# ENVIRONMENT AND SUSTAINABILITY IN COMMERCIAL OFFICE BUILDINGS

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This three year project, commencing in 1998, involves a comprehensive analysis and documentation of all options involved in the pre-planning, specification, design, construction and post-occupancy management required to achieve an office building of high environmental performance. The ultimate aim of the project is to provide a building delivery model for the future. The project is essentially about the life cycle management of an environmentally designed, ecologically sustainable, commercial office building. In the case of this research, there are two projects proceeding in parallel. The first is the research itself and the second is an actual building project. The research includes the provision of property, design and construction aids which will culminate in a brief to an actual project delivery team. It will involve monitoring of the design and construction process including the placement of data logging equipment during the construction process. After the building has been commissioned, it will also involve the extraction of data in order to measure the energy requirements of the building taking into account the operations and behaviour of the occupants. Thus the research team will provide the development brief, will monitor the design and construction and will take measurements on completion.

Keywords: Ecological sustainability, environmental design, office building.

## INTRODUCTION

There is widespread recognition of the need to develop new models in all spheres of human activity to achieve the goal of ecological sustainability. Building design and construction constitute one of the most significant areas in which these new models are needed because buildings have long lives and over the course of those lives poorly designed buildings can significantly contribute to environmental degradation. By contrast environmentally well designed buildings could make an important contribution to the achievement of ecological sustainability.

The overall aim of the research is to examine how a high environmentally performing building of attractive design could be built for a cost that can be fully justified in commercial terms ( based on an assessment of capital and running costs). It is also to carry out a comprehensive sequential review of all the sustainability and environmental health options involved in pre-planning, design, construction, furnishing and use of an office building of high environmental performance.

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Other specific aims of the research are:

- to take part in and review the initial occupancy and site analyses;
- to prepare detailed environmental performance specifications for the new building and to cost alternative approaches;
- to review the detailed design of the building to assess the way that the environmental specification is incorporated into the design;
- to model environmental performance and cost alternatives for the building;
- to analyse and review the construction process to assess the way that the structure as built and the construction process meet environmental performance standards;
- to assess the actual costs of constructing and running a building of this kind and measure the actual performance of the building;
- to help specify and to assess the way the occupiers of the building contribute to the environmental management of the building;
- to compare models and predictions with actual performance
- to write up and publicise the finding:

An additional aim is to develop international collaborations with researchers in other countries working on similar projects to compare techniques, approaches and research findings.

A key principle informing the whole of the research and supported by the industry partners is that at every step in the development of the project - from the first decisions about the future needs of the host organisation and its ownership options - all ecologically sustainable options (both high and low-tech) will be thoroughly explored. The documentation of this sequential process forms an important and distinctive part of the research. A second distinctive aspect of the research is its emphasis not only on the building science involved in sustainable offices but also on the behaviour of people in the building. A third is the emphasis on architecture as the expression of sustainable practice. Very few other research projects of similar kind anywhere in the world have attempted such a thorough and comprehensive analysis.

## RESEARCH PLAN

### Literature and case studies

Early literature on sustainable building had a significant focus on the house (Vale and Vale 1991). Many energy-saving and autonomous house projects have been carried out, several in Australia. Some with which the researchers have been directly involved were the Trombe House for Merchant Builders and energy saving houses for Landmark project builders (Ohanessian and Charters 1978.) and a winning competition entry for solar residential development in Belgrade (Radovic 1994, Progress Architecture 1991).

Many principles applicable to housing can also be applied to office and other buildings. There are however additional factors that need to be considered in designing and managing offices and larger buildings of high environmental performance. An increasing literature on sustainable office building has developed recently in a number of different themes. There are many texts on energy efficiency and specific aspects of sustainability such as climate control (Roaf and Hancock 1992,

Toerney, et al 1985).There are similarly texts on building materials (Lawson 1996). Several of these texts have extensive case study reviews (ECD and Steemers 1992).There are also many general texts on sustainable building (Annik, Boonstra and Mak 1995). There are also texts reporting the experience of building sustainable office buildings. An example is that related to Audubon House, New York (National Audubon Society 1994).

Most of the texts currently available, however, concentrate on the building science aspects of sustainability. While the building science is very important, it covers only a part of the task required for a comprehensive approach to sustainable practice. There are three other key parts of this research proposal which have little coverage in the literature. One is the examination of all sustainability options in the pre-planning of the project, for example in the internal business planning for the future operation of the organisation, the examination of the ownership options and the choice of site (Hartkopf 1995). The second concerns the significance of architectural expression as the signifier of the values needed to achieve a paradigm shift to sustainability. Jencks, Norberg-Schultz and others have for example argued that architectural language represents the spirit of the time in which the building was conceived and built (Jencks 1995, Norberg-Schultz 1981 ). The third concerns the role of the occupants of the building in managing and working to ensure high environmental performance. Some preliminary explorations of these issues has been carried out (Hopfenbeck 1993) but little comprehensive attention has been given to them in the way envisioned in this research.

