the model to extrapolate over a year, it suggests that the system could produce about 700-800kWhr/yr, provided that more attention was paid to the insulation of the storage tank and some of the pipework.

Costed on a do-it-yourself basis (ie no labour charges), the system would pay for itself in about 25 years against gas prices or about 10 years against on-peak electricity. Since this system was built there have been significant advances in the use of high-temperature-resistant plastics for plumbing and if they were used the system could well become more cost effective.

Differential Temperature Integrator

In order to assess the cost effectiveness of energy saving measures it is essential to be able to monitor their effectiveness relatively accurately, one of the most important indicators being the temperature both inside and outside buildings. As was explained in the Energy Audit for Wavendon Tower offices, a good way to study the thermal properties of a building is to compare weeky fuel consumptions with weekly average outside air temperatures. For detailed studies of building insulation however, knowing only the outside temperature may be inadequate. Researchers are more likely to be interested in the average weekly inside-outside temperature differences, since that is what governs the amount of heat flowing out through the walls and roof of the building.

The problem is that gathering temperature data, inside or outside, can be rather time-consuming. Traditionally it has required the use of small clockwork chart recorders called thermographs, which are cheap and fairly reliable but are tedius to read, particularly in needing the researcher to go into occupied houses to take the readings.

The Differential Temperature Integrator (DTI) is a kind of house temperature meter, and replaces some of the functions of the thermograph. Being small, battery powered and able to be sited and read remotely from the temperature measuring point, it overcomes most of the problems associated with thermographs. It was specially developed for the Pennyland monitoring project, but has a potentially wider application.

The DTI is designed to be wired up to platinum resistance thermometers situated inside a house, nominally one for each zone in the living room, kitchen and a bedroom. A fourth temperature sensor is situated on the outside of the house. The DTI measures each of the inside temperatures, subtracts the outside temperature from each of them and integrates with respect to time. The results, three sets of measured degree-days, one for each zone of the house, are clocked and displayed on the box. The measured space heating consumptions can then be correlated with the measured degree-days and solar radiation measurements in order to work out the passive solar contribution to heating. Instantaneous readings of temperatures can also be obtained from the DTI for the assessment of comfort conditions.

The DTI box itself can be situated on the outside of the house, in the meter cupboard, where it can be read weekly along with the gas and electricity meters and a space heating meter. The box, which was produced by the OU Electronics Common Facility, is now being used successfully on work being carried out on the Pennyland project.

Fig. 33 The Differential Temperature Integrator

6 INFORMATION AND ADVICE

When the Energy Consultative Unit was set up in 1976 there was very little sure knowledge, other than on the subject of insulation, that people could be given. Most innovations on solar energy for instance were untried and untested. However, in recent years, knowledge has gradually become more certain as information has been exchanged with researchers throughout the country and experience has been gained through the work on the considerable number of projects going on in Milton Keynes.

Because of the innovative projects being developed, Milton Keynes attracts a large number of visitors from many organisations from a number of countries, and information has been passed out to researchers and interested members of the public. The Unit has already produced several technical reports and others are in preparation. Also, the Energy Research Group at the Open University have produced a television course entitled 'Energy in the Home', the aim of which is to educate people in the use of energy in their own homes; the course has already been completed by several thousand people.

Energy Advice Centre

People may be aware that they could save money if they introduced fuel saving measures, but they first need the incentive to carry them out. Rising fuel costs have, however, given people a sense of urgency to examine opportunities for fuel saving, and agencies concerned with social issues are taking a particular interest because it is the poorest section of the community that is most affected by fuel price rises, since they spend proportionately the most on fuel.

Residents could be made more aware that introducing fuel saving measures need not disrupt the home, nor need the modifications necessarily be costly to install. So often it has been shown that it is not new systems and appliances that people need; it is understanding how to use existing systems more effectively. Simple measures such as improving draught-stripping, increasing the level of insulation, and improving people's use of the central heating controls have all been seen to assist considerably in reducing fuel bills. A recent survey in Milton Keynes has confirmed that residents could benefit from advice.

