

Submission from the

EcoDesign Foundation

to

Improving the Future Performance of Buildings

Productivity Commission Issues Paper June 1999

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EcoDesign Foundation
PO Box 369 Rozelle NSW 2039
Ph: 02 9555 9412
Fax: 02 9555 9564
email: edf@edf.edu.au web: www.edf.edu.au
Principal contact: Dr Tony Fry, Director

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1. CONTEXT: ECODESIGN FOUNDATION'S INITIATIVES IN BUILDING PERFORMANCE

The EcoDesign Foundation comes to this study with considerable experience in the building design and construction industry having acted as ESD consultant, environmental manager and specialist researcher on a range of diverse, high level projects. Much of our work for clients has involved working collaboratively in multidisciplinary teams to develop sustainable design solutions - for architectural and urban design projects, product development, and, to a lesser extent, corporate environmental management. This has meant having a developed understanding of design processes and project management, as well as grasping the possibilities for design as a means to advance sustainability. It has also required familiarity with formal Environmental Management Systems (such as ISO 14000) and various methodologies, such as Life Cycle Assessment.

Founded in 1991 as an incorporated non-profit association, the EcoDesign Foundation is dedicated to the development of ecological sustainability. Through its commissioned and independent research, professional and postgraduate education program and high level consultancies to a wide range of activities - from design and construction, through urban planning and policy formulation, to product innovation -the EcoDesign Foundation is now recognised as the organisation at the forefront of sustainable design in Australia.

Because design for sustainability is such a new area, the major projects we have worked on have been leading edge, thus providing opportunities to learn on the job, innovate, develop new work ecologies and team dynamics. On these projects we have contributed to concept development; undertaken site and social studies; run ESD workshops; written and implemented Environmental Management Plans (EMP's); comparatively assessed design and specification options; extensively researched and made recommendations on low impacting products, materials and technologies.

A brief account of just some of this work is detailed below.

New buildings

In 1995 the EcoDesign Foundation acted as ecological design consultants for the development of Brambles Records Management facility at Albury-Wodonga. More recently, we have acted as ESD consultants and Environmental Plan Managers to Ryder SJPH Architects for the Concept and Detailed Design of the Olympic Velodrome at Bankstown. We are currently working as consultants on a project for a housing development at Cronulla.

Retro-fitting

In 1993 the EcoDesign Foundation took over a former school building in Rozelle, Sydney and redesigned it as a display and research centre to demonstrate low impact design solutions and products, and featuring the first grid-connected photovoltaic system in a retro-fitted building in NSW.

In 1997 we were commissioned by the Department of Urban Affairs and Planning and the Department of Housing to prepare a site/social study and proposals for ESD retrofit options for a 36 house estate in Northern NSW.

Energy

A major aspect of the EcoDesign Foundation building retro-fit was the installation of a 4.5 kilowatt grid-connected photovoltaic system and demand management measures such as insulation, low wattage heating and natural ventilation enhancement. This Renewable Energy and Demand Management Project was supported by strategic investment from the Energy Research and Development Corporation, NSW Department of Energy and others (see Appendix 5).

From 1995 to 1997 the EcoDesign Foundation acted as project managers and ESD design researchers on ESCALS, a multi-partner research and development project to create an ecologically improved solar lighting and control system.

Studies and Reports

In 1995 the EcoDesign Foundation conducted an industry consultative study entitled 'Tendering as an Instrument of Ecologically Sustainable Development'. The study, commissioned by the Commonwealth EPA, examined the extent of knowledge of ESD and its take-up in the building and construction industries (see Appendix 1)

In 1996 the EcoDesign Foundation began research for a comprehensive publication on the sustainable use of timber for architectural specifiers and other building industry professionals. Supported by a fit-out company, Interior Directions, the book *Timber in Context.- a guide to sustainable use* was published in 1999 by Construction Information Systems as NATSPEC Guide No.3. It has received very positive reviews in a wide range of building industry journals

Tertiary and Professional Development Education:

The unique educational work of the EcoDesign Foundation has created a new space of exchange between higher education, professional practice and industry. This applies to the three main constituencies to whom we have delivered courses on design for sustainability and undertaken curriculum development: (i) tertiary students, postgraduates and educators; (ii) practising architects, engineers and other designers; (iii) managers in industry and government. The types of courses run include: commissioned courses within or for other institutions; short, professional development courses in a range of disciplines; and the development of distance learning materials, our 'Guides to Redirective Practice' (see Appendices 2 and 3).

In many ways, we see educating in design for sustainability as encompassing all of our activities. Opportunities have been created by our work on live design projects, which provide team learning opportunities in sustainable design and later serve as case study material for courses. For example, our work on several Olympic Projects enabled us to induct a range of engineers and architects into more sustainable practices through the mechanism of the Environmental Management Plan (EMP). The EMP process introduced them to a new way of managing environmental design projects over time, ESD goal setting and progress monitoring, assessing design options, sourcing and comparing appropriate materials and recognising long-term problems. Many of the measures learnt were subsequently adopted by design team members as general practice. Another example of the educational capability of our consultancy work is the development of the concept of an operational handbook for buildings (see Appendix 4).

Other Relevant Current Projects:

- EcoDesign Foundation has recently commenced a major international research project on 'the ecology of steel' and opportunities for the development of sustainability in the steel industry. This project is the research and development phase for a second materials related book that has attracted support from BHP Steel.

- Our second 'Guide to Redirective Practice', *Concepts and Opportunities for Sustainable Engineering* is being developed in consultation with the Institution of Engineers Australia (see Appendix 3).
- EcoDesign Foundation has also been commissioned by Gregory Industries to develop and manage a major new annual 3D design competition for senior tertiary students in a range of design disciplines.
- We are active members of the Institution of Engineers Australia Building Energy Task Force which was set up to address issues relating to the development of a sustainable energy future for Australia. We are also a member of the UNSW LCA Forum which reviews LCA as an analytical tool for environmental decision-support in industry.

2. RESPONSES TO ISSUE PAPER JUNE 1999: *Improving The Future Performance Of Buildings*

There is much in the issues paper that we concur with and support. There are also things which we think to be absent or underdeveloped. This part of our submission offers comments that are critical of the paper, but with constructive intent. Many of the points we make are elaborated and brought to specific examples in the Appendices (Indicated).

In general we feel the focus upon input saving technologies (IST's) places too much faith in technologies and existing economic mechanisms to deliver solutions. This is not to say we reject either technology, or economics, but rather recognise that these both need to be better informed and developed in response to environmental imperatives, while also being assisted far more substantially by project management strategies and professional development education. What follows are general responses to key sections of the issues paper.

