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THE EFFECT OF TREE PLANTING ON ENERGY USE IN PASSIVE SOLAR HOUSING

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THE EFFECT OF TREE PLANTING ON ENERGY USE IN PASSIVE SOLAR HOUSING

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THE AIM OF THE PROJECT

The aim of the project was to provide preliminary quantitative estimates of the effect on energy use of planting shelter belts, taking into account any losses from reduced solar gain, in relation to a limited number of housing estate layouts already studied as part of the ETSU Passive Solar Programme.

The work formed part of a series of studies on energy saving through site planning sponsored by the Property Services Agency in association with the Building Research Establishment.

SCOPE OF THE WORK

Work was concentrated on the following:

1 Measurement of the extra heating demand from perimeter shelter belts on three housing estates.

2 Generic studies of increased heating demand in relation to a variety of house/shelter belt configurations.

In addition, available literature on the design of shelter belts was reviewed and the implications for the planning of housing layouts was estimated.

ASSUMPTIONS MADE IN THE ANALYSES

For the purposes of measuring the effect on solar performance, the following assumptions were made:

* The shelter belts achieve 50% air porosity by using a mixture of deciduous trees and evergreens.

* An air porosity of 50% corresponds to a visual porosity of 30%; our solar obstruction measurements were corrected therefore by a factor of 0.7 to obtain the effect of trees.

* All percentage increases in heating demand are related to the optimum value of 7721 kWh/year calculated during our ETSU project for an unobstructed solar house facing South. The house design is the solar house at Great Linford, Milton Keynes, insulated to the 1982 Building Regulation Standard.

* The sites are flat.

* Heating demand is the net useful heating requirement which remains having made allowance for contributions from internal and solar gain. The breakdown of the contributions is:

- Total requirement	19666 kWh
- Useful internal gains	5466 kWh
- Useful solar gains	6479 kWh
- Net heat demand	7721 kWh

STUDIES OF HOUSING ESTATES

Five site layouts were measured to determine the effect of perimeter shelter planting on heating demand. Possible arrangements of mid-site shelter planting were investigated but not measured.

As our study was concerned with 'passive solar' house design, we limited our analysis to those site layouts which were designed using solar layout principles, ie with the orientation of the solar collection facade within 30 degrees of South.

The effect of tree belts to the West, South and East of the site were individually identified. The total percentage increase in heating demand, additional to that already resulting from the buildings on each layout, was found to be as follows:

Type of site		Site reference	Percentage increase due to trees: 10 metre belts	Percentage increase due to trees: 20 metre belts
Terraced	(1.51ha)	T2	2.70	-
Detached	(1.40ha)	D2	2.03	6.70
		D3	2.55	8.26
Mixed	(2.28ha)	M2	1.21	4.62
		M4	0.90	4.12

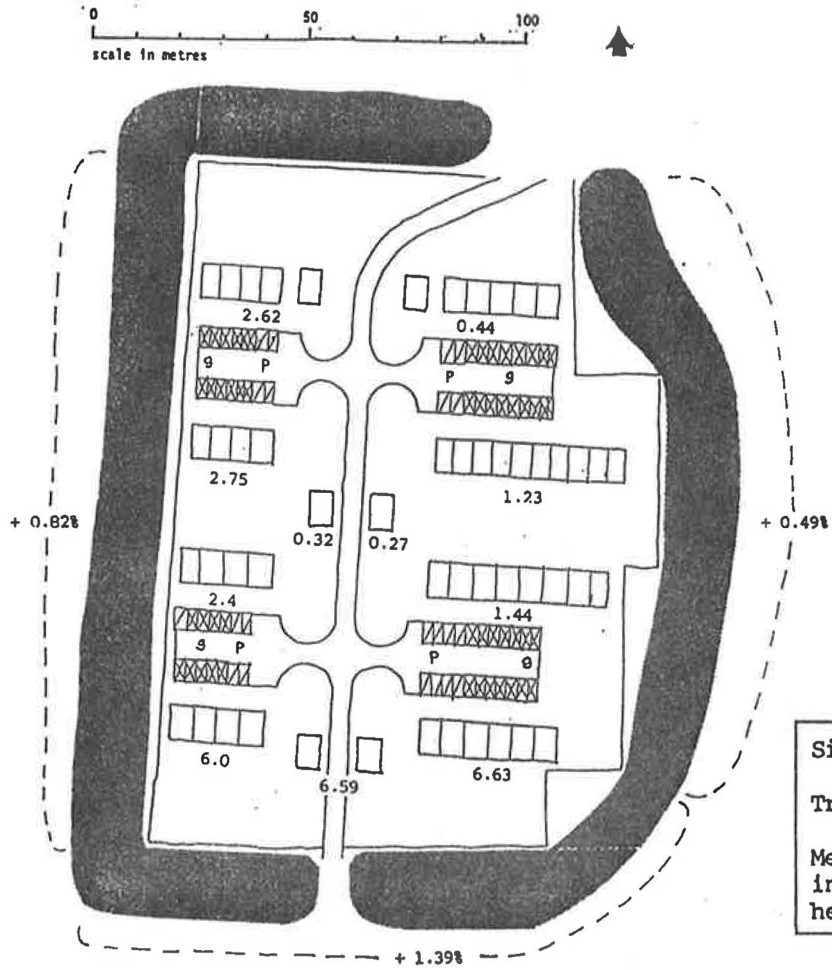
Note: Percentages are of 7721 kWh/year - the optimum heating requirement for our standard south facing unobstructed solar house.