It has been found that people need individual advice because the way houses are used by their occupiers varies dramatically. Although commonly assumed that families living in identical houses will have comparable fuel bills, this is not necessarily so. Careful monitoring of houses in different parts of the country has shown that there are variations of 5:1 in fuel use between identical houses. Even people living at the same average temperature can have 3:1 variations in their fuel bills.

Industrialists and occupiers of offices usually take a more commercial view of the possibilities of fuel savings than domestic users, but again there is still considerable scope for energy saving if technical advice is available and acted on.

Although there are commercial advisers and consultants available to give energy advice, professional services can be expensive for domestic users and small businesses. The Open University has been considering one way of providing advice, through establishing an Energy Advice Centre, somewhere where people could go to obtain advice easily. British Gas were the first to pioneer this concept using a shop in the centre of the Birmingham Shopping Centre. It seems to have been a great success and is currently handling 2,000 visitors and customers a week. Such a centre could be considered for Milton Keynes, its aims being:

1 To inform the general public through publicity and educational material of the gains to be made by energy conservation.

2 To provide people with advice and information on energy saving methods.

3 To act with the Development Corporation and welfare agencies to assist people who have particular problems with their fuel bills.

4 To act as a focus for people with longer term energy problems in need of research and development work.

Further consideration, however, should be given to whether energy advice for residents would be most effectively provided by such a centre or through local advisers working in housing areas.

7 OTHER ENERGY PROJECTS IN MILTON KEYNES

Although this report is primarily intended as a description of work in which the Energy Consultative Unit has had some part to play, there are many other projects in Milton Keynes which have had relatively little or no Unit involvement Some of these are given brief introductions in this section to give a more complete picture of energy research and development in the city.

Home Insulation Grants

The Borough of Milton Keynes has been making a contribution to energy saving in its administration of the Home Insulation Scheme, instigated by central government in 1978. Under this scheme, funds are allocated annually by central government to the Borough so that grants can be made available to residents to install insulation in their houses. Local residents living in older properties that did not have insulation installed during construction are eligible for the grants, for loft, tank and pipe insulation. They can receive up to 66% of the cost of the materials for the work, or £65, whichever is the less, and certain elderly people can receive more; their grant may be up to £90 or to a maximum of 90% of the cost

In the year 1980/81 the Borough Council approved over 500 insulation grants. Residents have either used a contractor to install the insulation or done the work themselves, a leaflet is available to assist people with the installation. There is an approved list of products for people to use, it generally allows for loft insulation material of 80mm thickness to be installed.

Rainbow Greenhouse

Brian Ford, from the Department of Design Research at the Royal College of Art, is studying the benefits of attached greenhouses on existing buildings as a passive solar measure. Such a greenhouse is known as a 'sunspace' and is an example of an indirect passive solar system as opposed to a direct system, ie. the sun shines into the greenhouse and the heat is transferred into the house.

In 1979, he constructed a greenhouse attached to one of the Railway Cottages of the Rainbow Co-operative in New Bradwell. The Department of Energy has funded the monitoring of the thermal performance of the system over the winter of 1980/81. This work has been carried out with the assistance of members of the Alternative Technology and Energy Research Groups at the Open University.

Preliminary conclusions from computer estimates suggest that a small greenhouse like this can contribute 1000-2000kWhr of space heating energy per year.

Fig. 34 Rainbow greenhouse

Great Linford Solar Court project

Solar Court, in Great Linford, is a group of 9 houses for sale, including six houses with active solar heating systems. They have been built by a consortium of John Laing R & D Ltd and the Calor Group. Three houses, built by Calor, have 40m^2 of active solar collectors each, connected to large water heat stores. Three houses, built by Laing's have 20m^2 of solar collectors, a heat pump and waste water heat recovery. The other three houses have a conventional heating system and form a control group. The aim of the project is to establish both the costs, benefits and saleability of large active solar systems providing space heating and hot water.