ITEM 1. Re. **Buildings**

'The environmental impact of buildings'

The paper's presentation of impacts is inadequate. Of course all buildings have impacts, what is at issue is the recognition, nature and response to these impacts. In our view the impacts that need acknowledgement and consideration are as follows:

Impacts on the environment of the building over its life cycle resulting from:

- **impact on site and relational connections** - while the site is viewed as a geographic and legal specificity it is seldom an environment with a contained ecology. Water, air, animals, insects, dust move over, across, under it. The more these relational connections are ignored the greater the negative impacts over time will be.
- **impacts in construction** - this includes embodied energy, pollutants/emissions generated by materials extraction and manufacture; off site and on site waste generation; transportation impacts; non-renewable energy uptake and the social impact of site and building works.
- **impacts in use** - this includes water use, stormwater run-off, sewerage, non-renewable energy uptake and operational, waste generation.
- **impacts in adaptive reuse** - this includes the impacts of non-renewable energy used in retro-fitting or disassembly. transportation and reassembly and waste generation.
- **impact of building destruction** - this includes the disposal of building waste,- noise, air/dust/water; transportation of contaminants and the consequences of site remediation.

Impact of the building as an environment over its life cycle resulting from:

- **impact of indoor emissions** - this includes the effects of off-gassing from building, fit-out materials and industrial, service and office equipment as they influence indoor air quality.
- **impact of building design** - this includes the impact on environmental health/the health of workers which in addition to the issue of indoor air quality involves the effects of noise, insufficient daylight, work space ergonomics, dust etc.

'Complexity of buildings'

While the paper acknowledges that the 'design, construction and operation of a building is complex' the level of complexity is underplayed once building performance and environmental impacts are introduced into the picture. Strategically each of these areas of complexity need to be looked at in turn in relation to the identification of problems and solutions. To illustrate the point consider:

Building design performance (functional and environmental) - this encompasses building to site issues such as solar access, micro-climate, air movement and quality, shade and noise in relation to factors like the design and management of thermal mass, ventilation, use of daylight, workspace design, work-ecology, worker/building interaction, type of work and more. The point is that variations of location, work function, building technologies and work function technologies all make the creation of standard design models problematic. This fact points to the need for standard design processes that are capable of dealing with the variables.

Building construction performance - this has to be viewed in terms of the construction process; the life-process of the building as it is able to sustain itself as built fabric, an operational system of services and a place of work; the adaptive performance of the building's space; and the end-of-life capability of the building to be adaptively reused, disassembled/reassembled or demolished with a maximum recovery of materials.

Building operation - here there are a number of points worth making:

- Financial structuring that make investments in IST's/sustainable design and technology attractive and viable is required. Specifically, financial models need to be adopted that redress the problem of short term cost analysis. For example, most developers currently do not see any benefit to themselves in the creation of the recurrent cost saving that comes from more capital intensive investments in IST's/sustainable design and technology, because they walk away from the building once it is developed. The ideal developer from a sustainability perspective currently is the owner/user. There is a need for mechanisms that create a pay back to all investor with an additional return. In this respect the 'build, own and operate' and 'build, own and operate and transfer' (BOO and BOOT) contracts that have been used for some public Infrastructure developments in recent years have the potential for the inscription of ongoing ecological sustainability, but this potential is not yet being realised. For the BOO or BOOT contractor, investments in capital costs can be offset by savings in recurrent costs (as in the case of installing solar water heating or a photovoltaic system).
- Connected to financial structures is the need for legal/contractual arrangements that pass responsibility for the sustainable functioning and maintenance of a sustainably designed building from party to party over the life of a building. This could encompass sale and purchase contracts; maintenance contracts; body corporate responsibilities, facilities management contracts etc.
- There is a 'cultural' tendency amongst developers to err on the side of technological solutions for specific problems that may not be the best solutions once put into a broader context. For example, there is often resistance to passive solutions like natural ventilation.
- Appropriate building operation, especially as it influences building performance, requires the right information being in the right people's hands at the right moment. Our society is used to handbooks being part of the purchase package of electronic goods, cars, lawn mowers, sewing machines and a host of other things. Few buildings arrive with an operational handbook (at best mechanical service elements will come with this information) however it is essential to building performance. Instruction on how to 'drive' the building's systems, schedules of inspections and reviews, maintenance, cleaning, environmental management, staff instruction and record keeping all need to be well communicated. (see Appendix 4 for an outline of an operational handbook prepared by the EcoDesign Foundation)

ITEM 2. Re. The performance of buildings

'Different perspectives on performance'

Far more than 'list the bottom-line' needs to be brought into the picture. How well a building performs the job for which it was designed and is able to sustain its economic and socio-cultural function long term, is crucial. Equally, how well it performs in, and as, an environment is essential to acknowledge. What has to be seen to converge are the joint and connected needs of economic and environmental sustainment.

'Environmental performance'

Our comment here focuses on an absence in the paper which constitutes a major means to advance environmental performance. The EcoDesign Foundation, along with other consultants involved in the environmental management of the Sydney Olympics 2000 construction projects, have discovered that construction based environmental management plans (EMPs) can be a path to increasing environmental performance. EMP's bring general environmental performance norms together with specific environmental performance goal setting for a particular project, tying the activity into the design and construction process as all object of full reporting and accountability. Each stage (concept design, detailed design, site works/construction/fitout and building use) is reviewed and signed off by the ESD manager, who is part of the project team. This is not a matter of check box ticking, but a customised activity that requires ongoing research, technical input and evaluation. The areas an EMP call cover include: energy (passive and active systems); water use and management; air quality; construction materials; technologies; waste; land care; noise; social impacts; biodiversity and social ecology. (Please note: hard copy EMP material can be supplied on request.)

'Life-cycle costing'

It needs to be pointed out that there is still a very limited understanding of life-cycle costing in the industry (and among most quantity surveyors). Rarely is a quantity surveyor asked to cost building construction, plus ongoing operation over a designated period, plus end of life materials recovery (the fact that the latter, when it is rarely considered, is referred to as 'scrap' or 'salvage' is in itself indicative of short term thinking). There is also an unfortunate tendency to conflate methods of *economic* and *ecological* assessment, which often reveals a lack of understanding of what sorts of ecological judgements are important to make in what circumstances. For example, the Olympic Co-ordination Authority's tender documents required design consultants to present design options with both life cycle cost analysis and life cycle assessment (LCA) the latter according to the ISO 14000 Standard on LCA. To conduct all LCA of any product or combination of products (as in an assembly of building elements) is a lengthy and complex process and unrealistic given the time pressures on most construction projects. Proper LCA's were not in fact conducted as part of the design process of Olympic facilities (though some were conducted afterwards). Work does need to be done to identify appropriate assessment methods that factor in and weight ecological and economic costs across the projected lifespan of a building. But this will not arrive by simply bolting together two pre-existing approaches developed for different purposes. Currently the ability to do this is limited and requires the education of all involved in costing and cost evaluation.

