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The Potential of Land-use Planning and Development Control to Help Achieve Favourable Microclimates around Buildings: A European Review

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ABSTRACT

Improving the microclimate of built-up areas can be a useful element in strategies to improve the energy efficiency of buildings, with added benefits for the habitability and value of outdoor spaces. This paper reviews techniques suited mainly to temperate climates, and reports the initial findings of a survey of the U.K. and three other north European countries to determine the extent to which development control does or could help to achieve better microclimates around buildings.

While at present there is little specific recognition of energy saving through microclimate in national development control objectives, the mechanisms for achieving it exist. Much more interest seems to have been shown at local level, where development control has been linked to other aims such as demonstrating or marketing energy-saving technologies. The lessons from successful local actions need to be more widely disseminated among land-use policy makers and development control practitioners.

1. INTRODUCTION

The quality and efficiency of the built environment where most people spend the greater part of their lives, whether at work, recreation or rest, is of pressing concern throughout the world. On the one hand the growth of built-up areas has often led to degradation of the environment, whether through pollution and heat stress in hot climates, or through adverse wind and thermal conditions, and sometimes rapid deterioration of buildings, in colder regions. On the other hand there is now an even more urgent need to conserve energy, following recognition of the risks of global warming prompted by the ever-increasing use of fossil fuels.

These imperatives suggest that serious consideration should be given to any technique capable of making outdoor environments more habitable while also reducing the amount of energy needed to maintain acceptable internal conditions in buildings. Both these aims can often be met when urban layout, built form and landscape are designed deliberately to create a sheltered microclimate, exploiting favourable climatic influences and protecting against unfavourable ones. The environment can be made more habitable, while the climatic demands on buildings, and therefore their performance requirements, are reduced. Microclimatic design therefore has the potential to help satisfy current concerns about the environmental and energy problems posed by ever-increasing population and consequent further urbanization.

Experience shows that landscape and buildings can have significant effects on microclimate, and observations of urban climates all over the world reveal how microclimate can be degraded through unplanned development. Yet interest in the opportunity to integrate energy and environmental policies to improve microclimates in urban environments is only

equally through planned development

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just awakening. The initiatives which have been taken suggest that, once the potential of this approach is recognized, it can be accommodated within existing legislative frameworks. In addition, where investment in general environmental improvement is already contemplated, the microclimatic benefits can be obtained as a bonus.

2. TECHNICAL BACKGROUND AND POTENTIAL

In Europe — the subject of this paper — microclimatic design may have two distinct aims:

(a) In western, maritime regions with cooler summers, the key need is to relieve the chill, wind and wet of the relatively long cold season; this would extend the period when outdoor conditions feel comfortable, and reduce energy demand for space-heating in buildings.

(b) In southern, continental regions with hot summers, priority may need to be given to countering sultry conditions, especially in urban areas; both outdoor and indoor conditions would be made more tolerable, and energy savings realized if cooling of buildings is no longer needed, or operates at a lower demand.

In practice, a well-conceived urban or site design, using the full potential of built form and landscape elements (hard, soft and water, with seasonal changes) may be able to achieve both aims.

For cooler climates (aim (a) above), attention to both solar access and wind control is important if creation of a small-scale "urban heat island" is intended. The subtle but effective warming of built environments under still-air conditions is easily dissipated when cool air from above is mixed in as wind speed increases. This is noticeable in dramatic form in the wind-chilled conditions often found around high buildings, even when relative calm prevails elsewhere at ground level [1]. Solar gains to the interiors of buildings, present in most buildings but exploited deliberately in passive solar designs, are distinct from changes in microclimate, but provide a further reason for designing with solar access in mind.

Solar access

Control of overshadowing can be fairly straightforward, and much can be achieved simply by visual inspection at the design stage. Some basic rules for housing, suggested in recent work for the U.K. Dept. of Energy's Energy Technology Support Unit (ETSU) [2] include:

- maximum use of roads running within ±15° of E–W;
- higher buildings towards the north of sites, for example two-storey houses to the north of single-storey;
- terraces on E–W roads, detached houses on NE–SW or NW–SE roads;
- plot shapes allowing wide, south-facing frontages;
- coniferous tree planting to the north of houses, deciduous to the south.

Various architectural design aids, such as sunpath diagrams and overlays, can give more in the way of quantitative information on periods of overshadowing. Recently, stand-alone computer software has been developed [3] which can both save time and give better-integrated information, for example, totalling the reduced amounts of solar radiation received at different times of the year in overshadowed situations (Fig. 1). In the near future it should be feasible to combine computer-held land-form data about a site and its surroundings, which is being widely implemented through Geographic Information Systems [4], with CAD-based models for proposed buildings and landscape development, and thus examine overshadowing routinely along with other design variables and constraints. This would allow more sophisticated treatment of solar access than the relatively simple sunshine duration criteria currently adopted *e.g.*, in the U.S.A. or Australia [5].

