ENVIRONMENT DESIGN GUIDE

THE ROLE OF BUILDING ENVIRONMENTAL PERFORMANCE ASSESSMENT IN DESIGN

Peter Graham
Department of Building and Construction Economics, RMIT University

SUMMARY OF

ACTIONS TOWARDS SUSTAINABLE OUTCOMES

Environmental Issues/Principle Impacts

- Environmental performance assessments are procedures that determine to what extent a building might influence the environment, so that the building design or operation can be altered to reduce harm and improve amenity (Trinius, 1998).
- Environmental performance assessments rely on *tools* for the analysis of the environmental performance of buildings and a design process that meaningfully accommodates life cycle environmental thinking.
- Using *tools* during design also provides a systematic and transparent description of the decisions that lead to environmental design solutions.

The use of environmental performance assessment tools allows designers to rigorously study design alternatives and then to produce buildings that are:

- comfortable, in terms of thermal, visual, acoustical and air quality aspects
- frugal in their use of energy and other resources; and
- gentle overall to the environment, in terms of reduced air pollution, avoiding use of ozone-depleting refrigerants, emissions of solid and liquid waste and damage to biodiversity.

Basic Strategies

In many design circumstances, you will have boundaries and constraints that limit the application of cutting EDGe actions. However, two decisions must *be made in order to assess effectively, environmental implications of design decisions using environmental performance assessment tools.*

- Firstly, there needs to be a clear statement of the environmental goals of the project; and
- secondly, there must be a commitment to allow time for environmental assessment during the design process.

Other basic strategies include:

- using ratings tools to assess the operational energy efficiency or greenhouse gas emissions of the building during concept design stage
- identifying LCA impacts of a building.

Cutting EDGe Strategies

- Use consultative experts
- use detailed modelling tools to predict the actual performance of a building over a range of environmental criteria
- use building material specific checklists
- use performance assessment tools.

Synergies and References

- Australian environmental design tools, rating schemes and instruments as outlined in this note.
- *BDP Environment Design Guide*: GEN 16, DES 17, DES 21, DES 22, DES 23, TEC 7, PRO 1, PRO 3.

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There was a time when the success of a building project was judged on how well it met the time, cost and quality objectives of the client. With increasing environmental awareness, has come the desire for a building project's environmental performance to be considered as an important criterion for the success of a project. With this desire comes increasing accountability for demonstrating that the environmental performance expectations of clients, interest groups and the public, have been met. Doing this requires tools and methods for assessing the environmental performance of buildings at the design phase and in use. This note provides information on what building environmental performance assessment is, how it is used in design, and profiles a number of assessment tools that are commercially available in Australia.

Key Words – Environmental performance, assessment, tools

1.0 INTRODUCTION – WHY USE ENVIRONMENTAL PERFORMANCE ASSESSMENT AS A TOOL IN DESIGN?

There is little doubt that there is increasing attention on the construction industry's contribution to the general decline in the quality of the Australian and global environment. During 1999, several major Australian initiatives brought the importance of the environmental performance of buildings into sharper focus. These included:

- The formation of the Australian Building Energy Council with the support of the Australian Greenhouse Office;
- The decision by the Australian Building Control Board to develop minimum energy performance standards for inclusion in the Building Code of Australia;
- The launch of the Sustainable Energy Development Authority's Commercial Building Greenhouse Rating Scheme in NSW (*Pedersen et al*, 1999); and
- The Productivity Commission's report into improving the life cycle performance of buildings (Productivity Commission, 1999).

These initiatives follow the mandatory inclusion of environmental management criteria into the tender conditions for all state government projects in NSW, and the compulsory energy rating of new homes in the ACT. The direction of change in Australia's building industry is toward sustainability.

Capable environmental designers must therefore be able to answer questions such as: have the environmental impacts of materials, energy, water and other resources consumed, been considered? Is the energy embodied in the building more or less than it's operational energy? What greenhouse emissions will this design cause? Will the indoor environment help people be comfortable, healthy and productive, rather than sick?

Design briefs that include performance requirements for ecologically sustainable development have been applied to land-mark projects such as the Sydney Olympic Village[1]. On this project, design teams had to demonstrate how their design complied with the performance requirements and therefore required a transparent environmental design process. Capable environmental designers must also be able to answer questions like: What was the basis of their environmental design decisions? Was it intuitive or derived by measured studies? What was the method of assessment? How environmentally sensitive are the new initiatives? (Peshos and Hall, 2000). Designers therefore need to be equipped with the knowledge and tools to be able to translate into design, the increasingly stringent environmental performance goals of clients, and create buildings that meet these new objectives.