The houses were built in 1980 and will be extensively monitored over the next three years with the aid of funding from the Department of Energy.

Fig. 35 Great Linford Solar Court project

Homeworld 81

Homeworld 81 was an exhibition organised by the Development Corporation of houses of the future. It aimed to be a showcase for developers who were invited to build houses which reflected what they felt would be selling in the future. Thirty-six developers took part in the exhibition which was seen by more than 140,000 people. The houses are now occupied and form part of the city.

The houses contain many novel features and designs, some features being unique to one house, others being demonstrated in several. The most often demonstrated features are the use of timber frame construction in the houses, and the higher standards of insulation that are provided. Over 95% of houses have better insulation than that required by current building regulations, developers undoubtedly feel that such fuel conserving measures would assist them in selling their houses.

Most of the houses have increased insulation in the walls and roofs but some houses have gone well beyond this, demonstrating energy houses where solar energy, high efficiency boilers and energy saving electric appliances have been incorporated. Four interesting examples of energy saving houses and projects at Homeworld are now described.

Fig. 36 Homeworld '81

Futurehome 2000

The Futurehome 2000, which was shown being designed, built and occupied in a series of television programmes, aimed to show sensible energy saving features which are available now.

The house, designed by Energy Conscious Design for the BBC Money Programme, has a large conservatory which faces south. This is heated by the sun, and small fans distribute the heat into the main house. The house is designed so that all major rooms face south and is very well insulated to about twice the current building regulation standards. It has double glazed windows with a special coating which lets in light but gives the equivalent thermal benefit of triple glazing, and is also draught sealed. Doors are foam filled to improve their insulation, and have special magnetic fridge type draught sealing.

The conservatory also serves to support a small solar system for heating domestic hot water, made by Pilkington Solar Products. Unlike normal solar heaters, it needs no separate store, pump or electronic controller, so is cheaper and maintenance free.

The appliances in the house were chosen for their low energy use, for instance, the lights use only a quarter of the energy for the same amount of light as a normal bulb.

Fig. 37 Futurehome 2000

Totem

The Futurehome 2000 also demonstrated three alternative heating systems which could be used, a gas boiler, a coal boiler, and a Totem mini power station. The Totem mini power station consists of a Fiat Car engine which has been adapted to run on gas and is housed inside an acoustic enclosure. The engine drives a generator to provide electricity for the house, while heat from the engine and exhaust which is normally wasted is instead absorbed into a heat exchanger and piped into the house radiators. The whole system is over 90% efficient, one use of it would probably best be applied to a group of up to ten well insulated houses which could be supplied with heat from the engine by small insulated pipes.

The Ideal Home house

This solar house is highly insulated, includes triple glazing and has 27m^2 of solar collectors on the roof. It is similar in principle to the Bradville house but it does incorporate some important improvements:

1 It has a conservatory to improve the level of passive solar energy received.

Fig. 38 Totem

2 The solar collectors are more steeply tilted to improve their level of performance in the winter, and they have an improved collector with a selective surface to increase performance.

3 The design incorporates a chemical phase-change salt heat store which is made by Calor Ltd to replace the idea of using water storage for the heat. This allows the size of the heat storage to be considerably reduced.

4 The heat leakage from the store is ducted into the heating system.

It is estimated that solar energy will supply over 50% of the heating requirements of the house. The project developed by the Ideal Home Magazine and the Copper Development Associations and was designed by Dominic Michaelis Associates.

Fig. 39 The Ideal Home house

Autarkic house

In this house, designed by Autarkic Potentials, energy use has been considered both in its construction and operation; it is a timber frame house using special wood to wood jointing techniques which are cheap and easy to produce in the factory. It can be erected easily with the minimum of labour needed.