The results of this analysis are encouraging in that the average increase in heating demand for sites with a 10 metre shelter belt is less than the estimates of the energy benefit thought by various researchers to result from tree planting. These range between 3 and 5 per cent.

Clearly, the 20 metre high belt has a greater impact than the 10 metre, the average increase in heating being between 4 and 8 per cent. There is as yet no information readily available with which to estimate the energy savings likely to result from the presence of shelter belts of different heights.

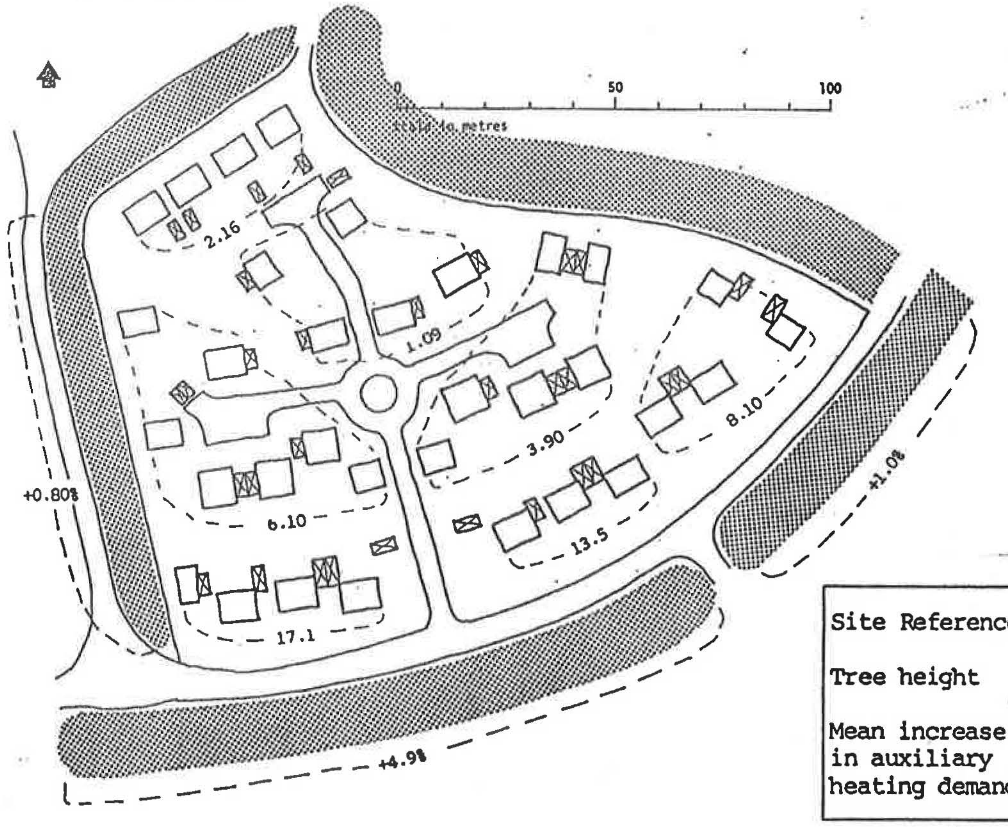
One layout from each site is illustrated on the following pages.