ITEM 3. Re. Input saving technologies (ISTs)

There appears to be a problem with the concept of IST - the term itself suggests singular identifiable technologies, whereas the paper defines ISTs very broadly to include many aspects of sustainable building design (p. 16). We support the latter. Designing a building which minimises the uptake of energy, water and other resources as well as generating minimal wastes and pollutants is an holistic exercise, rather than a matter of designing a standard building to which IST's are added. We would encourage the Productivity Commission not to beat about the bush and state clearly that the intention is to investigate ways of supporting sustainable building design

(albeit with the major focus on energy). The term IST encourages the kind of non-relational thinking and designing that is one of the root causes of unsustainable building practice.

Following on from discussion above on life cycle costing, we would suggest that an appropriate method of economic and ecological assessment, the latter based upon the LCA principles of estimating and assessing resource inputs and pollutant outputs over designated time spans, be developed. This could offer a major means of evaluating all the areas of concern in this section. Additionally, IST strategies (or rather, design strategies) for particular building types and retrofits would be required on a case by case basis.

'Appropriate input pricing'

Our brief comments here go generally to the notion of appropriate pricing.

Concessions on sustainable technologies (like solar water heating, photovoltaic energy generation, wind turbines and heat pumps) that initially reduce cost to create market demand and increase market size, are essential to establish a true reduction of the market cost of these technologies. In NSW SEDA's program of direct subsidy for building integrated pv systems is a very, worthwhile initiative. On the other hand, market reform measures that make non-renewable energy generation cheaper, work directly against the market interest of sustainable energy technologies. They also act to lower the value of fossil fuels which increasingly need to be viewed not as fuel but as raw materials with a high value added product potential. In our view a double sliding pricing scale needs developing that promotes the advancement of renewables and the replacement (as exports and energy generation) of a significant percentage of non-renewables over a measured period (eg. 25% over 20 years).

Another means of creating incentives for the uptake of ISTs/sustainable design practices is the mechanism of more attractive depreciation allowances and other tax concessions. This certainly begs further investigation.

'The availability of information'

The issues paper proposes the following question: "Many organisations, both government and non-government provide information on ISTs, particularly, energy saving technology. Is this information transmitted to the building industry adequately?" Our answer is no and the reason goes not to the degree of technical information available as is often assumed, but to the need and desire for better professional development education within the building and construction industry. This statement is supported both by our research (see Appendix 1) and our experience as industry educators. This is further discussed in section 'Suggested Improvement Mechanisms'.

Brief Case Study: NSW State Office Block

This building, designed by architect Ken Woolley, is cited as an example of the problem (economic and environmental) of design and building performance. The following is an extract from session 6 of the EcoDesign Foundation's 'Redirective Practice Guide' *Essential Ideas for Sustainable Architecture*:

"Sydney's State Office Block was designed in 1967 in an era when the size and position of offices was correlated to the Public Service's staff grading system. To meet the needs of such a workplace, the architect for the State Office Block duly adopted a structural grid of closely spaced columns that defined the placement of the partition walls of the offices. The problem was that the functional life of the building - a multi-storey steel and concrete tower - far exceeded the model of workplace design on which it was based. It was demolished in 1998, one of the major reasons given by the building's owner being that the preponderance of columns made it incompatible with the requirements of contemporary open space office design. While the technology existed in the 1950s to produce large clear span spaces, in this case the cultural imperative did not. The result was a building locked into its era, which was then rejected by a later era. A new building

on the site of the former State Office Block is to be erected - designed by international architect Renzo Piano.

This is a circular process - cultural imperatives determine architectural form, the constructed architectural form determines modes of building use (Including cultural practices and meanings as well as basic functional uses). However this is a dynamic process - the circle turns again with changes in the organisation of work creating new architectural demands which render the old solutions irrelevant. Yet the buildings still stand. This leads to demolition and to new buildings being built for the new requirements, but these might change again. Clearly this is an unsustainable process when purpose-built buildings are designed for lifespans that outlive their purpose. The same cycle can be seen for other modern building types. We could ask for example, what is to become of the large shopping mall buildings that the retail industry are now labelling as dinosaurs? A wider range of more flexible solutions is needed - some of these are explored in the next session.

The cycle of creation and destruction of buildings which has gathered pace in the 20th century, is but one symptom of modernity's making of a world of unrestrained making. All of this has created huge demands on natural resources - raw materials, minerals, timber, fossil fuels, water - the use and transformation of which has caused multiple damaging effects on the global climate, the air, the earth itself, the world's oceans, forests, waterways, its animal life, plants, as well as our own habitats and bodies. In other words our making, our manufacturing, has become an unmaking. a defuturing. In our efforts to make a place for ourselves, in making our world, so much of what we have done, and are still doing, is destructive. What is slowly becoming evident is that in the construction of our world we are also constructing ourselves and the future of our species. The full weight of this seemingly obvious point has still not arrived for most people."

Building performance has to be seen and designed 'in time'. What this means is designing for, adaptive reuse', 'loose fit/long life' and disassembly/reassembly. In short, it means new building forms and new building economics. To design functional symbolic buildings (like Piano's Building), is totally unsustainable, often highly profitable in the short term and completely environmentally and economically irresponsible in the mid and long term.

3. SUGGESTED IMPROVEMENT MECHANISMS

The EcoDesign Foundation has a number of suggestions to improve the future performance of buildings. In putting these suggestions forward we acknowledge that there is already some technological momentum in the areas of energy efficiency, renewable energy, construction methods, building materials, waste management and facilities management. Clearly these developments need to continue and be built upon. In addition we have three areas of suggestion we feel to be of great importance.

Suggestion 1. Building design in time/building life planning

Building performance needs to be viewed over the life of the building. Most commercial buildings can be expected to go through a number of minor and often major changes during their lives. It follows that in order to sustain the operational performance (and thus economic performance) of a building, it has to be able to be maintained in a condition of change. This demands a conscientious front end and 'design for life' planning exercise that selects and works with a number of adaptive reuse principles. For example:

- long life loose fit (which implies a fixed clear span shell and service logistics that enable flexibility in fit-out)
- an eternal structure (which, when a building's function can be seen to be constant over time, is designed and constructed for a very 'long life' and a very low 'cost to use ratio')
- multi-cycle structure (this is where a limited life and specialist life function is required - in this case a 'design-for-disassembly/reassembly' structure is created that is able to be disassembled, transported, reassembled and retrofitted)

In all these examples performance is planned, designed and managed. One implication of this approach is that operational, environmental and economic performance has to drive aesthetics. This has the ability to become a new aesthetics against style-based architecture.