"Leading edge proponents of sustainable design practice are extending the envelope of sustainable design practice to a range of immaterial 'ecologies' such as work place design, user interaction and lifestyle design, reflecting a recognition that material structures design life-styles, expectations and user habits which themselves can be redesigned to produce more sustainable social and environmental outcomes". (Pedersen et al, 1999).

Environmental assessment tools will not address all of these aims of sustainable design. However, they will help inform the design process toward sustainable design by:

- including environmental performance assessment in the design process, providing an opportunity to improve the effectiveness of the design team by including a wider range of expertise in a systematic way;
- introducing environmental assessment tools into a design process, providing a process by which designers can learn about the environmental

1 This information is contained in the ESD design guidelines for the Sydney Olympic Village project provided by the project developers Mirvac/Lend Lease.

impact of buildings and the integrated issues of sustainability (Malin, 1998); and

- introducing systematic assessment of design options, providing a documented process demonstrating compliance to tender conditions or to client environmental performance goals.

In the UK, for example, the use of the BREEAM assessment method for completed buildings is now recognised as an industry benchmark for the environmental performance of buildings (Yates and Hampton, 1997).

Environmental assessment of building design varies in scope and application, depending on the stage of the design at which it is applied, the amount of time required for assessments to be carried out, the existing knowledge of the design team, access to information, and available financial resources. In most cases, environmental assessment is intended to help support design decisions. It therefore follows that for this to take place, the design decision-making process itself must be structured in a way that enables the inclusion of environmental information. This note will describe the range of environmental performance assessment tools currently commercially available in Australia and how they might be integrated into the process of designing a building.

2.0 WHAT ARE ENVIRONMENTAL PERFORMANCE ASSESSMENTS FOR BUILDINGS?

Eliminating or reducing the harm to our natural and built environment that buildings cause and, instead, creating buildings that work in harmony with nature, is the main focus of ecological design (Van Der Ryn and Cowan, 1996). It follows that in order to design with this attitude and avoid or reduce environmental harm, designers must be able to identify what life cycle environmental impacts of a building they are designing is likely to have. In addition, they must be able to determine whether the measures taken to increase the environmental benefit of their building will meet the expectations of their client and society.

The environmental harm caused by our existing building stock must not be ignored. Ways of determining whether the environmental performance of an existing building meets the expectations of clients and society, and encouraging building owners, tenants and operators to progressively improve a building's environmental performance, are also required.

Environmental performance assessments are procedures that determine to what extent a building might influence the environment, so that the building design or operation can be altered to reduce harm and improve amenity (Trinius, 1998). Environmental performance assessments rely on *tools* for the analysis of the environmental performance of buildings and a design process that meaningfully accommodates life cycle environmental thinking. Using *tools* during design also provides a systematic and transparent description of the decisions that lead to environmental design solutions.

As Bobenhausen and Witner (1998) state, the use of environmental design tools helps designers rigorously study design alternatives, and then produce buildings that are:

- comfortable, in terms of thermal, visual, acoustical and air quality aspects
- frugal in their use of energy and other resources; and
- gentle overall to the environment, in terms of reduced air pollution, avoiding use of ozone-depleting refrigerants, emissions of solid and liquid waste and damage to biodiversity.

There are a number of ways of determining the influence of design decisions on the environmental impact of a building. These include consulting experts, using detailed modelling tools to predict the actual performance of a building over a range of environmental criteria, using building material specific check-lists, or performance assessment tools. Methods, tools and instruments for environmental performance assessment of buildings, have been a major focus of research and commercial development in the Northern Hemisphere for more than ten years, more recently receiving increased attention in Australia. This Note concentrates on environmental performance assessment *tools*, so it is necessary at the outset to clarify exactly what *tools* are and how they differ from *methods* and *instruments* for environmental performance assessment.

2.1 Methods

According to the International Energy Agency Annex 31 on "Assessing the energy related environmental impacts of buildings" a method of environmental assessment refers to "scientifically oriented rules of procedure" (IEA Annex31, 1997). The Life Cycle Assessment (LCA) Approach, set out in ISO 14040 is an example of a method. Many assessment *tools* are based on an LCA method. Designers need to be aware of the method by which an assessment tool provides results in order to understand the scope and detail of assessment that the tool provides (see GEN 16 for a more detailed description of LCA).

