#5940

SOLAR ENERGY
A Renewable Energy

SOLAR BUILDING STUDY

Summary Report

Oak Farm Road

ETSU S 1160/SBS/10

The work described in this report was funded by the Department of Energy and managed by the Energy Technology Support Unit (ETSU) at Harwell. The views and judgements expressed in the report are those of the contractor and do not necessarily reflect those of ETSU or the Department of Energy.

In preparing this report we acknowledge the assistance of the Building Research Establishment, who provide technical consultancy services to the Department of Energy's Passive Solar Design Programme.

"This report is one product of the Energy Performance Assessments project, a programme of field trials in a wide range of occupied buildings, covering the range of UK latitudes and climates.

The aim of the field trials is to assess the costs and benefits (energy, financial and amenity/environment) associated with incorporating passive solar principles within building design."

ENERGY PERFORMANCE
ASSESSMENTS

SOLAR BUILDING STUDY

EPA SUMMARY REPORT
RESEARCH RESULTS

OAK FARM ROAD HOUSE

The total fuel use of 12400 kWh was low, and the space heating fuel use of 8000 kWh is about a third less than that of a conventional house.

The solar performance resulted in a measured solar contribution of 855 kWh. In a typical weather year solar gains can displace up to 25% of the heat required from the space heating systems.

The house was built for 2% less than an equivalent non-solar house of the same size, built to the same insulation standards.

The occupants liked the daylight and view provided by the large windows on the south of the house. The north facing kitchen was considered to have too little daylight.

More regular use of the blinds in the living room could have increased the solar gains.

ENERGY PERFORMANCE ASSESSMENTS

Client
Bournville Village Trust

Architect
A. Plasted

Building Type:
Two-Storey, Semi-Detached

Solar Features:
Direct gain by extensive south-facing glazing.

Location:
Birmingham

Date Occupied:
1985

Size:
Gross Floor Area 77m²

EVALUATIONS

ENERGY	★★★★
SOLAR DESIGN	★★★★
AMENITY	★★★
COST	★★★★★

These evaluations are based on 12 months monitoring, interviews, questionnaires, and modelling studies. For ease of comparison with other studies in this series, performance has been summarised under the four headings in the following way. Five stars indicate an excellent, three an average, and one a poor standard.

THE BUILDING

DESIGN

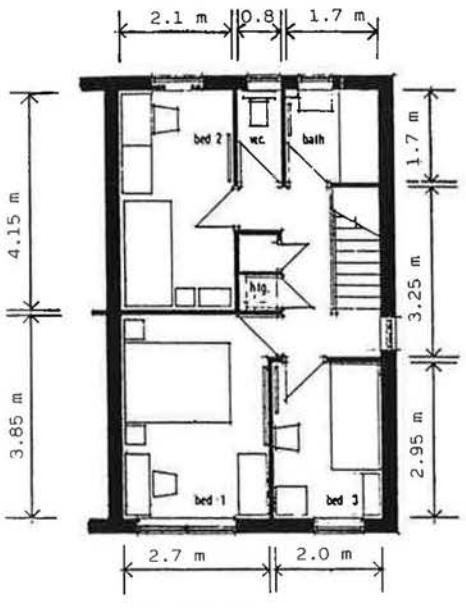
The Oak Farm Road house was built during 1984 as part of a housing estate of around 300 passive solar houses. It is a two-storey semi-detached south facing house with the main entrance on the north side and the south facade overlooking the rear garden.

The primary requirement of the buildings was for them to be constructed with a highly insulated envelope ('U' value 0.3 W/m^2K) and with the concrete ground floor, partition walls and a 100 mm concrete inner leaf to all external walls acting as the heat storage medium.

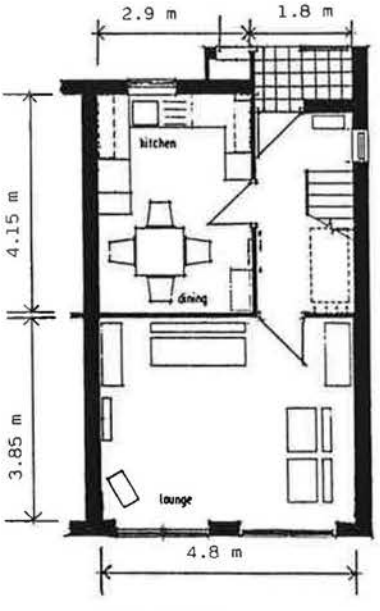
The initial solar design objective of the Bournville Village Trust solar housing development at Oak Farm Road was to orientate the buildings concerned so that all of the main living areas faced south (or within 30° of S). This involved attention to site layout and landscaping.