Suggestion 2. Building use management

The way buildings are managed and used needs to be far more developed to secure and maintain performance. Currently, in most cases, building design and construction, workplace planning/design, facilities management and staff training are disarticulated from each other. In terms of sustaining the performance of a building, they need to be connected. Recent research has shown that there is a direct correlation between how workers feel about their place of work and their ability to have some control over their environment, and this directly affects the performative quality of their work. Thus building performance directly links to a building's economic outputs.

One of the most significant tools to deliver 'integrated performance' over time, as already indicated, is an EMP, supported by a building handbook (see Appendix 4).

Suggestion 3: Education

Out of the industry consultation the EcoDesign Foundation undertook on a Federally funded research project on ESD and the tendering process (see Appendix 1) one overwhelming message was evident - industry wants more education on ESD. Both Multiplex and AMP Property Management came to the Report presentation to emphasise this finding of the report. While some

progress has been made, this situation still pertains. In the context of the improvement of building performance we would headline three areas of education that are needed.

- To make real advances towards ESD being the norm in the design, construction and operation of all (rather than a few 'green') buildings, all stakeholders have to acquire general and higher level of understanding on the problems and the advantages of ESD-based buildings. 'Sustainability' performance, opportunity, economics can all be brought into convergence. Too often ESD is not recognised as an opportunity - it is reduced to a hand full of disarticulated compromises.
- Developers., architects and builders need education on the economies and technicalities of sustainable building design, construction, operation and management. A particular example would be the need for more architectural education in return brief development and retro-fit design. Equally, far more quantity surveyors need skilling in 'whole-of-life' costing methods.
- Policy makers need to learn how to create and employ more creative funding and contractual arrangements that take more responsibility for the built environment. Specifically they need to learn how to take better advantage of recurrent cost reduction, the establishment of a higher level of building user responsibility for their environment and a better perception of means to improve asset management/materials conservation over time.

The mode of delivery of such education is critical. The first task is to promote the need to know and the acquisition of knowledge as a significant investment with valuable returns (this is a promotional exercise); the second task is to develop a higher level of general understanding (this via short events and the production of curriculum material for use in tertiary and professional development education); and the third task is to have resources available where people can go to learn more (this to take advantage of electronic and physical media and existing materials).

Concluding comment

The EcoDesign Foundation makes this submission in order to bring our experience as researchers, consultants and educators in this area to bear on many of the problems voiced in the issues paper. While much of our submission reinforces the direction, and some of the comment, of the paper, we believe it is necessary to take things further, often by stepping back and viewing the problems from the perspective of their causes. In general, we believe that issues of long term goal setting, monitoring and delivery, effective task integration and management and the sourcing and comparing of appropriate materials and design options, are all key issues in creating more sustainable building design and construction projects and can all be greatly enhanced by the adoption of the Environmental Management Plan mechanism. In relation to this, we also strongly, believe that the development of tailored professional educational services is vital to the development of a more sustainable building and construction industry. From our involvement in architectural education we also think it important to emphasise that sustainability is now being widely regarded as a major driver of architecture's future development - this by institutions, students and professional bodies. We hope our contribution communicates how important we think the issue of improving the future performance of buildings is, and we sincerely hope the study leads to effective actions.

APPENDIX 1

The Tendering Process as an Instrument of ESD.. executive summary of a consultative research project

In 1995 the EcoDesign Foundation undertook a Federally funded research project on the tendering process as an instrument of ecologically sustainable development (ESD) in the building and construction industry. By the end of the project, one overwhelmingly clear message had emerged - industry both needs and wants more education on ESD, particularly in relation to issues of project management and decision-making. While there have been some advances in the industry since we undertook this project, particularly in availability of information on the comparative environmental performance of products, materials etc, the need for education has remained substantially unmet, often overdetermined by technical and technological 'solutions' that do not address the more substantial problems.

This project set out to develop a strategy that could accelerate the uptake of ESD in the building and construction industry by inscribing the use of ecologically low impact materials, cleaner production methods and environmentally responsible structures, products and services into the tendering process and within the larger context of building procurement and documentation. The tendering process was selected as a focus because it was seen to have the potential to prompt, guide and support ESD based innovation. The project was based upon the proposition that commercial purchasing power can be directed, via the tendering process, towards the creation of demands that can drive the Australian economy increasingly toward ecologically sustainable development. The project aimed to stimulate action by a particular approach to inquiry and consultation. What resulted was a clear picture of the operation of the tendering process and the state of the art of ESD delivery in the industry and a good profile of needs.

A list of major clients, developers, builders, architects, quantity surveyors and regulatory authorities was compiled. Over 40 detailed interviews were then conducted, followed by two workshops and the compilation of case studies. From interviews and workshop responses, a consultative paper addressing ways to 'design in' ESD actions as structural features of the tendering process was circulated to key project participants for comment. Companies and organisations who played a significant consultative role in the project included Multiplex, Fletcher, Devine Erby Mazlin, Standards Australia, Natspec, Department of Urban Affairs & Planning, Housing Industry Association, NSW Public Works, Sinclair Knight Merz, Keys Young, AV Jennings, Mirvac, Mitchell Guirgola Thorp, CMPS& F, Landcom, State Superannuation, AMP Property.

Several key findings emerged from the consultation and review process:

- While the impact of ESD on the building industry was evident in its increased inclusion in undergraduate, post graduate and professional development programs, in the generation of a literature, in the growth of policy, and in the development of practices, there was an urgent need and desire for more industry directed ESD education. This extended across the board from clients, to the design professions to site workers.
- It was evident that no common understanding or language of ESD existed - the term was found to be either an abstraction or defined in very limited terms. It was concluded that there was a strong need for ESD theory and direction.
- When addressing ESD in the industry, there was a clear tendency to focus upon narrow action limited to existing specialisms. This was seen to reflect both the lack of a common understanding of ESD generally, and the lack of appropriate guidance and management of ESD decision-making and implementation in projects.