Energy conservation has been an important feature of the design. The house is intended to be more draught-proof and airtight than standard designs, so preventing energy losses. The cavity walls are partly filled with foam, but an air cavity has also been kept to form part of a comprehensive ventilation system. The system has been combined with a conservatory to provide low cost heating as well. Even without the ventilation system, solar energy can be stored in a glass wall filled with Calor eutectic phase-change salts. The ventilation system increases the effectiveness of this by recycling the warm air stored in the salts and distributing it around the house.

Autarkic Potentials calculate that these systems can achieve a 30% saving on the costs of heating the house.

Fig. 40 The Autarkic House

Milton Keynes District General Hospital

The Milton Keynes District General Hospital is currently under construction, and will ultimately contain 800 beds, the first phase being planned to open in 1983. The building's construction is the first example of the Oxford Method, a computer aided design system developed by the Oxford Regional Hospital Board architects which enables design times and building costs to be significantly reduced.

Hospitals are normally very large users of energy since, unlike houses, they need to be heated continuously and generally have to be kept at a higher average temperature than houses. Because of there being large fuel bills, the designers have tended to apply many energy conserving features to the hospital design. One of these is a very high standard of wall insulation which is over four times higher than the normal standards of a few years ago.

Large amounts of energy are used to heat hot water in hospitals. The designers plan to reduce this by using a large 150m^2 array of solar panels to heat the water. Incoming cold water would be preheated by the panels, and then boosted to the required temperature by conventional heating.

The solar panels currently available, normally made up of a metal plate with integral tubes insulated on the back and protected with a glazed box, are expensive. The Unit has researched other possible forms of panel including unglazed plastic panels, the type normally used for heating swimming pools. These panels are considerably cheaper and calculations have shown that they could pay back in about six years or less.

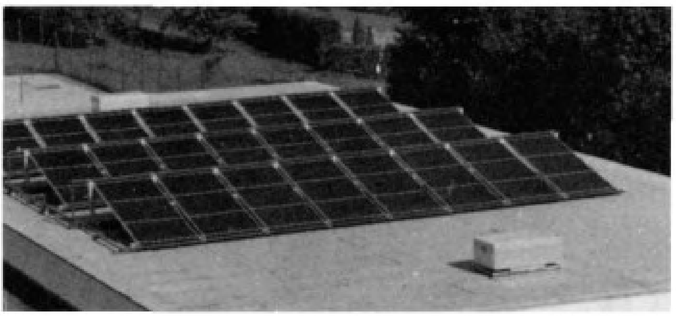


Fig. 41 A roof mounted solar panel array

Prometheus

This is a solar energy project which is being developed as a small prototype by the OU Physics Department in conjunction with the Energy Research Group.

A full scale project would be a set of flat plate evacuated solar panels and an insulated rock bed to store heat, carrying over solar energy interseasonally from summer through to winter, it is hoped providing all year round space and hot water heating for up to 100 houses. The most difficult part of the project is the development of a highly efficient inexpensive solar panel, the prototype uses a vacuum between its double glazing to reduce heat losses and promises to be both effective and relatively cheap.

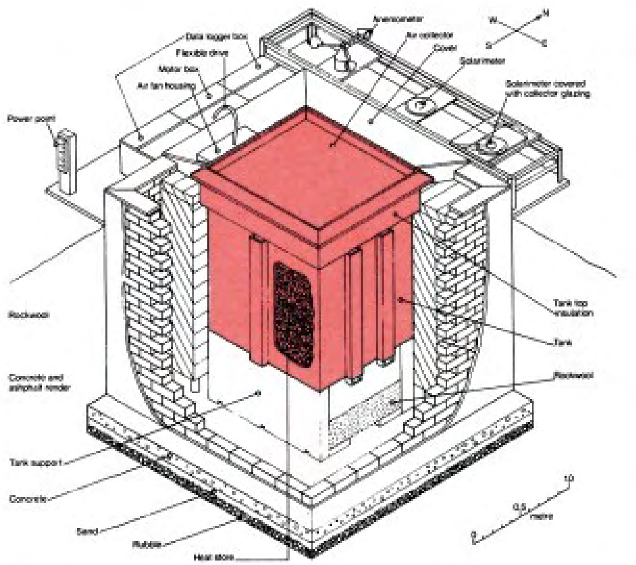


Fig. 42 Prometheus Project

Chemical heat pump

This is a joint project between the Energy Research Group and the Rutherford Laboratories and is being funded by the Science Research Council.