Glazing to approximately 50% of the total south facing wall area was the main passive solar design feature. Heat reflective blinds for control of night-time radiation and solar protection were specified for all windows. Externally, reflective ground finishes were specified in front of the south facing windows.

Minimal heat loss to the north, east and west elevations was ensured with all areas of glazing on these sides being as small as possible. Double glazing and weather-stripping of all external doors and window openings were also employed. The architect believed that it was necessary to have blinds/shutters in order to avoid excessive heat gain during hot summer periods and to retain stored heat during night-time.



first floor plan



ground floor plan

Designer
A. Plasted
Bournville Village Trust

Site Data
Sheltered urban site, unobstructed to the south.
Latitude 52°25'N
Altitude 132m

Climate Data
Degree Days

Mar 87 - Feb 88	2451
20 year average	2495

THE BUILDING

Floor Areas:	m^2
Living area	- 77
Habitable area	- 56.1

U-Values: (Theoretical)	W/(m^2K)
Floor	- 0.58
Wall	- 0.30
Roof	- 0.35
Window (incl frames)	- 2.04

Space Heating:
12 kW Harvey Habridge Impala 2 low pressure hot water gas boiler.

Design Condition:	
Internal Temp	- 17°C

Glazing Distribution		m^2
South	(74%)	11.0
North	(18%)	2.7
West		-
East	(8%)	1.1
TOTAL		14.8

DESCRIPTION

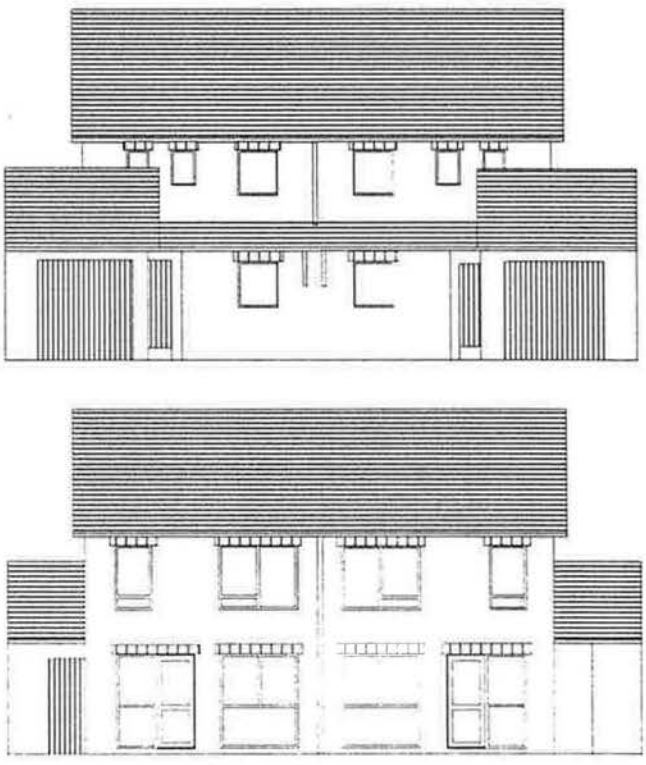
It is a two-storey semi-detached south facing house with the main entrance on the north side and the south facade overlooking the rear garden. The pitched roof is of symmetric design with a 32° pitch. The ground floor consists of a north facing kitchen/diner, a south facing lounge, and a hall and stairwell. On the upper floor, there comprises a north facing bedroom, bathroom and separate WC, two south facing bedrooms, and the landing and stairwell. The house has a gross floor area of 77 m^2 and the design seems typical of the three bedroom semi-detached private-developer market. The garage was detached, situated to the north of the house.

CONSTRUCTION

Cavity wall construction with 100mm facing brick, 100mm granular polystyrene insulation, 100mm dense concrete block inner skin. Internal walls of 100mm dense concrete block. Ground floor reinforced concrete on 50mm thick by 900mm wide polystyrene edge insulation.

PASSIVE FEATURES

* Glazing to approximately 50% of the total south facing wall area.
* South orientated house (as is the whole site).
* Heat reflective blinds for overheating protection and night control on all windows.
* External, sunlight reflective, ground finishes to south facing windows.



