Submission to
Productivity Commission Inquiry;
Improving the Future Performance of Buildings

28 July 1999

In 1998 The University of Melbourne faculties of Engineering and Architecture, Building and Planning commenced a project, to investigate, over three years the Procurement and Performance of Commercial Building.

ACF GREEN OFFICE BUILDING PROJECT

1. Introduction

The project is more fully titled *The specification modelling and post-construction performance measurement of an environmentally designed, ecologically sustainable commercial office building.*
It is an ARC funded collaborative research project (Strategic Partnership with Industry - Research and Training (SPIRT) Grant) with the University of Melbourne, the Australian Conservation Foundation and Lincolne Scott Australia as partners. The funding is for the research that is being carried out in parallel with an actual construction project which is funded by others.

The four main research activities are:
1. The compiling of source material for application at various stages of the construction project to enable the project to be compared with other similar projects as well as world's best practice.
2. The recording of the whole project delivery process from pre-design work such as property acquisition, through the appointment of consultants, project documentation, tendering, construction and commissioning to occupation and ongoing management.
3. The energy modelling of the selected building or buildings in their current condition and during the design stages as certain features are considered. On completion and occupation of the building, the measurement of energy performance is to take place and this will require the installation of data logging equipment during construction.
4. The survey of the Australian Property and Construction industry's attitudes to sustainable architecture, construction and property and facilities management in particular to establish ways in which a more sustainable view may be achieved.

2. Source Material

The compilation of source material is being undertaken in two main categories:
1. Design and construction (Ms Margaret Kam, holder of an Australian Postgraduate Award (Industry) and reading for a PhD in the Faculty of Architecture Building and Planning at the University of Melbourne). Particular attention is being paid to :
• the nature of green design and construction
• case studies of successful projects
• reduction of materials usage
• reduction and elimination of toxic and other deleterious materials
• attitudes of developers, consultants, building owners and users and the community to green design and construction

2. Technology (Dr Lu Aye, a part time Research Fellow associated with the Department of Civil and Environmental Engineering at the University of Melbourne). There is a concentration on:
• energy performance and modelling
• comparative analysis of models and programs

3. Project Delivery Process

The recording of the project delivery process is classified into four main phases:
1 Predesign
• the provision of accommodation including a discussion of rent vs buy, the construction of a new building vs the refurbishment of an existing building, sale and leaseback and other options (Prof Jon Robinson).
- locational issues including accessibility to staff and clients to road transport, to public transport and to developed urban infrastructure (Dr Darko Radovic, Mr Nick Bamford, Prof Jon Robinson).
- search for real estate including inspecting suitable properties (Prof Jon Robinson) .
- acquisition of a property including establishment of an ownership and financing vehicles (Prof Jon Robinson).
- a preliminary client brief to establish broad accommodation requirements (Mr Nick Bamford, Dr Darko Radovic).
- preliminary energy modelling to establish the relative embodied energy, operation energy and creation of greenhouse gas emissions (Prof Bill Charters, Dr Lu Aye, Mr Nick Bamford).
- a comparative life cycle cost study to cover property acquisition, design and construction, operational management with an emphasis on energy and greenhouse gases, disposal and returns from any excess accommodation created (Prof Jon Robinson, Dr Lu Aye, Mr Nick Bamford).
- questionnaires and focus groups to provide an assessment of image from the point of view of employees and managers as well as ACF members (Dr Darko Radovic, Mr Nick Bamford).

2. Design (Dr Darko Radovic, Mr Nick Bamford)
• appointment of consultants including process (public notice, shortlisting and interview) and prequalification assessment (Mr Tony Mussen, Mr Tony Mills)
• preparation of client's brief
• green design
• energy modelling of options and design features during the design process
• assessment of barriers to green design (Ms Margaret Kam)
• estimating and costing
• preparation of contract documentation

3. Construction (Prof Jon Robinson, Mr Tony Mills)
• discussion about construction project delivery
• contractor prequalification
• tendering process
• form of contract
• project management and administration
• green construction and the minimisation and disposal of construction waste
Operation (Prof Jon Robinson, Prof Bill Charters, Dr Lu Aye)
• the move
• evaluation and measurement of the performance of the premises

- evaluation of the behaviour of the occupants of the premises (Dr Darko Radovic, Ms Margaret Kam)
- commercialism including dealing with surplus space, synergies with other tenants