Wind control

Successful wind control is likely to be a more subtle art. The basic need on exposed sites is to try to ensure that the wind-speed profile in the finished development is more like that of a town than of open country, with faster-moving air confined to rooftop level or above. Planting shelter belts at the edges of, or perhaps outside, the site is one possibility [6], but this may prove difficult to realize where high land values prevail, unless there is the possibility of environmental trade-offs. Failing this, suitable arrangement of buildings and associated planting, walls and fences on the windward edges of the site can act as

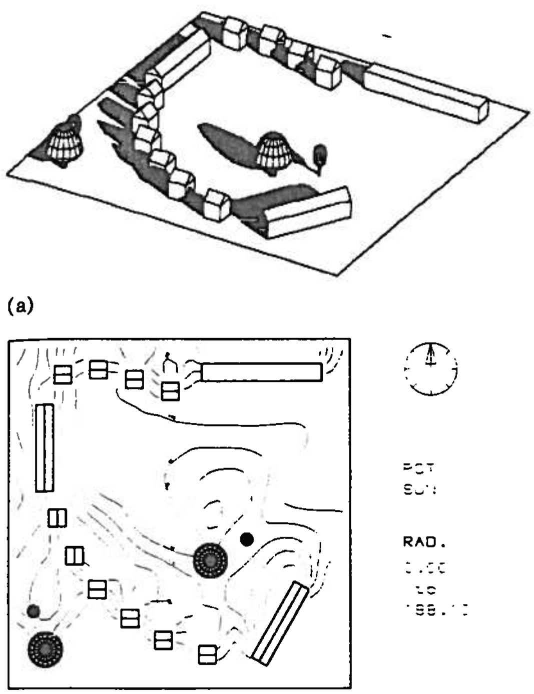


Fig. 1. Computer-generated views of shadowed areas (BRE/CEC Ispra). (a) View of shadows cast at 08:00, September 21 for latitude 51 °N. (b) Plan showing isopleths of accumulated direct irradiation (potential sunshine) during December and January, in MJ/m² (maximum (unobstructed) value 188.1).

barriers to the wind, offering shelter to the interior.

However, edge shelter is only one component of a wind control strategy, and needs to be complemented with more localized actions to maintain the "roughness" of the site, without provoking downdraughts or turbulence. For example:

— arrange buildings in an irregular plan, but avoid sudden changes in height;

— make space between buildings no more than 2.5 to 3 times their overall height, but avoid small gaps likely to funnel the wind;

— use medium-pitched rather than low-pitched or flat roofs, and hips in preference to gable ends;

— form courtyards for maximum shelter, either fully enclosed or with openings away from dominant wind directions.

Less is available by way of design aids for wind control than for solar radiation, so the principles have to be applied largely by intuition. Modelling airflow around buildings by computer is at a relatively early stage, and the use of physical models in wind tunnels is normally economical only for large-scale developments involving exceptional risks of adverse wind environments or loads. However, the protective effect of shelterbelts and windbreaks has been studied for many years in connection with agriculture and husbandry [Fig. 2]. The sheltered area provided by barriers of particular heights and porosities, placed in different types of wind flow, can be calculated [7, 8].

As it happens, many of the suggested wind-control features are consistent with modern practice that has come about for different reasons. Most road layouts in housing areas are complex and irregular for reasons of interest and road safety, the use of vernacular styles for buildings of all scales has broken with the rectilinear forms of the recent past, and the market-driven need to present schemes with high-quality outdoor visual environments is leading to better provision of both hard and soft landscaping. These factors suggest that, if the appeal and practical benefits of wind-sheltered, microclimatic design are seen as marketable features (which would complement any requirements arising from development control), much could be achieved by fine-tuning present practices.

Influencing development

To implement solar and wind-protective features in site layouts, changes would be

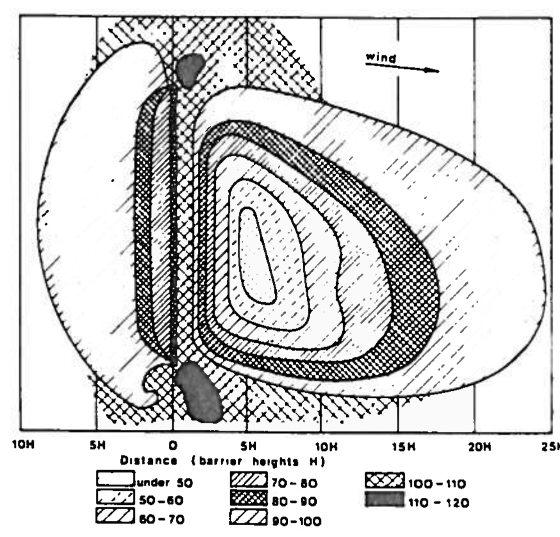


Fig. 2. Typical sheltered area behind shelterbelt (after Naegeli) showing the zones of wind velocity near a shelterbelt of moderate permeability.