Site of TERRACED houses with 10 metre tree belts (T2)



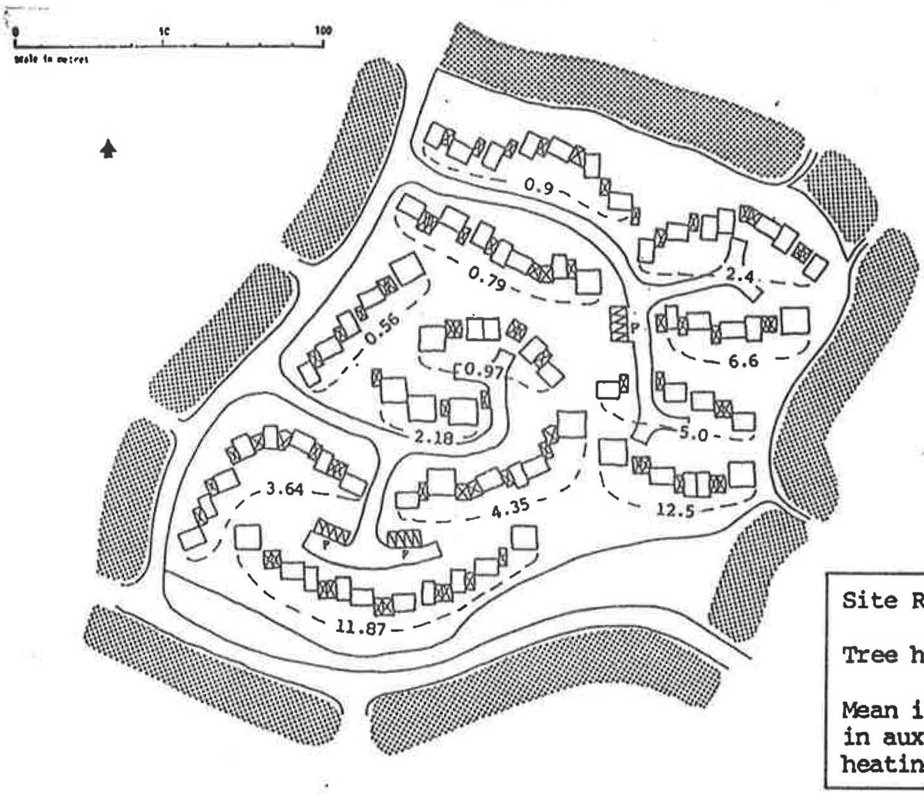
Site Reference	T2
Tree height	10 metres
Mean increase in auxiliary heating demand	+2.7%

Site of DETACHED houses with 20 metre tree belts (D3)



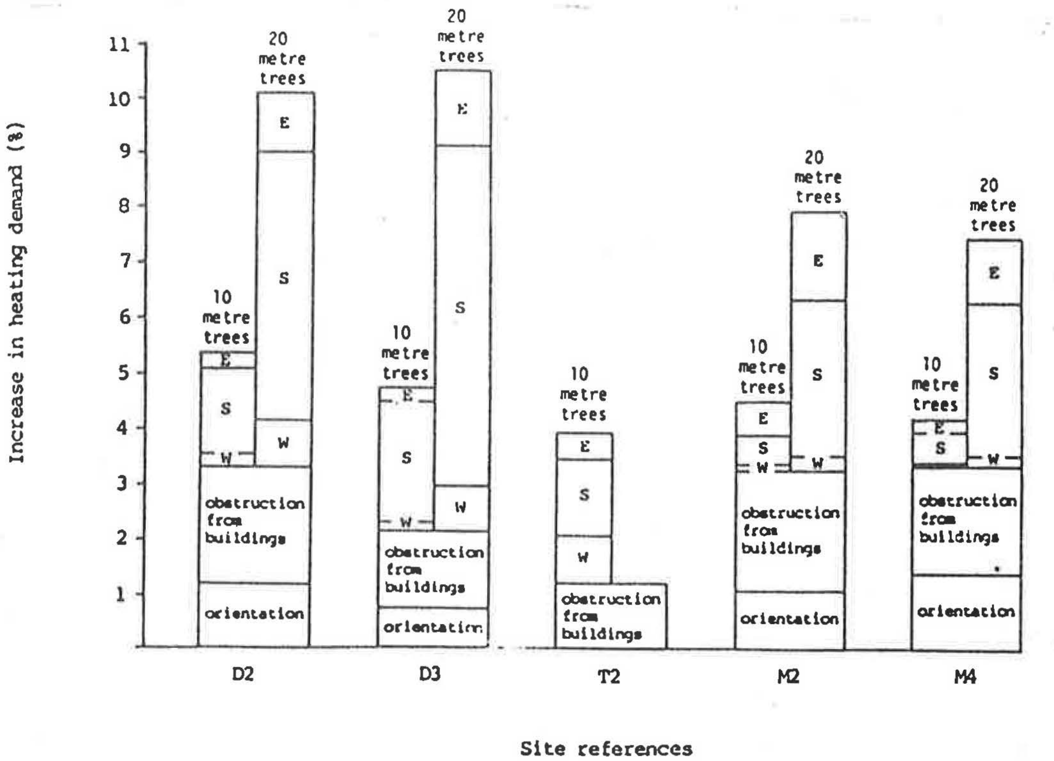
Site Reference	D2
Tree height	20 metre
Mean increase in auxiliary heating demand	+6.70%