2.2 Instruments

Instruments support the preparation of design decisions, but normally do not allow the direct input of project specific data. A checklist for choosing environmentally high performance materials is an example of an instrument. The development of the checklist and the rating or profile of materials contained within it may have been based on an assessment of materials using a tool and method. However, in this case, the designer must choose to accept the advice provided by the instrument on the relative environmental impacts of different building materials, products or systems (IEA Annex 31, 1997).

2.3 Tools

Tools are described as mainly "computer aided conversions of calculation and assessment methods" (IEA Annex31, 1997). The assessment tool provides an interface for the input of project data, suitable access to the calculations and environmental information databases, calculation of assessment and suitable representation of outputs. LCAid (Peshos and Hall, 2000) and EcoQuantum (Mak *et al*, 1997) are examples of tools that provide a user-friendly interface for producing environmental assessments using the LCA method.

The process of building design is an iterative process requiring the generation of integrated solutions to complex problems. In many cases, the generation of the solution to a design problem creates a deeper awareness of the problem, and therefore the generation of yet more solutions. In this process, the many aspects of the design brief are weighed against each other. Some tools are therefore designed to predict the environmental implications of design decisions as the design is being developed.

A number of environmental assessment tools have been developed in Australia and overseas for use during the design process. Some of these are built around LCA databases of building materials, and include interface or integration with energy modelling software.

Overseas development of environmental assessment tools has seen a number of life cycle based tools released for use by practitioners. Tools such as the Dutch Eco-Quantum (Mak *et al*, 1997), EcoProfile from Norway (Fossdal, 1997) and ATHENA from Canada (Trusty *et al*, 1998) are notable examples. However, in Australia at present most tools are based on energy modelling programs and concentrate on providing information on life cycle energy related environmental impacts only.

Environmental performance assessment tools assist designers in understanding the potential environmental impacts of design decisions. They do not make integrated decisions about whether the impacts identified by a design decision will diminish the capacity of ecosystems to continually meet the needs of human beings. In other words, they cannot assess a building's contribution to ecological sustainability.

3.0 WHAT TOOLS ARE AVAILABLE AND WHAT DO THEY DO?

A number of Australian tools have been developed to help designers understand, in some detail, the environmental effects of design decisions on the environmental performance of a building. At the same time, other tools have been developed to provide general guidance on reducing the energy consumption and greenhouse emissions of buildings in operation, and to provide a rating of performance that might influence market demand for low energy and low emissions buildings. These assessment tools are being developed in response to the growing awareness within the industry and prospective client groups of environmental, and more recently, sustainability issues related to building construction, operation, refurbishment and demolition.

The environmental performance assessment tools available for designers in Australia can be categorised as:

- LCA tools that identify the life cycle environmental impacts of building materials and products
- modelling tools that predict the energy-related environmental performance of entire buildings, components or systems during building design
- hybrid tools that integrate modelling of energy performance with the prediction of other influences on building environmental performance such as initial embodied energy, acoustics and indoor air quality; and
- rating tools that rate the operational energy efficiency or greenhouse gas emissions of completed buildings.

A seminar held on the 8th December 1999 at RMIT was convened by the Australian Building Energy Council and the Australian Green Building Challenge Team to give Australian design tool developers the opportunity to present the state of the art in available systems. The following are brief synopses of the commercially available tools presented on that day. This is not a comprehensive list of the tools available in Australia, however it does summarise the attributes of the major commercially available tools in use. Other Australian tools for building energy analysis such as the CSIRO's Cheenath 9 building energy performance prediction tool, and CAD-based embodied energy calculation tools exist and are also available.

3.1 LCA tools

LCAid

LCAid™ is a conceptual and design development tool with an interactive link with ECOTECT as a DDE (Dynamic Data Exchange) so that, the moment an object is drawn in ECOTECT, a material can be associated in LCAid™ and the quantity automatically calculated by ECOTECT. An input to read a 3D CAD file as a DXF file, allows the user to select stems from the file and make associations with materials.

It is also possible to read in other sets of LCA data from the Boustead Model or from other LCA models. A template is provided for the format of data to be read by LCAid™ from other LCA models. Depending on future demand, a reader may be created to read directly from the outputs of other LCA models.

LCAid™ contains algorithms for calculating the waste generated and the water consumed over the life cycle of the building. It also provides the LCA of the Australian energy supply system and links to calculate energy consumption results from thermal engines. LCAid™ also has feedback loops for the energy required to produce water from the public supply system, which can be significant for buildings such as houses, for example.