The chemical heat pump energy storage system is based on the dilution and reconcentration of a sulphuric acid/water mixture. The use of this process as a heat pump is not new, it was commonly used for ice making in the nineteenth century. Several prototypes have been built at Rutherford over the past few years.

The process has potential for both the storage of solar heat from summer to winter and the use of waste heat from industrial processes, both storing it and in increasing the temperature.

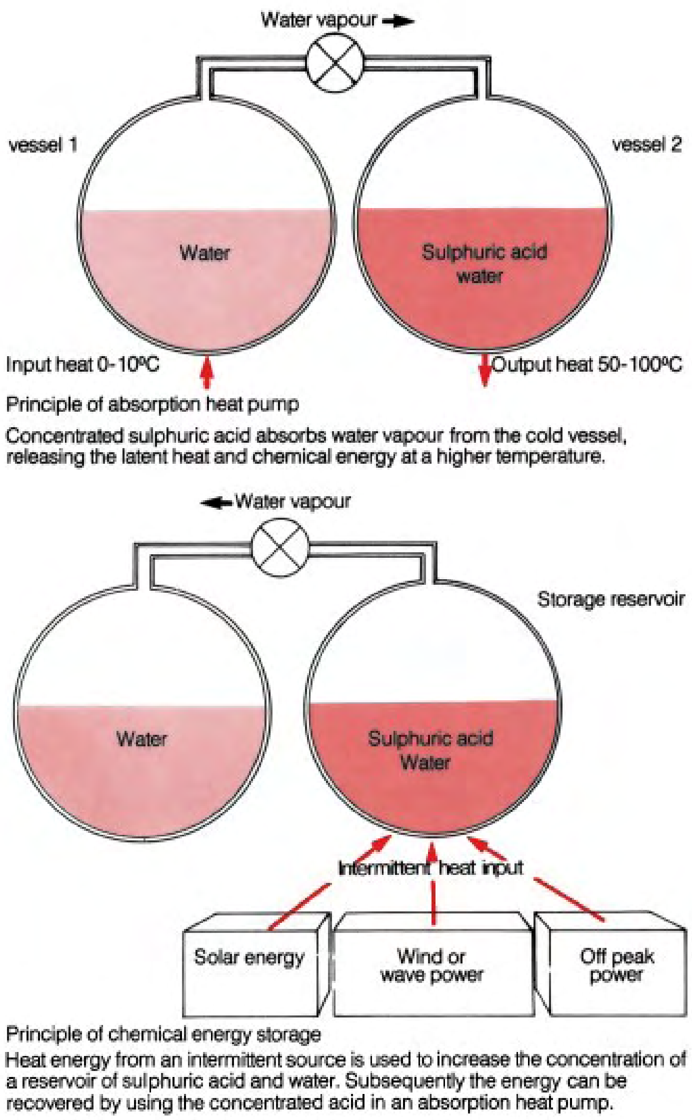


Fig. 43 A chemical heat pump

Car sharing meter

The average British motorist spends about £500 per year on petrol but motorists are usually unaware of how much money they spend, it can easily be double the amount that people might spend on heating their home. Much of the time cars carry only one person, and this can be extremely wasteful of energy.

The car sharing meter developed by the Open University Alternative Technology Group is a device designed to promote the shared ownership of cars, thus keeping capital costs down.

The costs are shared on a pence-per-mile basis, the meter keeping a continuous record of the number of miles driven by each user. The meter calculates a continuous bill for use for each driver, in much the same way as a taxi meter. The users are thus made continually aware of their travelling costs, a factor which is very likely to keep down unnecessary journeys and make them consider alternative modes of transport

The car-sharing meter is currently being developed with a Microprocessor Development Grant from the Department of Trade and Industry.