The project should therefore make a significant contribution to the literature related to building science but in addition make important original contributions to the literature related to comprehensive planning and management for sustainability and to role of design as a potential signifier of environmental values.

**Property, ownership and life cycle analysis**

The first decisions involving a relocation or new office concern business and occupancy planning, ownership options and site selection. Environmental principles should apply to the evaluation of all these business, occupancy and ownership options and to the assessment of any type of site whether green field or high density urban and whatever the exposure or orientation. Thus several alternatives will need to be tested prior to site selection.

The ownership options include:

- do nothing - the ACF remains where it is and makes no attempt to refurbish the premises. This is the basis against which all other options should be measured.
- refurbishment of existing premises - the ACF carries out an environmentally friendly refurbishment of its existing premises
- lease - the ACF leases suitable premises given the glut of space available for lease.
- build new premises - the ACF acquires a suitable site and builds new environmentally friendly premises.
- refurbish old premises - the ACF acquires a well located building and undertakes environmentally friendly refurbishment.

In all of the above, except the do nothing option, a new fit-out will be required. Whatever the options, some form of assessment needs to be undertaken to compare

them. The normal method is to reduce all items to a money equivalent and to apply the concept of the time value of money in order to achieve the optimum result. This is a form of cost-benefit analysis sometimes referred to as life cycle costing. It uses the principles of discounted cash flow to obtain the time value of money.

Many environmental costs and benefits are, however, externalised from, or only partially reflected in the price of goods and services. Therefore, traditional financial life cycle analysis needs to be supplemented by environmental life cycle analysis. Analysis of embodied energy (in the building fabric, furnishings and equipment) and recurrent energy use from building operation and commuting (a function of building design, location, equipment and work practices)usually provides a good first order estimate of environmental life cycle costs. Choice of energy sources and measures to reduce energy use are particularly important as they can have a major impact on the level of greenhouse gas emissions and the environmental impacts associated with extraction, refinement and delivery of energy. Other issues which should be taken into account in an environmental life cycle analysis include the ecological value and possible enhancement of the site, relationship with neighbours(e.g. avoiding overshadowing, sharing facilities), water sourcing and use, use of recycled/reusable materials and facilitation of recycling/reuse, use of ozone depleting substances, use of hazardous substances, and management of wastes.

There are various models available for such an analysis. BREEAM (Prior,1993: Bunn 1997) is one UK-based methodology for performing environmental assessments of office designs. Standards Australia is seeking to adapt the BREEAM model to Australian conditions. Life Cycle Assessment (LCA) is regarded internationally as being a rigorous model. Another model, Building Materials, Energy and the Environment, developed at the University of NSW, mostly deals with materials. An evaluation of each of these models, prior to the selection of that seen as most suitable for this project, is part of the research proposed.

**Performance specification**

In the past performance specifications have related solely to buildings and their services. Such specifications only cover the supply of the building and the immediate needs of their occupants. In this project, performance specifications are proposed to encompass the whole of the life of the building from concept design to long term use, change and performance (building churn). By adopting at the outset a model for organisational needs and expected occupancy demands, in terms of hours of operation, occupancy variability and levels of facility provided to the organisation (the 'business' dimensions of the "office of the future"), the set of performances which the facility must deliver can be demand driven, rather than being supply driven as is the case with the majority of office building stock presently existing in Australasia.

This is not to say that the facility should be purpose-designed to meet the presently identified requirements of the intended occupants, but rather that value management should be applied to both demand and supply aspects of the project delivery and occupation process. It is therefore intended that performance specification be applied to each aspect of the design and procurement process (analysis, briefing, specification of materials and plans and construction).

An important part of the research is to record and analyse these processes, in order to develop a measure of the relative contribution and effectiveness of the range of activities which might be pursued in seeking to achieve ecologically sustainable practice.

**Modelling of the expected performance**

There are tools now available to enable occupancy demands, construction type, materials, energy sources and energy conversion equipment to be dynamically modelled. The outputs from modelling can be in forms which are easy to communicate, thereby enabling a wide audience to use the results. Both computer based graphical methods and data-based modelling techniques can be used to predict the environmental and ecological consequences of the proposed facility.

Modelling can also be used to predict organisational demands on the facility and how the various options for meeting the needs of the occupying organisation might be met, by both facility based and other means. This latter form of demand prediction, rather than facility response prediction, will be employed to prepare specifications for the facility. The comparison of projected and actual demands is expected to improve the use of demand management as a tool in providing sustainable facilities.

An attempt will also be made to model and test the semantic performance of the building (its effectiveness as architectural expression).

**Contractor selection and construction overseeing**

Given the environmental objectives for the project, the design and construction of the building can not be merely code compliant. The project needs to be concerned with the highest principles of building practice.

Approximately half of the total capital cost of any building is labour and management. So while a large amount of effort will be expended to ensure that the building materials used are environmentally friendly, the labour and management practices also need to be motivated by the highest standards and most ethical principles possible.