Inputs

Three input categories are required:

1. General information
   building type
   number of occupants
   region for climate data.
2. Material type and quantity
   select materials from the LCA library of materials and enter the quantities.
3. Waste generation, water and energy use
   automatically generated from building design information.

Outputs

Evaluation

A comparison between a number of design solutions, so a relative performance can be gauged. One of the design solutions is set as a benchmark and provides the basis of the comparison. It is then possible to assess the performance of the design solution as being “good” or “bad” relative to the benchmark.

For each evaluation, the following eco-indicators are provided:

- life cycle greenhouse gas emissions
- life cycle embodied energy
- ozone depletion
- nutriphication
- heavy metals
- acidification
- summer/winter smog
- carconogenisis
- solid wastes
- water consumption
- primary fuels.

Analysis

Presents the results of one design solution so that the areas of greatest impact can be identified in the life cycle of the building. This acts as the mechanism to identify areas of large impact and to try to reduce these impacts with an alternative design solution.

Building types

All types

Target user group

Architects, engineers, students, LCA practitioners and evaluators at all levels of government and private industry.

Computer needs

PC using WINDOWS 95 and above.

3.2 Energy modelling tools

BUNYIP

There are two versions of BUNYIP: one aimed at architects interested in evaluating options on the building design and the other aimed at HVAC engineers that adds detailed HVAC modelling and peak load estimation capabilities.

BUNYIP is designed to evaluate the thermal performance of non-residential buildings and is a design tool, rather than a research tool. BUNYIP is used to model conceptual and design development phase or retrofit.

Inputs

Building Geometry entered via integrated 2D CAD interface.

Building Location Selection of customised construction details for building elements.

Outputs

- Design of external fixed shading schemes
- specification for schedules, including optional hourly profiles
- selection of energy tariffs from library
- details of occupancy, lighting, equipment, infiltration and thermostat for each zone
- simple HVAC model
- detailed HVAC model covering packaged units, air handling systems and thermal plant
- miscellaneous equipment like lifts, DHW, etc
- energy consumption
- operating energy costs using local tariffs
- internal temperatures in unconditioned or under-conditioned spaces
- peak heating and cooling loads (engineers’ version)
- comparison between design options on basis of energy consumption or cost.

Building types

Non-residential buildings.

Target user group

Architects, engineers and students

Computer needs

IBM PC or compatible, Windows 3.1, 95, 98 or NT.

BEAVER/ ESPII

Windows based modelling tool developed in America providing for a range of operating schedules for the building use and individual components of the air conditioning system. It is applied during final design. Assumes buildings have HVAC. It cannot be used for passively heated and cooled buildings.

Inputs

- Hourly climatic data
- detailed description of the building construction including shading and occupancy

- detailed description of the building services including secondary and unitary air handling plant, chillers, boilers, hot and chilled heater storage tanks, solar collectors, on-site generators etc, as required.

Outputs

- Energy consumption of building by fuel type, by component and by time of day
- energy consumption of the building services (chillers, boilers, pumps, fans, cooling towers, on-site generators etc), and all other energy consuming devices (domestic hot water, lifts, etc) in the building
- space temperature variation
- plant loadings
- hourly or daily peak demands.

Building types

Air-conditioned commercial, institutional and residential buildings.

Target user group

Building services designers, including consultants, contractors and government departments.

Computer needs

IBM PC or compatible, Windows 3.1, 95, 98 or NT.

DOE 2.2

DOE-2 is another building energy analysis program from the USA. It can predict the energy use and cost for all types of buildings. DOE-2 uses a description of the building layout, constructions, usage, conditioning systems (lighting, HVAC, etc) and utility rates provided by the user, along with weather data, to perform an hourly simulation of the building and to estimate utility bills. DOE 2.2 calculates predicted operational energy demand and cost but does not indicate the environmental impact of energy consumption. It is used primarily for design detailing.

Inputs

- Building layout, constructions, usage, conditioning systems (lighting, HVAC, etc)
- utility rates
- weather data.

Outputs

Comprehensive energy modelling. The latest version also includes calculation for:

- natural ventilation capability in all single-duct system types
- enhanced residential system with forced ventilation
- inside surface temperature calculation
- additional day lighting controls.

Building types

Air-conditioned commercial, institutional and residential buildings.

Target user group

Building services designers including consultants, contractors and government departments.

Computer needs

IBM PC or compatible, Windows 3.1, 95, 98 or NT.