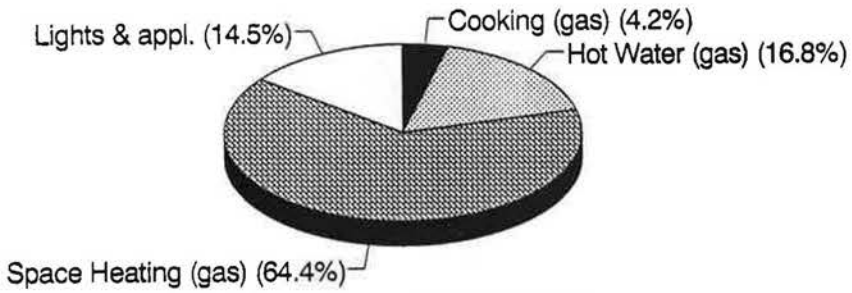
PERFORMANCE

ENERGY AND ENVIRONMENT

To derive the data on this page, climate, internal temperature and fuel use were measured automatically for a year and other measurements were made in a short concentrated study period. The data here were obtained from monitoring carried out between March 1987 to February 1988.

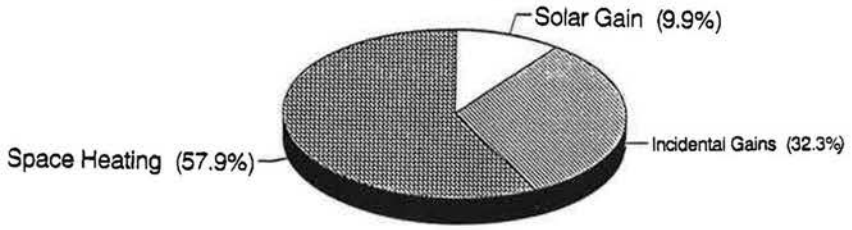
Annual delivered fuel use during the monitored year was 12405 kWh. Of this some 104 kWh/m^2 was used for space heating. This compares favourably to average figures for the type and size of dwelling.

Annual Delivered Fuel



	kWh	GJ	kWh/m^2	Primary Energy
Gas	10600	38.2	138	11340
Elec	1805	6.5	23.4	6890
Total	12405	44.7	161	18230

Annual Energy Balance for Heating



	kWh	GJ
Space Heating	5023	18.1
Incidental Gains	2799	10.1
Solar Gains	855	3.1
Total	8677	31.2

MEASURED PERFORMANCE

Heat Loss Coefficient	130W/K
Effective Solar Aperture	5m^2
Solar Displaced Space Heating	17%
Solar Contribution	10%

OCCUPANCY

The house was occupied by two working adults. The heating periods were morning and evening during weekdays. Generally low internal temperatures were accepted.

MONITORING CONDITIONS

Mean Internal Temp:	18.1°C
Mean External Temp:	6.28°C
Degree Days (15.5°C)	2451
Vertical South Solar Radiation	496 kWh/m^2

20 YEAR AVERAGE WEATHER

Degree Days	2495
Vertical South Solar Radiation	749 kWh/m^2
Solar Displaced Space Heating	6.6 GJ

ADJUSTED PERFORMANCE

Solar Gain	**1270**
Space Heating Energy	**4880**
Solar Displaced Space Heating	**26%**
Solar Contribution	**14%**

Using the blinds in line with the designers intention could increase the solar gains by about 15%.

Solar Displaced Space Heating: The amount of space heating energy displaced by solar gains. Expressed as:- (SG/SH)*100%

Solar Contribution: The relative contribution of solar gains to the overall energy loss of the building. Expressed as:- (SG/(SG+SH+IG))*100%

PERFORMANCE

MODELLING DATA

Climate: Kew 1964-65
Occupancy demands:
Typical

Annual Building Heat Loss:	14054 kWh
Space Heating	4330 kWh
Solar Gains	2906 kWh
Solar Displaced Space Heating	67%
Solar Contribution	21%

Simulating the observed use of the blinds indicated a reduction in solar gains of 505 kWh/yr.

REFERENCE MODELLING
(Monitored Conditions)
(Over Heating Season)

Mean Internal Temp:	18.1°C
Mean External Temp:	6.28°C
Annual Degree Days (15.5 °C)	2451

BREDEM PREDICTIONS

Reference 1: Insulated to the same level as Oak Farm Road.

Annual Building Energy Balance kWh:	
Solar Gain	1613
Space Heating	6768

Reference 2: Insulated to the Building Regulations of 1982.