4. Energy and Technology

Detailed energy modelling and technology issues include ongoing work by the researchers and investigators in the team. There are six main categories (Prof Bill Charters, Dr Lu Aye)

1. Energy modelling and performance measurement
2. Heat pump technology
3. Photovoltaic cell technology
4. Metal hydride technology
5 . Greenhouse gas emissions
6. Indoor air quality (Mr Peter Williams)

5. Industry Attitudes

The survey of industry attitudes is the main component of the PhD research project (Ms Margaret Kam) which has the working title *Sustainable Architecture: Implementation in Australia*. The main components of the research are:

1. Definition of sustainability and sustainable architecture
2. Implementation of sustainable architecture
3. Obstacles for sustainable architecture
4. Research design
5. Quantitative research
6. Qualitative research
7. Formulation of a framework for the promotion of sustainable architecture.

6. Research in Progress

The activities which have been taking place at the university are in two groups:

1. Staff activities have resulted in the following publications and work in progress:

• Bamford N, W Charters, R Lacey, A Mills, D Radovic, J Robinson, P Williams & D Yencken (1998). Environment and sustainability in commercial office buildings, *Fourteenth Annual Conference, Association of Researchers in Construction Management*, Reading: University of Reading, 9-11 Sept.

Abstract;

A range of property and construction options is analysed using standard life cycle costing methodology. The options are to renovate the existing building, buy an alternative building and renovate and buy a development site and construct a new building. The do nothing option and a hypothetical option to construct a new building on an ideal site are analysed as benchmarks. Life cycle costing principles are discussed in particular where assessment difficulties are caused as a result of market pricing and taxation related to energy tariffs, greenhouse gas emissions, tax deductibility and depreciation allowances. The results show that the optimum option is to buy a suitable site and construct a new building and that the least sustainable option, in the case study, is to stay in the existing property and renovate the building. Although staying in the existing building and doing nothing is the lowest financial cost, the energy and greenhouse emissions are significantly worse than the alternative options.

Key words

Building accommodation options, Energy efficiency, Greenhouse gas emissions, Life cycle costing.

• Charters WWS, L Aye & RWG Macdonald (1999). Electrical and engine driven heat pumps for effective utilisation of renewable energy resources *World Renewable Energy, Congress, Renewable Energy Technologies and Policies for Sustainable Development,* Perth: Murdoch University, 10-13 Feb.

Abstract

Much of the energy used for domestic, commercial and industrial purposes is to provide efficient and effective heating of conditioned spaces and for specialist niche applications in process heat systems. Vapour compression heat pumps driven by electric motors or engines provide the real capability of upgrading low temperature sources of ambient and waste heat to match the desired load temperatures in such heating applications. Major source of ambient heat stem from the storage of solar energy in the ground, in lakes and rivers, and in atmospheric air. Heat pumps can therefore be used to effectively harness indirectly the daily solar radiation input. In addition many industries have major sources of waste low grade heat in the form of air or water discharged >from the industrial process heat stream. Heat pumps are generally formally classified therefore as air source, ground source or water source units although there has also been considerable interest recently in hybrid units combining the attributes of two or more of these specific types mentioned above.

All vapour compression heat pumps use refrigerant working fluids capable of evaporating and condensing at the appropriate temperature levels of the heat source and the load. With the recent attention given to global warming and the destruction of the ozone layer in the upper atmosphere it is imperative to ensure that all future refrigerant fluids satisfy the criteria of low global warming potential (GWP) and low ozone depletion potential (ODP). This has caused major research into new fluids moving >from chlorofluorocarbons (CFC's) through hydrochlorofluorocarbons (HCFC's) and hydrofluorocarbons (HFC's) to pure hydrocarbons (HC's). The focus is on efficient and safe operation of these new fluids and the older natural fluids such as ammonia for heat pump units under both domestic and commercial conditions of operation.

For effective design purposes all heat pump systems should be rated to include heating and cooling capacity limits, and realistic measurements of system coefficient of performance (SCOP) on a seasonal or annual basis. Often in practice manufacturers give only the compressor coefficient of performance (CCOP) and that often on an instantaneous and not time average basis.

Hybrid heat pump systems currently under investigation include ground source/air source units, and solar assisted and solar boosted air source and water source units.