- Following this, the project showed the significance of the leadership of client groups of the building and construction industry (Illustrated by the involvement of, for example, the State Superannuation Board, AMP Property, NSW Public Works, Landcom). As the creators of projects, they were seen as a key group to focus upon and develop in terms of ESD awareness and leadership. This also because ESD criteria must be written into the client's brief, otherwise they are unlikely to make their way into tender documents for subcontractors or final documentation, unless the head contractor operates with their own ESD policy. This points to two possibilities: the importance of client ESD education and the encouragement of ESD policies/ practices of large contractors. Industry initiatives in both these areas need to be built upon.
- It was also found that while current understanding of ESD was generally quite poor, there was an enormous amount of goodwill toward it in the industry and significant leads were already, being taken in a number of sectors. There was for example significant movement across several sectors (building owners, property investors, building economists) towards extending the time frame of the economic evaluation of building projects. This was seen as very advantageous for ESD and begs further development, particularly in bringing methods such as life cycle costing and total asset management together with the more progressive end of environmental economics. The feasibility of economic incentives such as tax concessions and depreciation allowances for implementation of ESD measures was also found to need further inquiry. There was considerable support from clients, developers and project managers in contributing to the investigation of these possibilities.
- Despite this goodwill however, it was also found the building industry will only respond via those structures and to those organisations whose legitimacy it recognises as having expertise in the building industry (professional organisations, government authorities). Many developers and architects believe that it is appropriate that these should lead the way. Standards, and building codes were identified as mechanisms worthy of more serious consideration as instruments of ESD development. However it was also recognised that the usefulness of standards is context dependent, being of little value in terms of overall project conception but of greater value to those 'further down the line' such as specifiers and sub-contractors.
- The success of the workshops, attended by a diversity of industry professionals, highlighted the need for networking and information exchange on ESD. It also indicated that collaborative group work could be a key way to advance ESD in the building and construction industry.
- Review of the case studies revealed that the best ESD projects to date had resulted from design competitions.

From these findings key recommendations were put forward:

1. the development of key informational and evaluative tools.
2. the production of an ESD guide for the building and construction industry.
3. the creation of an ESD pro-active community development program that brings together both individuals and groups; and the organisation of a number of small national focus group workshops.
4. the production of (i) a guideline document for ESD to be incorporated as all 'Integral component of any design competition and (ii) the promotion of at least one annual ESD based joint venture 'live' design competition.
5. the production of educational materials/guideline documents to support ESD professional development and the organisation of a program of professional development education.

APPENDIX 2

Essential Ideas for Sustainable Architecture: outline and summary of a learning resource

The EcoDesign Foundation's series of Guides to Redirective Practice aim to assist a wide range of professionals redirect their existing abilities toward developing sustainability. The Guides are not technical 'how-to' manuals - they are being developed in recognition of the great demand for the acquisition of new knowledge and skills capable of dealing with ecological, cultural and economic challenges.

Essential Ideas for Sustainable Architecture, the first of the Guides, aims to equip professional architects with the ability to better understand and judge the proliferation of information now available on ecological architecture and its technical aspects. The Guide takes familiar concepts such as site, construction, space and environment, showing them to be far richer when reworked in terms of the sustainability agenda. A careful rethinking of many of the fundamental assumptions about architectural practice is presented by explanation, example and exercise. The Guide consists of ten sessions exploring key ideas with exercises and background materials. The first sessions introduce several key design concepts. The last four sessions work with some major areas of practical activity.

The Guide has been peer reviewed and is available to purchase outright or with tutorial support from EcoDesign staff. The tutor-supported option is accredited by the Royal Australian Institute of Architects as part of the Professional Development points scheme. Further information on ordering this Guide is attached.

The aim is for those doing the Guide to acquire:

- a deeper understanding of sustainability
- contextual knowledges to assist judgements of technical information
- an ability to make connections between material and immaterial impacts methods that can be applied to concept design and brief development
- ways of thinking through the complex relations between factors such as space, materials, energy, lifespan, use and social relations.

Below is a brief outline of each of the ten sessions.

Session 1: Sustainability and Relationality

This explores the difficult question 'what is sustainability?' and introduces the concept of 'relationality'- the ability to see and make connections between things. This session suggests that before being able to create sustainable architecture we need to acquire sustain-ability - the ability to sustain. This can only happen if we develop a sense of the nature and extent of unsustainability, including an understanding of how unsustainability has arrived by design and how it is inscribed into the objects, structures, systems and even the modes of thinking of our everyday lives. From this perspective, the meaning and purpose of sustainable architecture significantly expands into the activity of thinking in other ways in order to design more sustainably. This depends upon an openness to learning and developing the ability to see relationally.

Session 2: Orders of Design (the eight essential factors) This session extends the discussion of sustainability and relationality by introducing further concepts:

'orders of design', which introduce a set of perspectives on such areas as site, construction, materials and use. The eight orders of design provide the organising principle for sessions 3 to 10.

'defuturing' and 'futuring'. These concepts provide the learner with a means for understanding unsustainability and thereby gaining insights into what is needed for the development of sustainability. Defuturing means doing something that takes a future away or prevents it from arriving (eg exhausting a soil, or making it infertile by other means, takes away the future possibility of growing a crop). Futuring means the reverse - ie giving a future to something by, conservation or by creation (eg bringing an engineered soil to a fertility-depleted site to use as a growing medium - thus making the cultivation of a crop possible, in conjunction with the existing land drainage).

Session 3: Community and Lifestyle

This session explores Design Order 1, which provides a social context for designing, from the perspectives of 'community' and 'lifestyle'. These are explored as concepts which have undergone significant changes with significant implications for the question of sustainability. The session presents 'community' as one way of naming the fundamental condition of our social interdependence, tracing its changing meanings particularly in the context of urban design. Following this, transformations in the meaning of 'lifestyle' are elaborated, leading to the proposition that contemporary notions of 'lifestyle' are frequently at odds with aspirations for 'community'. This problem is then worked through by bringing design and ecology into the picture. Inter-dispersed through the session are a number of exercises that encourage the learner to re-examine their own attitudes towards the issues. These are followed by examples and exercises that prompt design responses to identified problems.

Session 4: Space and Environment

This session outlines the spatial context for designing. It considers the following questions: What is space? What is environment? What do they have to do with each other? The session aims to question the way in which environment is commonly thought of as being something separate from us, 'over there' or 'out there'. Examples are discussed to show how our understanding of space has prefigured how we occupy it (turning it into place) and how this in turn has a profound effect on what we call 'environment'. The exercises are aimed to prompt a realisation that for architecture to contribute to sustainability a more complex understanding of space as well as a concern with what created environments themselves create, maintain or destroy materially and immaterially, is required.

Session 5: The Site (conducting a relational site audit)

Following the introduction of the idea of relationality in session 1, this session takes it up and gives it a more specific focus. Relationality is elaborated in general terms and compared to a similar, but not identical concept, that of 'system'. The implications of relationality for building and architecture are considered. The key example is how a construction 'site' can be thought about relationally and then how this transforms action. The session ends with an extensive 'relational site audit' checklist, which forms the basis of some of the exercises in later sessions.