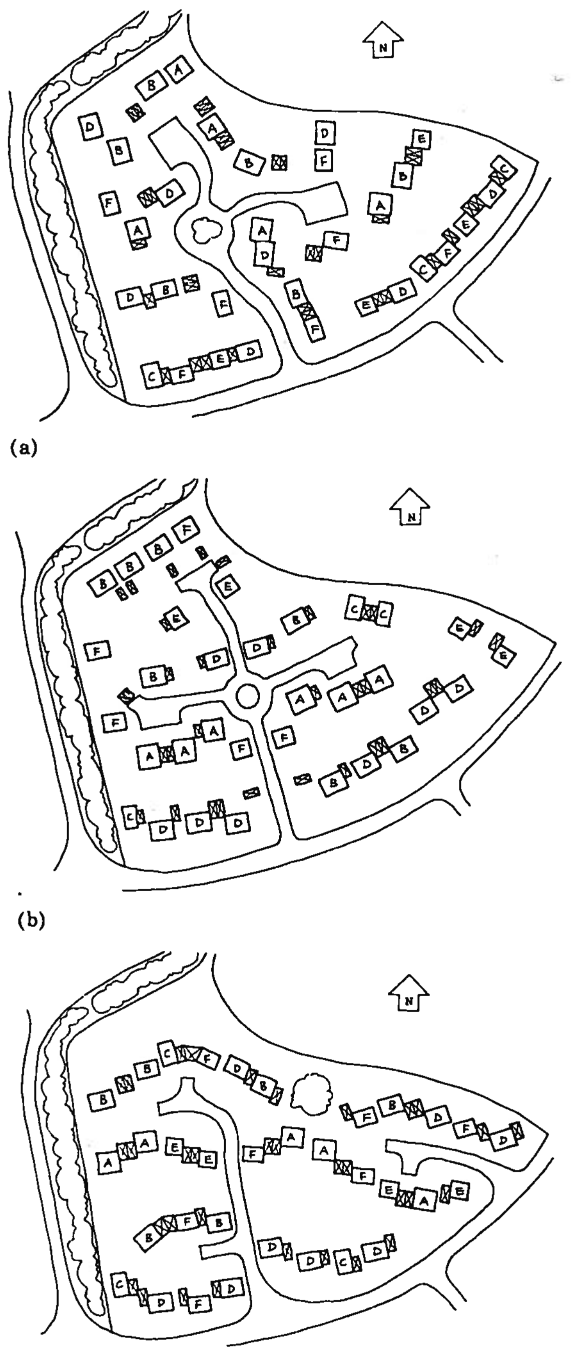

(a)
(b)
(c)

Fig. 3. Conventional and passive solar site layouts (ETSU). (a) The original estate of detached houses. (b) MCJ's improved layout. (c) SEF's improved layout.

needed in the sequence or priority of decisions at initial design stage. Road layout is often determined at the outset on quite different criteria, for example to minimize paved area and main service runs, while achieving access to maximum developable area. Roads and plot subdivisions determined on this basis alone could be a major constraint to microclimatic design, and this would be a key aspect on which development control could have a decisive effect. This is not to say that infrastructure costs or site densities would need to be markedly different: design studies for ETSU on passive solar site layouts (Fig. 3) suggest that, at densities up to 40 dwellings/hectare, the costs of conventional and passive designs are likely to be very similar.

This ETSU work offers some calculation-based conclusions about energy saving, but these are expressed mainly in terms of house designs containing substantial passive solar features. These tend to be particularly sensitive to overshadowing, so the performance of the site layouts was reported in terms of their *disadvantage* relative to a totally unobstructed setting. However, in many cases, lack of obstructions will coincide with exposure to wind and also to driving rain, so that the full energy argument is more intricate.

Can we predict the energy benefits that might be expected from a microclimatic approach? At the moment little data are available for western, maritime regions of Europe, as this aspect of energy efficiency has received little attention, rather surprisingly in view of the wet and windy climate. In the rather different climatic conditions of Sweden, it has been noted that energy consumption in houses in the centre of a town or village may be up to 20% less than on the exposed edge [9]. This can be attributed to wind shelter, coupled with other elements of the urban heat island, bringing mutual benefits to tightly packed dwellings, clustered together for warmth.

One study within the British Isles, undertaken in Eire and sponsored by the European Community Research and Development programme, showed space-heating energy savings of around 5% for wind shelter effects only [10]. However, the height of windbreak used was only 2 metres, protecting single-storey buildings. The site for this experiment was chosen *because* it was typical and not extremely exposed to the wind. It was argued that, on the coast and on high ground, the case for wind shelter is self-evident. BRE, as part of its research programme for the DOE Property Services Agency (Landscape), is currently undertaking a complementary study in

eastern England [11], using a higher windbreak protecting two-storey housing.

Another practical application is the sheltered, microclimatic design adopted for the Milton Keynes Energy Park [12], a major U.K. demonstration scheme for low-energy techniques. With the opportunity of an integrated development, Milton Keynes Development Corporation was able to review the microclimatic characteristics of different parts of the 1 km × 2 km site, and decide which part would be more suited to a design strategy based mainly on wind shelter, and which would benefit more from solar access. The design of a microclimatic landscape infrastructure is complemented with controls on built form and with energy design targets for buildings, and actual energy consumptions are being monitored.

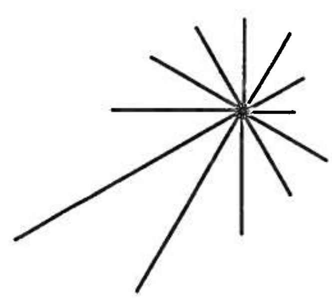
Comfort in Outdoor Spaces

Improved outdoor comfort for a greater part of the year may be as valuable a benefit as space-heating energy saving. The idea is consistent with increasing leisure-time and the pursuit of outdoor activities in general, and especially with the needs of the growing retired population. At the same time access to comfortable outdoor areas has a continuing appeal to those with young children at home, who make up a substantial proportion of the users of sheltered public open spaces such as parks. Also, studies suggest that the old and the very young are influenced more by the weather in their use of outdoor spaces than are other groups in the population.

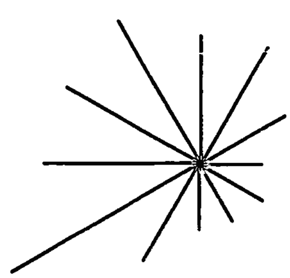
Although the use of outdoor spaces is likely to increase progressively with increasing air temperature, the threshold of 12 °C can be taken as the point at which people begin to regard it as pleasant [13]. This seems especially significant in many parts of the U.K. because, with our relatively mild winters, the air temperature approximates to this value on many days during the cooler parts of the year. Often therefore conditions outdoors may be regarded as uncomfortable when exposed to the chill of the wind, but comfortable when sheltered. The penetration of sunshine into outdoor spaces has also been shown to have a marked effect on usage, over and above its influence on temperature sensation.