The potential for energy conservation in the built environment and the efficient utilisation of energy in cascaded heat recovery systems in industrial process heat application is immense. In fact the International Energy Agency has several times identified the heat pump as the single most energy conservation technology on a world scale. There are also many opportunities for melding together the efficiency of heat pump systems with the inherent environmental advantages of renewable technologies.

• Kam M (1999). Sustainable architecture: identifying obstacles and initiating strategies for the building industry, *Passive and Low Energy Architecture Conference,* Brisbane: University of Queensland, Sep.

Abstract

The building industry is responsible for a large portion of greenhouse gas emissions in Australia. Actors in the building industry have the capability to cut down emissions considerably. However, despite existing knowledge and emerging technologies, we are still constructing unsustainable buildings. A gap exists between current and best practice.

The aim of this paper is to suggest ways in which this gap might be bridged. To do this, the paper begins by providing a definition of the concept of sustainable architecture. It

then identifies possible obstacles inhibiting the more widespread adoption of sustainable architecture; using the reduction of greenhouse gas emissions as an example. This leads to some conclusions on areas of potential improvement in the planning, design and construction of buildings, and appropriate intervention in the regulatory framework.

• Radovic D (1999). Green office building: notes on architectural brief development, *Passive and Low Energy Architecture Conference, Brisbane:* University of Queensland, Sep.

• Aye L. N Bamford, W Charters. et al (1999). Optimising embodied and operational energy in commercial office development, *The Challenge of Change. Construction and Building for the New Millennium,* Salford: the University of Salford, 1-2 Sep.(in preparation)

Abstract;
The effect on embodied energy of materials, building aspect ratio and number of floors of a small office building has been investigated. A simplified mathematical model was constructed for this study. The investigated aspect ratios range for one to four and the investigated stories ranges from one to ten. It was found that the number of stories strongly influenced the embodied energy but the aspect ratio did not have major influence on the embodied energy.

Keywords
Building configuration, commercial office development, embodied energy

- Aye L, N Bamford J Robinson et al (1999). Environmentally sustainable development: a life cycle costing approach for a commercial office building, *Association of Researchers in Construction Management*, Liverpool: John Moores University, 15-17 Sep. (in preparation).

- Aye L & W Charters (1999). Economic Evaluation of a grid-connected photovoltaic system for a typical residential building in Melbourne. (in preparation).

Abstract
A grid-connected photovoltaic system for a typical family house in Melbourne has been designed. The system includes crystalline modules integrated into the roofing system, an inverter, a control centre, an electricity meter, and connecting wires. Life-cycle costs and benefits of the system were analysed. Grid electricity cost savings and global environmental benefits were also investigated. The major findings of this design study are presented in this paper.

2. Student activities have taken place in the following Faculties/Department at the University of Melbourne:

- Green Building Design Studio, Design 4, 1998, Tutors Paul Haar and Nick Bamford, Faculty of Architecture Building and Planning (17 students)
- Final Year Investigation Project, 1998, Prof Bill Charters and Dr Lu Aye, Department of Mechanical and Manufacturing Engineering (8 students)
- Environmental Design, Office Buildings in Temperate and Cold Climates, 1999, Dr Darko Radovic and Ms Margaret Kam (17 students)
- Final Year Investigation Project, 1999, Prof Bill Charters and Dr Lu Aye, Department of Mechanical and Manufacturing Engineering (2 students)

- Final Year Investigation Project, 1999, Prof Bill Charters and Dr Lu Aye, Department of Electrical and Electronic Engineering (I student)
- Short investigation project, 1999, group of international students from Thailand, Prof Bill Charters and Dr Lu Aye, Department of Mechanical and Manufacturing Engineering (2 students)
- Short Investigation project, 1999, Dr Lu Aye, International Technologies Centre (2 Students)

- Coursework Masters Student Assignment, 1999, Prof Bill Charters and Dr Lu Aye, Department of Civil and Environmental Engineering (3 students).

Topics: i. Energy saving strategies for office buildings
ii. Energy efficiency in building construction
iii. Thermal performance and life cycle costing of buildings

Web Page.

As part of the project, a WEB page;

http://www.arbld.unimelb.edu.au/~ncb/acf/acf-home.htm

has been established to provide background information on the research and updates on the progress of the research and building projects.

It is clear that much of the interest of the Commission is parallel to that of the Green Building Research team

Nick Bamford
Research Administrator
ACF Green Building Project

Faculty of Architecture, Building and Planning
University of Melbourne
Parkville VIC 3052