Session 6: Construction (from building to 'world making')

This session poses the question "what is it that we construct by architectural design?" This directly follows on from and overlaps with session 5 in which *the site*, the assumed 'ground' of architectural practice, was shown to be a more complex idea than at first it appears. This session aims to do the same for another fundamental architectural concept - that of construction. This is done by exploring: construction as world-making, taking the example of the relation between the design of offices and the nature of office work; construction as material and immaterial; technology as a constructional force that increasingly impinges upon the biological. Connections are also made to session 3 in which the constructed nature of environments, lifestyles and communities was discussed.

Session 7: The Form of Time

This session explores the relation between time and design in a variety of ways. First, a general understanding of time and lifespan is presented. This is then brought to lifecycle methodologies, which are further explored through the example of retrofitting. Lastly, a typology of examples of

buildings types (eternal, retro-fitted, long life/loose fit, etc) that display an appropriate designing with time is presented.

Session 8: Sun, Light, Air and Energy

This session explores energy in terms of why we need it, what we use it for and how through the design, we can harness what already exists to meet these needs. This involves consideration of four themes: the sun as an active and passive energy source; air flow as a key factor for thermal performance; the quality of indoor environments; and daylight as a light source. Following this, various renewable energy technologies are outlined, with a more detailed case study of photovoltaics. The consideration of sun, daylight and air is linked back to the building types discussed in the previous session, particularly as one of the major tasks in retro-fitting a building is to improve thermal performance, daylighting and air quality.

Session 9: Materials (understanding their impacts)

This session begins by examining some of the ways in which materials are currently, being environmentally assessed, such as embodied energy comparisons and life cycle assessment (LCA). It then expands on these methodologies by raising commonly overlooked 'impact factors' in the use of materials, especially aesthetics and cultural perceptions. This point is elaborated by demonstrating how the unique properties of a material are a 'designing factor' that can be used for or against sustainability, taking concrete as an example. Materials synergy, or how materials can be used in combination either sustainably or unsustainably is introduced. The session ends with a case study of timber, to show the complexity of factors bearing upon the sustainable use of a material.

Session 10: Building Use

In this session the use of buildings, which is a crucial aspect of sustainable architecture, is explored. This is done by reconsidering what is meant by sustainable use and by presenting a model of how to care for a building that can inform both the design of a building's functional elements and be passed onto the building's users. The session covers:

- Landscape
- Water
- Building fabric
- Building operation
- Cleaning
- Waste management
- Building log book

APPENDIX 3:

Concepts and Opportunities for Sustainable Engineering: outline of a learning resource

This is the second of the EcoDesign Foundation's Guides to Redirective Practice.

Engineers are the key to sustainable futures. As those making infrastructural decisions in all aspects of our modern world, it is essential that all engineers have a strong understanding of sustainability. This guide to the principles and processes of sustainability, aimed at senior engineering students, recent graduates and engineering technologists, provides a way of understanding engineering as a central driver in the development of sustainability. Rather than present sustainability as an additional factor, this guide shows how sustainability can become a new organising objective for the process of engineering. Sustainability is defined as having a wider ambition than environmental protection or ecological impact minimisation. The Guide identifies those elements in engineering thinking and practice that already make substantial, though often unrecognised, contributions to the development of sustainability. The result is a more entrepreneurial form of engineering, that sees sustainability as a business opportunity and a challenging revitalising of the profession.

The research and development of this guide has been done in close collaboration with the Institute of Engineers, Australia. It has been designed as a casual distance learning package, with readings and exercises. Professionals working through the guide can receive email feedback from the authors in a tutoring arrangement that accompanies the purchase of the guide.

Outline of Sessions

1. A survey of the applicability and limits of currently used environmental impact assessment processes and management systems.
2. An examination of how sustainability alters and expands the nature of the sort of problems that engineering seeks to solve.
3. An introduction to understanding how engineering impacts on sustainability, providing an expanded sense of the significance of engineered products.
4. A case study showing how engineering's distinctively pragmatic way of approaching problems when used within the context of longer time frames, can generate sustainable innovations.
5. An examination of how to assess the sustainability of materials beyond the ecological impact of their manufacture, with case studies of concrete and plastic.
6. A critical review of currently used Life Cycle Assessment techniques and the way they can be applied to engineering decision making and on-going management of engineered products.
7. An introduction to the way engineering can influence behaviour and encourage sustainable attitudes and actions by drawing attention to the way engineered products and environments work, with a focus on building service engineering,
8. An exploration of the relation between efficiency, economy and social benefit, with reference to the appropriate technology movement out of which current ideas of sustainability grew.
9. A case study demonstrating ways of introducing sustainability into a client's brief and the sort of team work required, especially on larger projects to deliver sustainable outcomes.
10. An introduction to the sorts of issues that arise when engineering in intercultural settings and how sustainability can become a focus for such projects.

APPENDIX 4

Olympic Experience Centre Handbook: outline of a design resource

Context

In Australia, in the last decade, the initial abstract idea and general intentions of ESD have been turned into workable concepts and practical actions. Architecture, design, building and manufacturing have been at the forefront of this activity. One of the Consequences has been the emergence of more sustainable buildings, building construction methods, materials, services and technologies. While there is still a very long way to go and much has to be learnt, a great deal of new knowledge has been acquired and put into practice. What is quite clear is that ESD is not simply a matter of new technologies, products and structures. It also needs new ways of working, new habits and new values -issues that go directly to the environmental performance of buildings over their lives.

The EcoDesign Foundation developed the concept of an operational handbook for buildings in recognition of and response to these needs. This concept is similar to that of the instruction manual that comes with many of the products we buy. Such manuals teach us how to use products, care for them and extend their lives. The handbook brings this concept to the complicated products of the building and construction industry. This innovation recognises that while many ESD features may have been incorporated into a building's design to ensure it will have minimal environmental impacts over its life, unless this design intent is communicated to building users, equipping them with the information they need to sustain this design, it is quite likely that many of these features will over time be subverted.

Olympic Experience Centre

As part of its work as ESD consultant and design team member for the Olympic Experience Centre, EcoDesign developed a prototype operational handbook. While the Centre itself was not eventually built, the concept of an operational handbook for buildings has been retained as a valuable tool for sustaining ESD features in the design, construction and ongoing management of buildings, providing essential information and instruction to building users and making sure that the building will environmentally perform as designed.

The design of the Olympic Experience Centre exemplified the application of ESD principles to the conception of a building in its design, construction, materials, technologies and operation. The purpose of the Olympic Experience Centre was to present the story of the Sydney Games through display and theatrical facilities. It was to be open for twelve hours per day, seven days a week. The building was also designated for a variety of events like receptions, presentations and product launches.