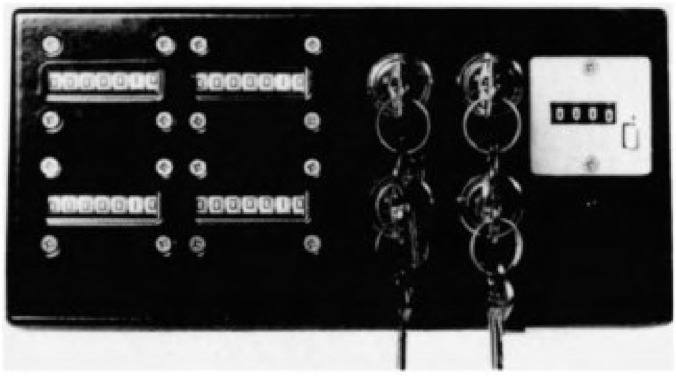


Fig. 44 Car sharing meter

Open University Energy Projects

A number of departments of the University have been involved in energy research, two groups particularly, the Energy Research Group and the Alternative Technology Group.

Energy Research Group

The Group was set up in 1974 as a result of interests in energy studies that arose during the production of a materials Science Course at the OU. Since 1978 it has officially been a part of the Technology Faculty and currently contains about 30 members.

Following the 1973 energy crisis there was a considerable increase in funding for energy projects, in particular detailed analysis of energy use in the UK economy. Projects have included detailed studies of the electricity industry, the gas industry and the potential for extracting crude oil from shale and tar sands. In 1976 the Transport and Road Research Laboratory commissioned a study on the long-term availability of fuels for transport, subsequently continued with studies of the potential for electric vehicles. Also in 1976 the initial foundations were laid for the housing projects in conjunction with the Development Corporation, the gas-fired heat pump project and the chemical heat pump project also described in this review.

In 1977-78 the Group produced an 'Energy in the Home' course for the Open University, aimed at teaching householders more about the practical problems of domestic energy conservation. Also in 1978 the group was commissioned by the National Consumer Council to undertake a study of consumer interest in energy policy.

There is a continuing interest in energy policy issues, particularly in the potential for energy conservation and the introduction of renewable energy resources. More recent work includes the analysis of the national potential for wind power, hydroelectric power and energy conservation, using detailed computer models, and the design and construction of an experimental electric heat pump system. Other work is more wide-ranging, such as the design of fuel saving cookers for the third world and agricultural investigations of growing several crops together to increase total yields.

The Alternative Technology Group

The Group was set up in 1976 and currently contains about 10 full-time research workers.

The watchword of this group is 'self-sufficiency' and as such the research covers the fields of recycling, energy conservation, cooperative organisation and community enterprises.

Some energy research in which the Group has been involved, the Car Sharing Scheme and Rainbow Greenhouse, have already been referred to in this report, other projects concern:

1 The food production efficiency of small-holdings; this has involved the work of Brenda and Robert Vale at their small-holding in Cambridgeshire;

2 The design of improved load-carrying tricycles for use in the third world;

3 Studies of community-scale waste paper recycling.

4 The construction of a 4.5 metre diameter windmill for electricity generation. This is a test rig for experimenting with different blade designs.

5 Community energy systems for developed and developing countries.

The group played a predominant role in organising COMTEK, a community technology festival which took place in Milton Keynes in 1979.

8 ACKNOWLEDGEMENTS AND CONTACTS

The Energy Consultative Unit was established in 1976 by Milton Keynes Development Corporation with Professor Chapman of the Open University. It currently comprises J Doggart of MKDC and R Everett of the Open University Energy Research Group, and is directed by D Ritson of MKDC.

This report has been compiled by S Fuller of MKDC with J Doggart and R Everett of the Unit. The projects described in the report represent the work of a considerable number of people, some are mentioned as contacts, but the majority are acknowledged in the individual technical papers.

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