> *"In searching for professionals to work on Audubon House, we used several guidelines. Each team member was expected to have a broad understanding of, and commitment to environmental and energy issues, a basic grasp of manufacturing processes; the ability and commitment to conduct research; and above all a willingness to work in an integrated fashion with other team members."* (National Audubon Society 1994)

The use of pre-qualification criteria for the selection of building contractor is important. It is in the interests of the ACF to choose its builder based not only on the lowest tender price, but also on a track record of environmental sustainability and ethical practice. The types of criteria that may be useful include:

- Construction waste minimisation and other environmentally friendly building practices.
- Commitment to training and skill formation.
- Demonstrated record of the high levels of occupational health and safety practice.
- Sound human resources management principles

In addition the contractor should have the appropriate technical and financial capacity to complete the work in a satisfactory manner.

Simulation during design can highlight those aspects of the facility that are most critical to achieving the target outcome. Audits during construction can then be focused on those aspects of the building design that are essential for the achievement of the key performances required. The adoption of quality systems for construction

delivery can ensure that all participants have the information and the monitoring systems available to achieve the desired standards with a minimum of effort. The research will assess how effective these various techniques are for the achievement of a building of high environmental performance.

**Selection of fittings and furnishings**

The recently released *Australia, State of the Environment 1996,* the first independent and comprehensive review of the state of the environment in Australia, gave significant attention to the issue of indoor air quality (State of the Environment Advisory Council pp. 5-33 & 34).Poor indoor air quality is a dimension of the well known sick building syndrome. Such are the dimensions of this problem in Sweden (a recent survey identified close to 500,000 people affected by the indoor climate) that the Swedish Council for Building has launched a new action research focus on "The Healthy Building"(Dawidowicz 1997).

Special attention will be given in this project to the assessment of all fittings and furnishings to ensure that they support both environmental health and sustainability objectives. This assessment will form a part of the analysis and documentation proposed for the research.

**Review of actual performance**

Technologies recently developed for building systems (e.g. thermal and lighting controls) enable data collection to be carried out simply and inexpensively. The growth in open systems, for example those employing technologies such as 'BACNET' or LONWORKS', can facilitate both control and data logging. Technologies of this type have been used to a limited degree in larger buildings, but rarely has the full potential as an energy minimisation tool been recorded and publicised. Wherever possible these standard control (and monitoring ) systems will be used to avoid the need to employ dedicated (specialised) monitoring and recording equipment .

A further key aim of the project is to involve the building users in monitoring and recording, since without the active involvement of all the building occupants, it is very difficult to achieve optimum building performance. Involvement of the building occupants is expected to help identify the relative contributions of 'use patterns', 'management actions 'and' structure/systems/planning' to the achievement of a sustainable office building..

**International collaboration**

All phases of the project will be developed in close collaboration with relevant organisations and researchers world-wide. Such co-operative work will use existing international networks such as the International Energy Agency (IEA) Solar Thermal Programme which involves many European Nations and Japan and the programmes co-ordinated in the USA by the National Renewable Energy Laboratory in Golden, Colorado and the Sandia National Laboratories in Albuquerque, New Mexico. Separately through other research and development programmes in Australia strong contacts have already been established with the IEA Heat Pump Centre at Sittard in the Netherlands and with the Geothermal Heat Pump Consortium in the USA.

The research team will also work to establish international research collaborations. One collaboration of this kind is proposed with the Building Research Institute, Tsukuba, Japan. Another collaborative arrangement is being sought with the UK

Building Research Establishment (BRE) Energy Efficient Office of the Future Project. Comparative studies with international projects with common aims, developed in an situation of common, globally shared knowledge but in very different local cultural situations offer rich opportunities for research and for better understanding of the opportunities for ecologically sustainable development in different countries.

Collaboration within Australia will be sought with bodies such as the Commonwealth Scientific and Industrial Research Organisation(CSIRO), the Energy Research and Development Corporation (ERDC) and Energy Victoria. An assessment will also be made of other building projects in Australia which have had related aims (e.g., Australian Geological Survey Organisation Building now under construction).

## SUMMARY

The planned outcomes of the research include:

- a significant contribution to the knowledge available world-wide and a specific contribution to the knowledge available in Australia of high environmentally performing buildings;
- a building and a decision process illustrating how environmental sustainability principles can be most effectively applied to office buildings in the future;
- information not now available anywhere in the world about the respective influence of environmentally conscious pre-planning, design, building science and occupant behaviour on the achievement of environmental outcomes;
- information about the capacity of researchers and design and construction specialists to specify and model accurately the expected environmental performance of a building;
- the development of industry knowledge and skills to enable buildings of this kind to be built in commercially viable ways in Australia in the future;
- opportunities for Australian firms to use the findings of and the techniques used in the research and the experience of the project in overseas markets;
- opportunities to compare techniques, approaches and outcomes with international researchers working on similar projects;
- a building which can be used as a demonstration model;
- publications and other means of disseminating the research for different audiences including:
    - academic researchers working in similar fields;
    - architects and engineers;
    - property specialists, developers and builders;
    - other decision makers.

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