The following aims were adopted in the design of the building and informed the development of its features:

- to design a structure for a lifespan of 30 years that functions during that time in the way it has been designed (or better)
- to design the building structure for ease and cost effectiveness of disassembly
- to ensure that the structure incorporates as many passive means as possible to minimise energy uptake to ensure that service technologies be selected on the basis of energy efficiency
- to import no topsoil or fill to the site and conserve and use what is already there
- to protect existing trees

- to design the landscaping and building to ensure appropriate collection and management of all stormwater on site
- to collect, filter and use roofwater
- to keep the use of potable water as low as possible
- to provide adequate sun shade provision
- to construct and use the building with a minimum impact on its site
- to ensure that the site is remediated when the building leaves the site
- to use reused materials on a low 'embodied energy' basis
- to select materials on their ability to be recovered, reused or recycled
- to select materials that are low in pollutants and that do not diminish indoor air quality

Of course, many *of* these aims crossed the path *of* the designers, architects, building managers and other building users. The intensity of building use and the volume of people envisaged to pass through the building coupled with the newness and unfamiliarity of the building's ESD principles, meant that some form of guidance and instruction as to the building's use and operation was going to be needed.

The handbook developed for the Olympic Experience Centre had three main roles:

- to inform building users and managers of the ESD features of the building and to provide instruction on issues of building use, care and maintenance
- to provide a log book - an integrated record and archive for the ongoing maintenance and management of the building.
- to provide a proto-type building handbook and to encourage the adoption of EMPs in the future projects of team members.

Handbook Style

The handbook was written to be as clear as possible, introducing and clearly outlining the purpose of the building and manner in which the building was designed. The bulk of the handbook was tabulated, clearly defining action areas, tasks, allocation of responsibilities per task and frequency of attention required. The action areas in the Experience Centre handbook were: landscape, water, building fabric, building operation, cleaning, energy management, waste, building movement, building disposal and site remediation (which falls under the jurisdiction of landscape). Example:

Action Area: Building operation	Specific Tasks	By Whom	When
(i) Air Quality	<ul style="list-style-type: none"> • inspect all air pathways to ensure they are not blocked by foreign materials • police the non-use of aerosols in the building • inspect any equipment that has an emissions capacity for proper functioning 	Manager	Weekly
(ii) Passive Performance: Ventilation and temperature	<ul style="list-style-type: none"> • surfaces of the construction materials – it is essential that floors and walls must not be covered with other materials or finishes 	Manager Manager	Continuous Weekly 24 hr policy

Log Book

The last section is the building log book, the aim of which was to provide a long term record of the building's use. The log was to keep an archive of all actions listed and programmed in the handbook, for the life of the building, including building disassembly and disposal. It was recommended that a keeper of the log should always be appointed (eg, the building maintenance or asset manager).

Keeping a log book helps to ensure that a program of care and maintenance is both laid out and adhered to, and provides a useful central archive of historical information and data documenting any changes in ownership, major repairs, renovations etc over the life of the building (in many respect every sustainable building is an experimental research project). Because building along ESD principles is a relatively new practice, what is able to be done in the future will depend on what is done today. Few buildings have long running records, even fewer are designed with a long term vision of their use in mind. This underscores why records of sustainably functioning buildings are of historical and research importance.

In large and complex buildings handbook information could be part of the Building Management System (BMS). This would make design demands on the content of control systems and software of a BMS that extend its scope from the operation of active building systems to environmental monitoring and care.

Concluding Comment

Buildings incorporating ESD features are not necessarily more complex to use and inhabit than non-ESD ones (in fact, a handbook may well also be a tool for introducing more sustainable habits in existing buildings). However, a different kind of culture of care is required. A key ESD issue in new buildings is that a building's entire life span is likely to have been taken into account in its design and thus there is a strong sense of the need for responsibility to be taken for it by its users. Building users need to be cognisant of any new or unfamiliar ESD processes that may affect the ways in which the building is used and maintained. This approach is not just about sustaining the building, it also serves to impart to it a new function: to induct people into working and living in more sustainable ways. As explained in Section 3 of this submission, Improvement Mechanisms, the development of a building handbook is also essential in supporting the EMP process that seeks to deliver 'integrated performance' over time.

NSW Department of Public Works/ State Projects; NSW Dept of Energy's Sustainable Energy Research & Development Fund (since displaced by SEDA); Pacific Power; Sydney Electricity (now Energy Australia); Solarhart; CSR Bradford; BP Solar.

Implementation (problems, issues, challenges) and Lessons Leant

The Renewable Energy/Demand Management design team was headed by Dr Tony Fry Director of EDF and drew expertise from Centre for Photovoltaics at UNSW, NSW Public Works/ State Projects, BP Solar and Sydney Electricity. The PV system was designed and specified at a time when PV was little used in urban contexts and grid-connected systems were still in early stages of development. There was no commercially available inverter that allowed full grid inter-activity, so the system was designed with battery storage and partial grid interactivity (see below). Since then, lower cost fully grid interactive inverters have become available, and the cost of PV cells is also set to fall. We were aware that the system we installed at the time was not commercially viable, but believed that it was important to familiarise the building industry with PV technology, in anticipation of increases in efficiency and lower prices that advances in r&d were indicating would occur.

This building was to be retrofitted as functional space with the aim of providing a Comfortable internal environment for most of the year, by taking advantage of the building's thermal mass, and to give the occupants a degree of control. Modifications to improve thermal performance included: ceiling insulation, window double glazing, operable window louvres and operable windows for ventilation and air flow cooling. The lighting and heating systems were also designed to reduce energy demand (see specifications below).

The budget for the retrofit was very small, but this limit was turned into an opportunity for sponsorship from many manufacturers and suppliers who donated environmentally responsible products and materials. Their contributions were acknowledged in the building's signage system, in purpose built product display areas, and in making their product literature available to the many building designers who have attended EDF's professional development courses.

Initially it was intended that changing product displays and organised tours of the building would be major activities. While building tours were conducted for the first two years after the retrofit, EDF found it could more effectively influence buildings designers by offering professional development courses and working as consultants on further design projects. However in all these activities, the DARC building, as EDF's premises, has continued to provide a live exemplification of the design principles advocated on other projects. The lesson learnt here is that demonstration buildings should always have a function beyond just demonstration.

The other problem with demonstration buildings is that the more they aspire to be 'state of the art' the more rapidly they date. Because ours was a minimal intervention retrofit, this has not been so much of a problem, nevertheless a number of products and techniques we specified at the time have now been overtaken by environmentally improved ones (eg since the building was painted [mainly with conventional water-based paints], inexpensive paints with almost nil volatile organic components are available from two major Australian paint manufacturers).