Wind-chill index is a measure that can directly describe the impact of air movement on temperature sensation, when expressed in terms of *wind-chill equivalent temperature.* For example, the still-air comfort threshold of 12 °C is matched in cooling power by 14 °C air at 4 m/s, or 15.5 °C air at 6 m/s, and so on. Conversely, 12 °C air at 4, 6 and 8 m/s feels like still air at 9.5, 8 and 6.5 °C respectively. This further illustrates the potential of windshelter to improve comfort. Note however that wind-chill equivalent temperatures are *not* valid indicators of relative heat losses from buildings under the combined effects of wind and low temperature.

Wind-chill index can also illustrate the directionality of wind and associated air temperatures at a site. In many locations a wind-chill rose will show substantial differences from a simple wind-direction rose (Fig. 4). For this purpose wind-chill is assessed as a cooling rate in W/m^2, and not as wind-chill equivalent temperature. Such roses can help in planning wind-protective and wind-control measures at a site, and will usually highlight the significance of shelter against the colder winds from the northerly points of the compass [13]. This is likely to be a good strategy in many places, which will also complement solar access needs by not blocking winter sun on the site.



(a)



(b)

Fig. 4. Wind rose and wind-chill rose (BRE/Met. Office). (a) and (b) Wyton, Cambs., (b) Siple–Passel Formula.

Climate, geography and landscape

There are of course important climatic differences across western Europe that condition the approach to microclimatic site design. Windiness increases towards the west and north, and on the western seaboard (and for some way inland) the persistence of the dominant westerlies may dictate wind protection against that direction. Special directional characteristics may apply on other coasts, and in certain areas where valleys funnel the wind. Solar radiation reduces less with increasing latitude than might at first be supposed, especially if the amounts received on south-facing walls and windows are considered. Because of the longer cool period, solar radiation can actually be more useful in the north, although there are difficulties in achieving good solar access with low sun angles.

Equally important are differences from site to site. The direction of any ground slope will significantly affect the building spacings needed for a given level of solar access. Less solar radiation may be available in existing built-up areas, especially where shaded by high buildings, large trees or other obstructions and, in some places, by hills. The wind exposure of coasts and upland sites, *e.g.*, hill-tops and moors, is evident on all but the calmest days, and the crests of hills and ridges present particular problems due to the way wind flows over them, bringing faster-moving air close to ground level. In hilly country, drainage of cold air into valley bottoms on cold, still nights can produce marked increases in the severity and persistence of frost.

While the urban heat island effect due to buildings and hard landscaping is desirable in cool conditions, the need for comfort in summer also needs consideration. Soft landscaping has an important role, since the period of foliation of deciduous plants is naturally matched to the march of the seasons, and the rate of transpiration increases with increasing temperature. Provision of deciduous species within a site is likely to be compatible with both winter and summer needs, since in bare-branch condition these will allow through some 60–80% of the needed solar radiation in winter. Coniferous trees, while also contributing to summer comfort, are essential for effective wind shelter in winter, especially for major shelter planting against northerly winds.

New guidance for the U.K. [14–16] aims to help planners, building designers and landscape specialists to incorporate microclimatic principles in settlement and scheme designs, and provides a possible model for the guides or codes needed in support of development control, as discussed later in this paper.

Applications

In the distant past, the siting and form of most settlements reflected the need for protection from winter winds, both to keep conditions within buildings tolerable and to provide sheltered outdoor spaces for essential craft work and small-scale industry. This was part of the vernacular tradition of building before the industrial revolution. The ability to distribute fuel easily reduced its scarcity and cost, and the development of effective heating systems led to a philosophy of building despite the climate, rather than in sympathy with it.

There is a range of reasons why the traditional approach, of planning built form and site layout in a climatically sensitive way, may be highly relevant to today's needs and circumstances (Fig. 5). People's expectations

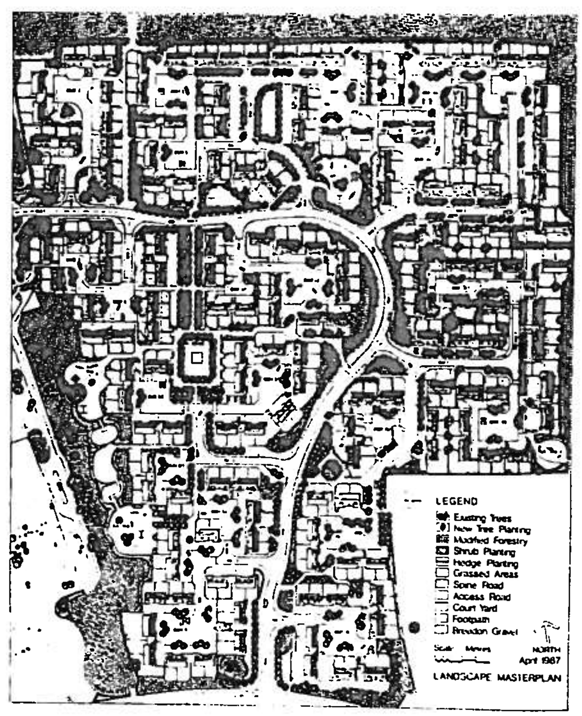


Fig. 5. Landscaped scheme for 326 dwellings on exposed site (PSA).

of quality in their home environment have already led to the provision of well-landscaped outdoor spaces becoming a valued feature. This trend can offer added value if landscape and buildings are also used to improve the appeal and utility of gardens and outdoor spaces generally, especially at times of the year when the weather is "in-between" — cool in the wind, but agreeable when sheltered.