Annual Building Energy Balance kWh:	
Solar Gain	1774
Space Heating	14196

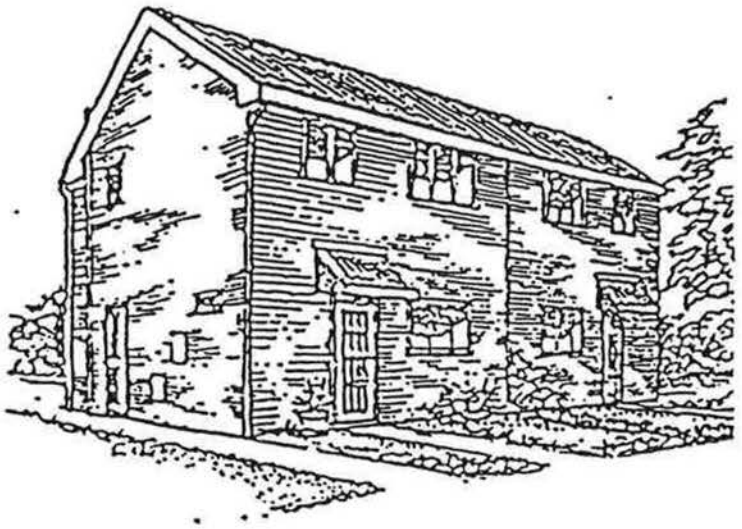
DESIGN STUDY

The energy consumption figures described to the left come from simulations using the SERI-RES computer model with standardised climate and occupancy conditions.

The range of values below are also derived from the model and indicate how the solar displaced heating energy responds to occupancy demands. The range of occupancy demands vary from; whole house heating all day with night setback as a high demand, to part house heating for part of the day for the low demand.

Occupancy Level	Temperature Demand	Solar Gain kWh	%Solar Contribution
High	20°C	2637	16
Medium	18°C	2906	21
Low	16°C	3243	29

REFERENCE HOUSE



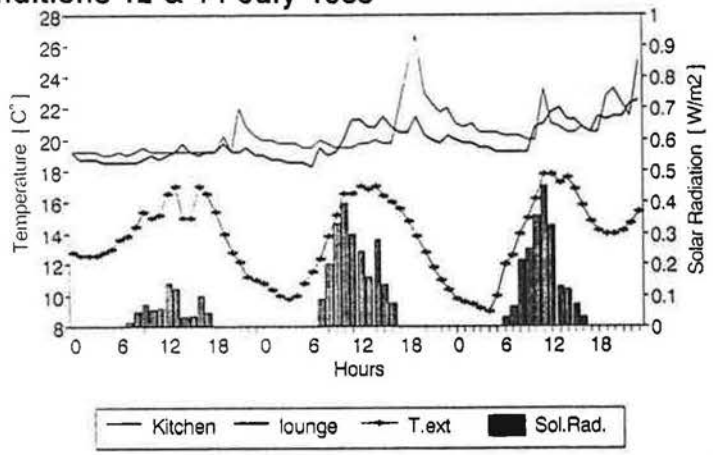
The results obtained show that for a low energy house, (Reference 1 - without passive solar features but to the same insulation standards) occupied in the same manner as Oak Farm Road, the fuel used for space heating would be 10175 kWh/yr. For the test house the *measured* results for the monitored year produced a value of 7979 kWH. If a direct comparison can be made, this would be a saving in bought energy of about 20%.

PERFORMANCE

AMENITY

The occupants were pleased with their passive solar home, it was thermally, visually and acoustically comfortable although they felt the house had one problem in that the kitchen could have been better daylit. They enjoyed the visual and thermal benefits of the large south facing windows in the lounge, but there was seen to be some conflict between daylighting benefits and thermal comfort. Keeping the blinds open to take advantage of early evening light caused unwanted heat loss. The house was seen as slightly out of the ordinary but not sufficiently so as to present any difficulty if resale became necessary. The occupants were pleased with their home's heating costs.

Two Day Plot of Internal Temperatures and External Conditions 12 & 14 July 1988



No major problems were identified regarding controlling environmental conditions. The day-to-day use of the house resulted in the blinds and curtains of the lounge being left closed on many days. This obscured the direct solar gain, and reduced the effective solar aperture of the house. Some of the sealed double glazing units failed, as condensation was sometimes found to be present within the panes. Energy and related issues played very little part in the occupants choice of house which was most influenced by advantageous purchasing arrangements and thermal comfort considerations. However, having lived in a passive solar home the presence of passive solar features would play an important part in the occupants decision to purchase any future home.

COST

The Oak Farm Road house was about £680 (2%) less expensive than an equivalent non-solar reference house to the same insulation standards. In this case it is worth noting that the latter had greater length of partition walls; larger window area and larger internal wall area.

Compared with a less well insulated reference house, Oak Farm Road was about £830 (2.8%) more expensive. This increase can possibly be weighed against the inclusion of double glazed windows (£329) and an increase in the insulation standards.