Site of MIXED development with 20 metre tree belts (M2)



Site Reference	M2
Tree height	20 metres
Mean increase in auxiliary heating demand	+4.62%

The histogram below shows the percentage increase in heating of the shelter planting above the increases due to obstructions and less than optimum orientation. Also shown is the effect of shelter belts at different orientations.



GENERIC STUDIES

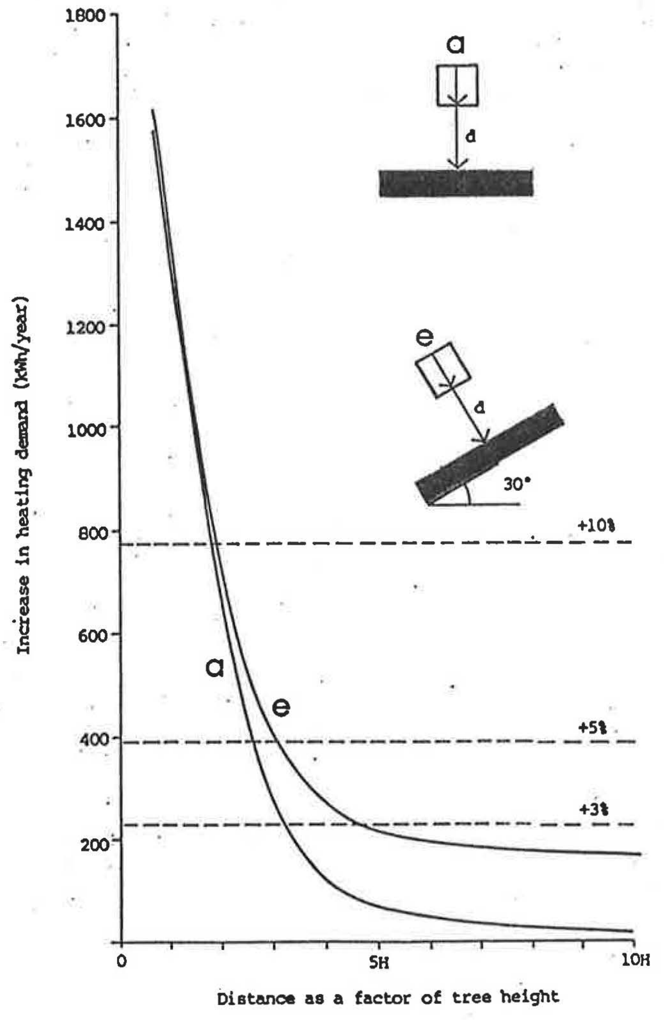
These studies explored the effect of placing a continuous shelter belt in different positions relative to houses whose facades were orientated at 180° and at 150° from North. The shelter belt orientations were related mainly to West and South-West wind directions, but the situation where the tree belt was directly opposite the house to the South or South East were also assessed.