Apart from its likely popular appeal, other trends and influences suggest that microclimate design will complement other current issues affecting the prospects for development. The potential is probably greatest on larger schemes, where the question of environmental impact often arises. Landscaping is recognized as being of benefit in such cases, but to produce a functional, sheltering landscape seems in sympathy with minimal intrusion on undeveloped land. Beyond this is the possibility of a collaborative approach to rural and urban land-use, where the trend towards "forest farms" on land released from agricultural production might be exploited to provide large-scale shelter planting adjacent to developable land.

Particular benefits are likely on the bleak, exposed locations of many districts or even entire settlements (Fig. 6). Where social housing is concerned, both owners and occupants may be attracted by the idea of providing an extra line of defence against the unforgiving weather, with benefits not only for energy but also for condensation risk and maintenance. Again, in hilly country, valley sites are often fully used and only exposed land is available. So microclimatic design should help to achieve a more habitable and energy-efficient environment, especially on marginal land, and also provide added value to developments in sought-after locations, such as coastal and lake-side settings.

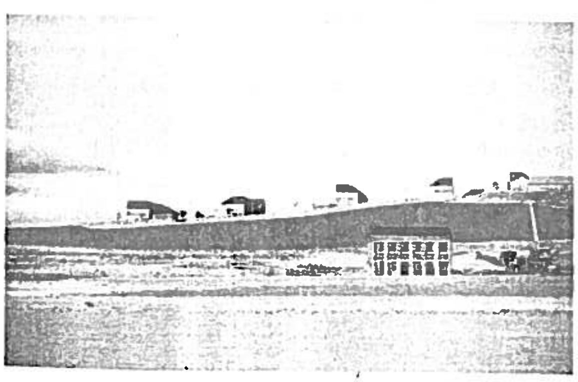


Fig. 6. Wind-exposed housing in northern England (Consett, County Durham).

An important research need is to assess the energy benefits of designing for better site microclimate, in different climatic regimes and topographies. This requires measurement of the distribution of the building stock in terms of its microclimatic exposure. The techniques could include the use of maps or other sources of geographic data, covering both climatic factors and the distribution and character of the building stock (the latter may have been prepared for planning purposes). Also, optical and infrared aerial and satellite photography, possible input directly to Geographic Information Systems, offer the possibility of a less labour-intensive method, capable of periodic updating as a means of monitoring the effects of any microclimatic development control policies.

3. THE ROLE OF LAND-USE PLANNING

Initially local authorities were empowered to regulate urban development in the interests of public health, safety and convenience. With the passage of time, however, increased attention has been paid to meeting the changing operational, social and environmental needs of society. Today there is widespread concern about environmental degradation, increased levels of pollution, depletion of resources, population growth and the destruction of natural habitats and wildlife [17]. This has led many countries to review the organization, workings, efficiency and effectiveness of their land-use planning systems [18].

In essence, land-use planning is both regulatory and selective in character, because the dynamic pressures for new development do not come from the planning process itself. It relies on three principal instruments, namely:

- land-use plans which define the objectives of planning policy and indicate the desired spatial patterns of uses;
- the exercise of control and influence over the development and use of land;
- the use of normative performance standards to regulate, *inter alia*, land allocations, building density, the provision of services and facilities and the incidence of environmental pollution, having regard to variations in

social, economic, climatic and other conditions [19].

4. U.K. STUDY FINDINGS

Development Plans

Development Plans constitute the means through which national and regional policies are interpreted in terms of their economic, social, physical and environmental outcomes. They also allow local issues to be brought to the attention of central and local government, other public bodies, private agencies and the general public, with a view to influencing both public policy and the investment decisions of the public and private sectors. In addition, they provide a land-use framework for the day-to-day exercise of development control powers. At present the development plan for a given area usually consists of the approved structure plan and the adopted local plan. Our previous study [20], which examined the role of development plans in achieving favourable microclimates, noted that:

• the policies in structure and local plans make provision, *inter alia*, for the designation of green belts, the protection of agriculture and the enhancement of landscape at the edges of urban areas;

• there is growing awareness of the need to integrate energy considerations into the structure planning process;

• there is increasing recognition of the benefits of taking proper account of climate in the design, layout and siting of buildings.

In this context, however, it should also be noted that government has discouraged the inclusion of energy-related objectives and policies in structure plans. Understandably there is uncertainty among local authorities about the legitimacy of energy efficiency/energy conservation as a strategic planning issue [21].

Development control

The exercise of control and influence over the location, layout, form and appearance of development is a key feature of the U.K. planning system. This often has a more direct effect on the individual than long-term development plans because it seeks, on a site-by-site basis, to strike a balance between the pressures of technological, social and economic change and the need to protect the natural and existing built environments. A developer is expected to submit a planning application and obtain planning permission before carrying out "... building, engineering, mining or other operations in, on, over or under the land". When determining a planning application, the local authority must have regard to the provisions of the development plan and to any other material considerations. This exercise of development control powers enables local authorities to draw the developer's attention to opportunities to incorporate energy-saving layout and landscape measures into submitted schemes. It is also a useful measure of the effectiveness of development plans and detailed design guidance.