AMENITY RATINGS

The occupants were asked to rate various aspects of their home on a scale of one to five. One denotes a very poor rating and five a very favourable rating.

Occupants' Ratings of their Home.

	M	F
Thermal comfort in the winter:	5	4
Thermal comfort in the summer:	5	5
The effort needed to keep the home warm in winter:	5	5
The effort needed to kept the home cool in summer:	5	5
Adequacy of heat distribution through the home:	4	3
Quality of the air indoors:	4	5
Soundproofness from outside noises:	4	4
Amount of daylight entering South facing rooms:	-	5
Amount of daylight entering north facing rooms:	-	2
Extent of the view of outside from indoors:	4	5
Privacy from outside viewers:	4	3
its standard of construction:	3	4
its general character & atmosphere:	5	4
External appearance from the rear (south):	4	2
External appearance from the front (north):	4	2
Internal appearance:	5	4
Internal layout and design:	5	4
its resaleability:	4	4
its heating costs:	5	5
OVERALL:	4	4

COSTS At 2nd Quarter 1989	£
Oak Farm Road	34,482
Reference 1	35,170
Reference 2 (to 1982 Building Regulations)	33,651

ASSESSMENT

EVALUATIONS

These evaluations are based on 12 months monitoring, interviews, questionnaires and modelling studies. For ease of comparison with other studies in this series performance has been summarised under the four headings in the following way. Five stars indicate an excellent, three an average, and one a poor standard.

ENERGY ★★★★

Basically, the house succeeds as a low energy house. Because of the low occupancy levels of the house, the annual fuel use is low. A more accurate measure of the energy performance of the house is the effective heat loss coefficient (~ 125 W/K) which is considered quite low and indicative of the building giving the desired level of heat loss. The house is quite tight in construction with good thermal insulation levels although infra-red thermography showed there was some thermal bridging through edges and corners, and some missing insulation.

SOLAR DESIGN ★★★★

The passive solar design features of the house had a significant effect on the building's energy use with a potential 26% displacement of the space heating energy, or a 14% solar contribution. Simulation with SERI-RES showed a potential increase of 17% in the solar gains if the lounge curtains were assumed to be operated as intended during week days.

AMENITY ★★★

In general, a moderately liked and aesthetically pleasing environment. The occupants enjoyed the benefits of the large south facing windows in the lounge and felt the house was energy efficient but thought the kitchen could have been better daylit. There was little incidence of overheating.

COST ★★★★★

The cost of the Oak Farm Road was about 2% (£700) less than an equivalent non-solar house built to the same insulation standards. At this reduced cost, the passive solar features have been provided, especially the inclusion of double glazed windows and a better than Building Regulations insulation standard. Compared with an equivalent house built to the lower Building Regulation standards (1982), the house cost about £800 more.

COMPOSITE ★★★★

A good energy and adequate solar performance obtained at no extra cost. A liked and affordable house with few faults. The dark kitchen/dining room was the major source of complaint.

ASSESSMENT

CONCLUSIONS

A low energy passive solar house can be constructed at no extra cost and provide useful energy savings. Simple direct gain design with the glazing redistributed to the south face can be successful and provide a satisfactory environment with little overheating.

A developer of good quality low cost housing can make a significant contribution to energy conservation by careful design.

LESSONS AND RECOMMENDATIONS

The house is a very straightforward design featuring redistribution of glazing from the north to the south facade. The simple direct gain design strategy can be little improved upon.

Reducing the size of windows on the north side, to reduce heat loss, should not be taken too far, as in this house the occupants disliked the gloomy kitchen. A consequence can be increased usage of electric lighting.

The occupants did not always operate the blinds as the designer intended. This had the effect of reducing the solar gains. The effect was small but it does show the potential for operation of solar devices to be at odds with the designers intentions.

Operation of solar control blinds and curtains should be made as simple as possible and amenable to the occupants' wishes.

FURTHER INFORMATION

ETSU Renewable Energy Enquiries Bureau:
Telephone: 0235 432450.

BRECSU Enquiries Bureau:
Telephone: 0923 664258.

EPA Technical Report:
ETSU Report - 1160/10

Solar Building Studies are summary reports of the Energy Performance Assessment project. This is funded by the Department of Energy through its Energy Technology Support Unit at Harwell. The R&D is carried out by Databuild (Birmingham) and UWCC (Cardiff). The views contained in this document are those of the authors. The EPA of Oak Farm Road was carried out by Databuild (Birmingham).

The co-operation and assistance of the occupants and all those concerned with the building reported here is gratefully acknowledged.