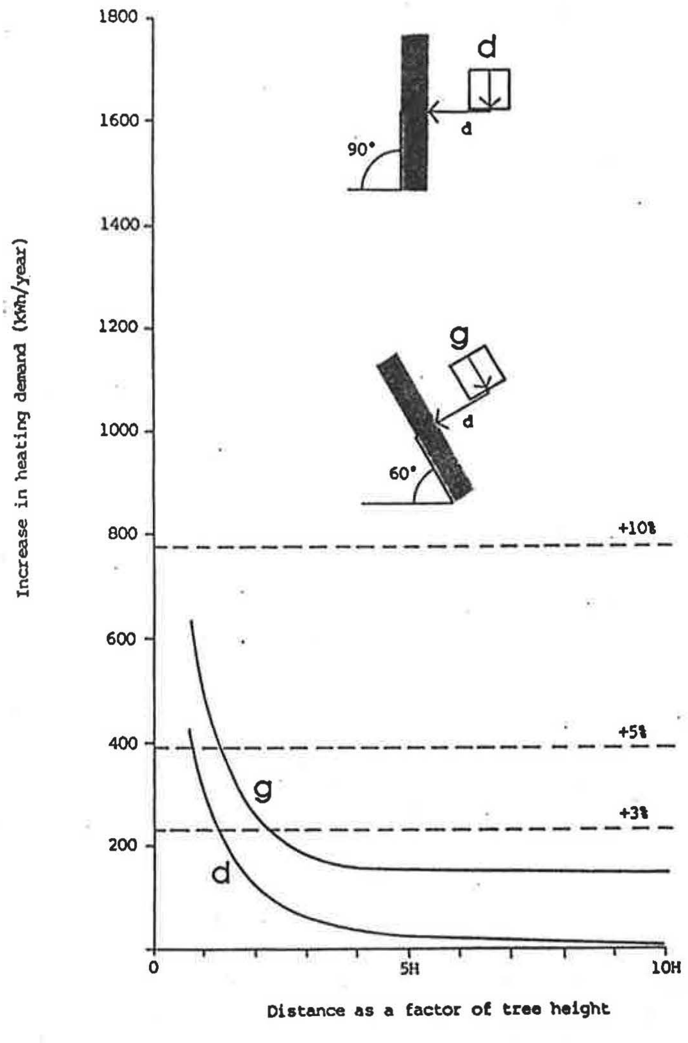
The distances are expressed in terms of a tree belt height of 10 metres, and the calculated additional heating demand included the effect of moving the house from a southerly orientation to one facing 150°. This allowed an assessment to be made of the benefits of changing house orientation to suit given shelter belt orientations.

The following conclusions can be drawn from the results:

* Shelter planting directly opposite houses (facing both 180° and 150°) has the greatest effect on heating demand, increasing sharply at distances less than 3 x tree height.

* Shelterbelts at right angles to the solar facade have the least effect, heating demand increasing by less than 10 per cent even at distances as near as one tree height.





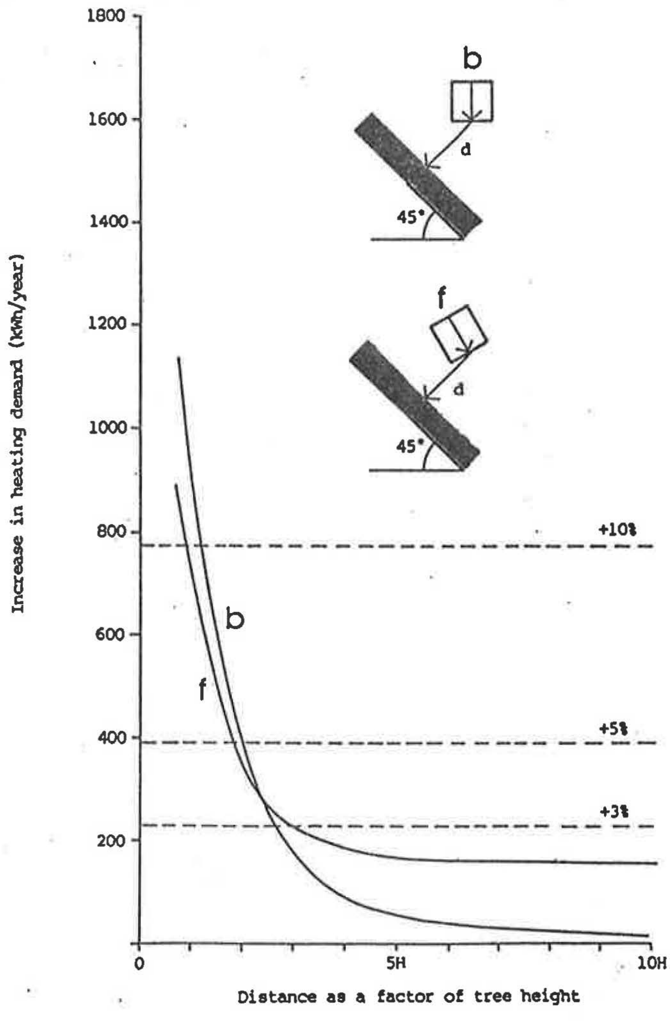
* The effect of moving the house orientation from 180° to 150° is to increase heating demand by about 2 per cent.