Conclusions

Our examination of the U.K. statutory planning system has shown that development plans constitute an appropriate mechanism for the formulation, promulgation and implementation of policies for energy-efficiency measures such as solar access and wind control. For example, the urban fringe area management approach, pioneered by the Countryside Commission, could be used to secure the planting of shelter belts with several functions, such as to:

• clearly define the urban edge;

• help create a favourable local climate, especially for developments in exposed locations;

• help control the spread of airborne pollution (*e.g.*, from industrial to non-industrial areas);

• contribute a protective buffer zone for urban fringe farming and recreation.

Our study has also shown that development control powers could be used to secure the incorporation of energy-saving measures, including solar access and planted shelter belts. Two essential operational pre-requisites have been identified. First, the development plans should adopt appropriate policies for energy efficiency in district and site layout and landscaping. Second, there is a need for well-presented technical advice on the building and landscape features needed to create a 'climatically sensitive' urban area or site layout.

5. EUROPEAN STUDY — INITIAL FINDINGS AND INTERIM CONCLUSIONS

A recent pilot study has extended the U.K. research to examine some other West

European countries (Denmark, Federal Republic of Germany plus Berlin, Sweden). Land-use planning systems in Europe [22] exhibit a number of common features, including similarities in the legal systems governing the specification and treatment of the subjects addressed, and the powers of municipal authorities [23]. The exercise of development control usually takes place within a national policy framework and a hierarchy of regional, sub-regional and local plans. Although there are different procedures to secure harmonization of local land-use planning with national and regional sectoral objectives, these harmonization procedures have traditionally operated from top to bottom. As a consequence, most local land-use plans observe national and regional objectives and priorities.

In recent years, however, the land-use planning systems in several European countries have witnessed significant changes in their policy concerns, modes of operation and economic, social and environmental objectives. Increasingly land-use planning is no longer viewed as an apolitical exercise of technical judgement. For example, increased political importance is now attached to the quality of life, ecology, wildlife preservation, landscape protection and enhancement, pollution control and energy efficiency. This in turn has highlighted the need for greater awareness and understanding of the spatial and environmental consequences of present-day economic, social, technological and ecological processes. The European Community Directive N 85/337, for example, states that the environmental effects of major development proposals must be taken into account at the earliest possible stage in technical planning and decision-making processes. Article 3 of this Directive requires that the environmental impact assessment (EIA) must identify, describe and assess the direct and indirect effects of a project on:

- human beings, fauna and flora;
- soil, water, air, climate and the landscape;
- the interaction between these factors;
- material assets and the cultural heritage.

A recent survey of land-use planning in some 22 European countries has revealed general agreement about the nature, purposes and failings of settlement planning [23]. It would appear that lower levels of economic growth, changes in demographic structure, degradation of natural and urban environments and increased awareness of the finite nature of non-renewable resources have also changed perceptions about the future development of settlements. Inevitably some planning policies will become less relevant while others will assume greater importance in the face of changing political imperatives. Already there are moves towards:

- a more comprehensive inter-sectoral approach to settlement planning;
- simplification of planning procedures in line with the decentralization of political power;
- greater public participation in the decision-making process governing settlement planning;
- improvement of the efficiency and effectiveness of planning procedures.

Implementation

Growing recognition of the need to integrate spatial land-use planning with economic, social, cultural, environmental and, in some cases, climatic factors has focused attention on the effectiveness of the mechanisms currently used in land-use planning. This in turn has highlighted a number of operational and procedural issues, including, for example:

- integration of specific projects within an overall development concept;
- definition of project and/or action programmes;
- the processes of lobbying and brokerage whereby local authorities enter into partnerships with the private sector;
- co-ordination of infrastructure and basic facilities;
- the need for special agencies to undertake project design, area improvements and performance monitoring.

In general the primary responsibility for implementing land-use plans falls on local authorities. There will always be some cases, however, which require participation either of central government or a regional authority. For example, major infrastructure projects, protection of national heritage or a regeneration of areas experiencing economic problems frequently require technical expertise and a level of resources not readily available in most local authorities. In some cases this has led to partnerships and/or coalitions comprising the state, regional authorities, local

authorities, public bodies and private agencies to secure the optimum use of scarce resources.

Local land-use plans

Most countries prepare a hierarchy of plans, involving national and regional policy statements, and local land-use plans. In many cases:

- the preparation of these plans is required by law;
- the responsible authorities have to observe well-established formal procedures;
- the approved plans are administratively binding on government departments and other public sector bodies, thus facilitating both vertical and horizontal integration;
- the higher-level plans provide a binding framework for the lower-level plans and programmes;
- there is very limited scope to challenge the higher-level plans either in the courts or in the higher levels of national administration.

Although the local land-use plans take many forms they can be grouped into two main categories:

- Generalized structure plans, usually prepared by an upper tier of local government, which depict the pattern of settlement, land uses and communications, and set out the general policies which will govern the development of the area as a whole. Their main function is to provide a framework for more detailed land-use plans.
- Site-specific zoning plans, usually prepared by the lowest tier of local government, which show the permitted use of every plot of land, and are complemented by detailed regulations governing the height, bulk and siting of buildings, the spaces between buildings, the uses of land and buildings, easements (permissions) for utilities and any other restrictions such as permitted noise levels, etc. There is of course a direct link between the provisions of such plans (and any accompanying regulations) and the processing of building permits. Clearly this affects the ability of current controls to reflect needs such as energy efficiency, solar access and wind shelter, since unless these are addressed specifically in the legislation, plans and regulations, no action can be taken to implement them. In Europe, as in the U.K., there is no barrier to the scope of controls being widened in these respects.