In general, the retrofit was informed by the following principles..

- designing with what is already designed, which is not to be confused with 'making do' with an existing building and its limitations. Rather it is based upon the knowledge that no design activity ever begins with a blank slate - it is always prefigured by previous solutions, technologies and what is already physically present (for example large windows and high ceilings meant that the design of air circulation could rely on passive measures, rather than needing or designing in air conditioning).
- a recognition that what is designed goes on designing, for example, the ways in which the configuration of spaces and equipment design work practices and social ecologies of work.

a desire to create an environment that fosters action towards sustainability through ecologically responsible actions becoming intuitive habits, rather than relying on 'raising awareness' and 'affitudinal change'- an example of this is the 2 hour timer installed on all the heaters, which creates a situation in which heat is used only when needed.

DARC Building - Renewable Energy and Demand Management - Specifications

(i) PVS system

The roof top photovoltaic (PV) array and battery inverter system generates power from the sun by converting sunlight into electrical current (and voltage). The system consists of 54, BP Solar 283, 83 watt modules mounted on a substructure over the existing roof. Modules are connected as 6 parallel strings, of 9 modules series connected per string, giving a total 4.5 kilowatt peak power at nominal 1220 volts DC output. From these solar panels, DC power is supplied to the 20, 6 volt, 207 ampere lead acid, wet cell batteries. The batteries have the capacity to store 25 kilowatt hours of electricity (about 10 hours of uninterruptible power supply [UPS]). They are 80% efficient in energy storage but not essential in grid connected PV.

The batteries provide 120 volts DC to the single phase, grid interactive sine wave inverter which converts the current into 240 volt, 50 herz AC. The inverter can operate from the PV array/battery supply, or in reverse, to charge the batteries from the grid if necessary (ie when there has been no sun for several days). The inverter is an intelligent controlled power electronic device, overseeing the control and safe operation of the system. This includes battery charging, grid interaction and disconnection. It also logs performance, allowing exports to be recompensed for imports. There are two different electrical systems operating in the building, the UPS which can supply computers and emergency lighting from the batteries if necessary, and the Main system which provides energy direct from the inverter to power all other electrical uses.

The inverter output is connected in a load sharing arrangement with the Energy Australia grid for supply of the building's electrical load. Electrical power generated by the PV system which is excess to the buildings needs is exported to the grid. This occurs on weekends and during sunny week-days in summer because of the size of the PV solar array and the energy efficiency and conservation measures used in the building. EDF's PV system is an example of a distributed generation approach for electricity supply whereby power is produced in dispersed locations around the electricity network. The present system in Australia is centralised - supplying electricity generated from large power stations to the end user.

(ii) Re- Wiring

For rewiring a non-PVC conduit (cross-linked polyethylene) was used. When burnt this crystallises without producing toxins (unlike PVC which emits chlorine). PVC was also avoided because it is nonbiodegradable, prohibitively expensive to recycle and toxic to produce.

(iii) Lighting

The design principle was low level ambient lighting (assisted by passive architectural measures enhancing natural lighting) with an emphasis in task specific lighting. Existing light fittings were reused with the luminaries being re-manufactured: the metal frames were sandblasted and polished or painted, the capacitors with PC13's were removed and replaced with electronic ballasts (which now allows the dimming of fluorescent lights), new reflectors were put in allowing the removal of one of the three tubes, and energy efficient fluorescent tubes were inserted. Ambient lighting in lesser used rooms is connected to timed light and motion sensors, which can be manually over ridden. Task specific lighting is provided by low cost desk lamps fitted with compact fluorescence, encouraging minimal energy usage by the reduced need for high level ambient lighting. Some display lighting is 12 volt DC with halogen lamps, running off the batteries.

(iv) Cooling and Heating

The building's thermal mass, orientation and fenestration mean that little cooling is needed in summer, the existing fans with operable windows suffice (no air conditioning is both more energy efficient and healthier). These elements have been enhanced by adjustable louvres (two of which are powered by externally mounted solar battery packs, the others from the PV system), and rockwool ceiling insulation. Window double glazing on the western and southern sides of the building double protection from the afternoon sun with sound dampening from Victoria Road (an extremely busy 6 lane thoroughfare). These windows were deemed non-operable given the road's exhaust fumes. Heating is provided by Safe-T-Heat low energy radiant heating pads consisting of a carbon element in Mylar plastic cassettes, producing low wattage infrared radiant heat which warms up surfaces (rather than air) in a similar way to heat from sunshine. The principle is low level ambient heating (2 to 3, 600 watt pads per room) supplemented by task specific heating (under-desk 200 watt pads). All heaters operate with individual, user-operated 2 hr timers.

(v) Water Heating

Solarhart supplied a solar-thermal hot water heater, though the building's demand for hot tap water is minimal.

Outcomes

After the retrofit was completed, energy monitoring was undertaken by the Energy Management Unit of the Department of Public Works and Services. The purpose was to aid in the evaluation of the effectiveness of the building in providing its energy and demand management aims. The monitoring project had two parts. The first was a survey undertaken to investigate occupant's impressions of the building as a work environment. The second part was a quantitative measurement system which was installed to determine the performance of the PV array and the energy consumption of the systems in the building. It also recorded environmental conditions in the building.

The results are documented in the monitoring report, which found, in summary:

"The building provides a pleasant work space for most of the year, with the exception of the winter months which tend to be cold. The operable windows are well used to provide additional cooling and reduce stuffiness during the summer months. The chosen system of heating (radiant heating panels) is appropriate, however the installation is not installed in the best manner, so its effectiveness is lessened (it would have been better had the heating panels suspended from the ceiling been installed on the walls thus reducing the amount of wall surface radiating 'cold').

The energy demand is quite low for most of the year, with the notable exception of June and July when electric heating, particularly additional plug-in heaters, approximately triples the energy consumption. The provision of timers and other local controls is effective in reducing the amount of energy used unnecessarily. If the plug-in heaters are to continue to be used, it is recommended that they be plugged into specially time controlled circuits to prevent their operation through the night.* The PV system provided about 40% of the building's total energy requirements. It appears to be well sized for the building load, as the system exports a small amount of electricity for most of the year."

Vicki Horan *EcoDesign Foundation - Renewable Energy Demand Management Project, Monitoring Report*
Energy Management Unit, Department of Public Works, NSW in collaboration with the EcoDesign Foundation,
1997 (a copy is available from EcoDesign Foundation for the cost of colour reproduction).

* This has since been addressed.