* If the effect of house orientation is not included in the analysis, a tree belt opposite a house increases heating demand by 3 per cent at 3 tree heights and by 10 percent at $1\frac{1}{2}$ tree heights; under the same circumstances, a tree belt at right angles never increases heating demand by more than 5 per cent.

* It seems possible to bring a shelter belt orientated for the prevailing wind (North West/South East) to a distance of 2 x tree height without incurring a penalty on heating demand greater than 5 per cent.

* Under the same circumstances, there is a distinct advantage in using a south facing house when the distance from the tree belt is greater than $2\frac{1}{2}$ times the tree height. At closer distances, the effect increases sharply to a point where at a distance of one tree height, the extra heating demand is more than 10 per cent.

* The effect is similar, although less onerous, when the tree belt is angled 30° away from North/South.



RECOMMENDATIONS FOR FUTURE WORK

In the time available for the project, it was not possible to investigate alternative design strategies for satisfactorily complementing solar and microclimatic housing layout. Our preliminary estimates show that, if shelter planting is orientated primarily for protection against the prevailing wind, the loss of solar gain to houses located for optimum solar benefit is generally outweighed by the benefits from shelter planting. This assumes that the benefits from shelter are at least as great as previous research has suggested.

It must be recognised, however, that the methods used to arrive at these estimates are themselves subject to certain limitations. For example, they are based on a limited number of site assessments using data from simulation work on a single house with its own particular thermal characteristics. The results of the analysis are also based on very broad assumptions as to the appropriate height of tree planting and no estimation of the different effects of the tree planting on houses located in various parts of the site and with different orientations.

For the future we would recommend that the following additional activities be carried out:

1 Review the solar analysis method to see if further simulation and study could provide firstly, better data for the solar analysis (including diffuse radiation) and secondly, a means within the model to estimate the effect on heating requirements of reductions in heat loss resulting from shelter planting.

2 Explore ways of reconciling or aggregating 'sheltering' factors to provide a more detailed basis for estimating the heat loss savings attributable to houses in particular locations on site and with different orientations, taking into account such factors as:

- the frequency distribution of wind direction (or wind chill)
- the orientation of the shelter belt
- the angle of the wind in relation to the house facades

3 Carry out further site layout studies in which the houses may be moved within their plots in order to improve solar access and orientation, given the presence of perimeter shelter belts.

4 As 3, but including proposals for mid-site planting.

5 Prepare a draft design guide for discussion in which the results of research are pulled together into a document that could be used to test preliminary design principles.

6 Devise a method of quantifying the effect on building heat loss of changes in wind speed etc, having regard to the form of construction, degree of air-tightness and method of ventilation.

BIBLIOGRAPHY

(1) NBA TECTONICS

A study of passive solar housing estate layout, final report to ETSU under the Passive Solar Programme, reference ETSU S-1126, April 1986.

(2) GANDEMER J
GUYOT A

Wind protection - The aerodynamics and practical design of windbreaks, (BRE translation by Eric Keeble and Chantal de Boissaison), Centre Scientifique et Technique du Batiment, Paris, June 1981.

(3) ORESZCZYN T
JONES B

Milton Keynes Energy Park : Wind Study, a report to the Milton Keynes Development Corporation, June 1984.