The control of development

A recent review of planning legislation in Western Europe found remarkable similarities between countries in the exercise of planning control and influence over development [24]. Local authorities are usually empowered to exercise control over public- and private-sector developments in furtherance of approved land-use policies. Although the detailed specification of what constitutes "development" may vary, there is a general requirement that development proposals must conform with the provisions of local land-use plans and regulations.

The planning instrument of development control usually takes the form of a building permit (or planning permission), obtained from the municipal authority. This reliance on detailed, unambiguous codification reflects the importance that many European countries attach to the concept of legal certainty. In essence, the exercise of planning control seeks to secure compliance with the definitions of development, and of related environmental performance, set out in national, regional and, sometimes, even local legislation, together with site-specific zoning plans and accompanying detailed building codes and regulations.

As a direct consequence of this approach, only those matters specifically identified in the legislation, plans, regulations and building codes, can be taken into account when deciding whether to issue a permit. This is in marked contrast to the U.K., where provision is made for other considerations to be taken into account provided that they relate properly to the development and the use of land and to the project in question. The evidence so far to hand suggests that the development control systems in many European countries are capable of ensuring that new development complies with either national or local requirements for favourable microclimates.

6. EXAMPLES OF CURRENT ACTIONS IN PLANNING AND RESEARCH

No general conclusions can yet be drawn about either the extent to which Authorities in the countries studied recognize climatic factors or the role of land-use planning in securing more favourable microclimates

around buildings. There is substantial published research on climatically sensitive urban and site layout, available as technical support to development control initiatives on favourable microclimates. In the more severe climates of northern Europe some of these measures have already been adopted. For example, the Swedish Building Code makes provision for sunlight in open spaces on housing estates [25]; Sweden has also given very high priority to energy saving (in the context of its non-nuclear electricity generation policy [26]) and to reducing pollution.

Examples from Germany illustrate both national awareness [27] and current actions at regional, urban and local scales. The regional scale is illustrated by planning studies by the Kommunalverband Ruehrgebiet, which led to a proposed plan for the Ruehr conurbation [28], making provision for:

- countryside protection;
- preservation, care and development of forests near the conurbation;
- re-establishment of ecological balance;
- reduction of pollution;
- safe movement and disposal of waste.

A further regional example can be found in Land Bavaria, in climatic studies commissioned from Munich University covering its major built-up areas [29].

In several countries, initiatives influencing microclimate have been taken at municipal rather than national level, allowing detailed attention to be given to the relationship between urban morphology, settlement size, land-use patterns, transport infrastructure and the movement of people and goods, landscape conservation and ecology. In Sweden, city-wide studies of urban structure, density and microclimate have been undertaken in Malmoe, Gothenburg, Uppsala and Sundborg, to assess the energy requirements and environmental pollution implications of different patterns of urban morphology and land use. In Finland, a methodology for comparing energy use in different municipalities was developed, intended as a planning aid [30]. While interest seems high in Denmark, an intended study of Copenhagen was deferred pending final decisions about the reform of local government.

In Germany, there are examples of urban studies and applications involving both energy-conservation and environmental impact assessment (EIA) for several large towns and cities. A city-wide study of West Berlin was used to produce maps dealing with landscape and nature protection which were incorporated in statutory documents [31], together with a climatic atlas. In Munich, a climatic study was made as a planning aid [34], while the projected redevelopment of the airport involved alternative proposals which were subjected to EIA in respect of their effects on air movement through the city [33]. In Bochum, an EIA of the urban transport system took account of the interactions of the system with topography and climate [34; Fig. 7].

At the micro-level there is a growing body of research into the effects of layout configuration, orientation, and wind shelter on air movement, daylight and sunlight, resultant microclimate and standards of outdoor comfort. In Denmark, microclimate has been taken into account in the various schemes for housing, shopping centres, public buildings, institutions and schools, such as in Slagelse, Ballerup [35; Fig. 8], Boligen [36] and Fredrikshaven [37; Fig. 9]. Particular attention is paid to the problems of housing in exposed situations at the urban edge. In West Berlin, studies of the ecology and microclimate are included in a substantial number of current proposals for social housing and other buildings for community and small business use [37]. In some cases these schemes are the subject of architectural competitions which include microclimatic criteria.

7. SOME TENTATIVE CONCLUSIONS

Growing concern in the late 1970s at the economic implications of the energy crisis resulted in both national and local initiatives to conserve energy. This concern was reinforced by the perceived effects of industrial pollution on the forests and woodlands of central and northern Europe. It has also highlighted the importance of geographical scale when adopting an integrated approach to microclimate, pollution, energy efficiency, landscape and ecology. The three spatial scales (regional, urban and local) offer different opportunities and trade-offs when seeking to influence microclimate. The approach is therefore likely to differ between whole

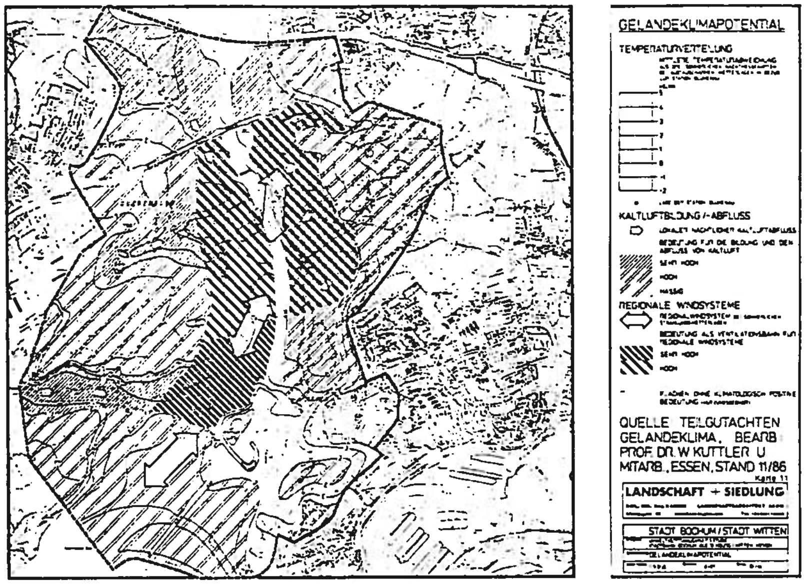


Fig. 7. Bochum: terrain/climate analysis.

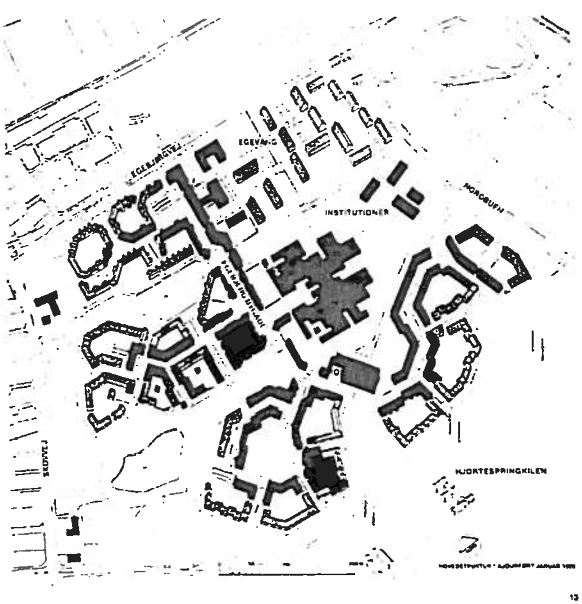


Fig. 8. Ballerup/Egerbjergaard: site plan.

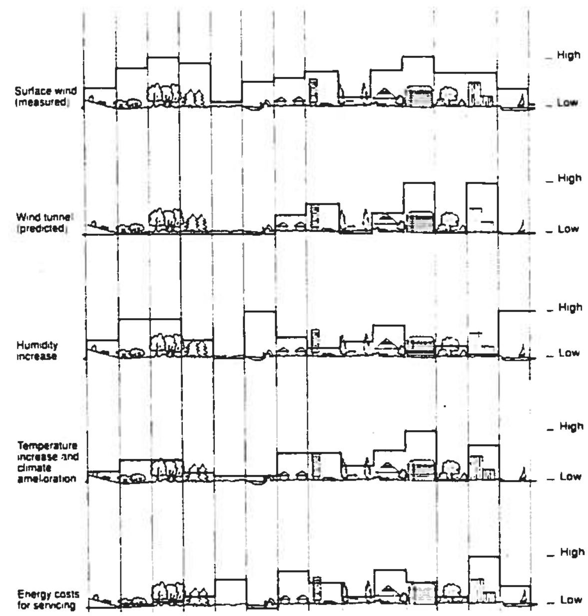


Fig. 9. Example of microclimate traverse across settlement (after Ulla Pinborg).

settlements, conurbations, urban areas, housing estates and groups of buildings.

The decentralization of political power and influence from central government to regional and local authorities will have a bearing on local approaches to microclimate. In some areas, especially those experiencing economic recession, local authorities may feel obliged to adopt a more flexible and less prescriptive approach to new development. Conversely, decentralization will enable local authorities, if they wish, to adopt policies and regulations which seek to improve microclimate, within an integrated economic framework, without recourse to national or regional legislation. One of the objectives of our pilot study is to

examine the processes whereby research findings are incorporated into:

• national, regional or local legislation;
• land-use plans and detailed regulations;
• building performance codes;
• the design practices of the public and private sectors.

The evidence so far to hand shows some regional and a significant number of municipal authorities adopting or likely to adopt policies which help to achieve favourable microclimates around buildings, whether in the centres of large conurbations, in the suburbs or in proposed new settlements. In each case the scale of intervention will vary, reflecting the different circumstances including the amount of new development likely to occur. For example, it seems likely that particular importance will be accorded to:

• pollution control, the alleviation of summertime heat and the reduction of adverse wind conditions, in city centres;
• protection from wind exposure for suburban developments located at the urban edge;
• the adoption of new town masterplans which achieve a favourable microclimate through an integrated approach to land-use, transport, energy efficiency, pollution control, ecology and nature conservation, both within the town and its adjacent countryside.

Various factors suggest that promoting favourable microclimates in the built environment may receive increasing attention in Western Europe, and possibly elsewhere. One of the strongest trends is the coincidence and mutuality of interest in environmental protection, energy efficiency and the quality of life. At the same time technical developments such as aerial photography and remotely sensed images now make it much easier to monitor the impact of new development on both the urban fabric and the surrounding countryside. The response of authorities to these trends will be an interesting test, and one of the aims of the further stages of this study is to analyse the trigger mechanisms that prompted the practical actions in different regions, cities and districts, given as examples above.

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