GSL - Giselle

GSL stands for Glazing Selector program. It is a tool specifically designed for building designers and designers of glazing, to provide guidance on glazing performance in the context of the overall energy performance of the building. The program is also designed to help building designers understand the reasons for the performance of particular glazing in their designs. GSL is intended as a means of comparing the energy performance of different window glazing systems and not as an alternative to detailed building energy modeling for thermal performance prediction (Bell *et al*, 2000).

The program allows the evaluation of glazing performance, without the need for detailed building plans or the use of other building simulation programs, and is designed to allow a rapid and comprehensive analysis of window glazing systems at concept design phase. The tool allows designers to select glazing systems including orientation, window size, shading, framing and actual glazing used. GSL would need to be used in conjunction with other assessment tools in order to assist in assessing the environmental performance of an entire building. GSL compares optimised results with a base case glazing system and provides an indication of comparative energy savings.

Inputs

Menu driven, includes:

- building location
- orientation of windows
- glazing type
- window size
- height above floor level.

Outputs

- Annual cooling energy
- annual heating energy
- annual lighting energy
- total annual energy
- energy saving compared to base case.

Building types

All types.

Target user group

Architects, facade designers, services engineers, window industry sales staff, and homeowners.

Computer needs

PC Windows 95 and NT.

3.3 Hybrid tools

ECOTECT

This software couples a 3D design interface with a wide range of performance analysis functions. The tool has been created for use during conceptual design and focuses on environmental impacts related to overall building shape and the materials used. It has been developed to interface with LCAid™ using building geometry as a bridge to incorporate LCA data into the design tool.

Inputs

The analysis functions are based on a progressive input philosophy where much of the required data is automatically inferred by the software, from the way the building is created. Designers must directly enter basic building or element geometry and materials using a CAD type interface for drawing elements.

Outputs

Shadow analysis

- Transparent shadows
- additional overshadowing
- shadow profiles
- stereographic analysis.

Energy analysis

- Sun penetration
- solar rays
- optimised shading design
- solar access
- natural and artificial lighting
- heating and cooling loads
- internal temperatures
- cumulative frequency
- smart power and retail energy.

Acoustics

- Statistical reverberation
- sprayed acoustic rays
- geometric ray tracing.

Environment

- Prevailing wind analysis
- material and environment costs
- life cycle embodied energy
- life cycle greenhouse emissions.

Building types

All types.

Target user group

Architects and students of architecture.

Computer needs

PC using WINDOWS 95 and above.

ENER-RATE

ENER-RATE is a complete and stand-alone tool based on a modification of ENER-WIN, a Windows®-based program, originally developed to perform thermal and energy simulations of buildings (Soebarto and Williamson, 1999). ENER-RATE allows the user to assess the environmental performance of a building and compare the results with a reference building, all in one package, supported by intelligent databases. It is designed for use during conceptual design.

The program contains a module for automatically generating a reference or a prototype building as well as a module that allows the user to change its parameters (to input a reference building corresponding to an existing building).

Inputs

- Building geometry
- building location
- building type.

Outputs

- Annual breakdown of energy use
- monthly and annual heating and cooling loads
- monthly energy use and costs
- life cycle energy use
- life cycle CO_2 emissions
- life cycle costs (initial, energy and total Present Worth of costs)
- break down of the embodied energy of the building envelope, and others.

Building types

15 Preset including: Residential, Offices, Schools, Hospitals, Retail, Theatre, Restaurants, Nursing home, Gymnasium, Auditorium, Warehouse, Hotel, Clinic.

Target user group

Architects.

Computer needs

PC Windows.

3.4 Rating schemes

NatHERS – Nationwide House Energy Rating Software

The NatHERS software has been developed by the CSIRO to provide quick assessment of house designs in an easy to use format. It is the reference-rating tool for the national House Energy Rating Scheme (HERS). It can be used during the conceptual and design development phase. The rating takes into account 27 climate zones that influence the amount of energy required for heating and cooling the home, predicts comfortable temperatures inside a home on an hourly basis for 365 days, and calculates the amount of energy needed to maintain these temperatures.

Inputs

- Key project details: address, postcode, etc
- selection of construction details for building elements (up to 3 alternatives each)

- dimensions of each building element entered via tables. A template speeds input of similar elements
- infiltration factors.

The following data is fixed:

- internal gains due to people, lights and equipment
- thermostat settings
- schedules for heating and cooling
- energy requirements for heating, cooling (energy *consumption* and cost are not estimated)
- internal temperatures in each zone during unconditioned hours.

Outputs

An energy rating certificate providing a 0–5 star rating for houses.

Building types

Residential buildings.

Target user group

Architects, builders, building surveyors, and students in these disciplines.

Computer needs

IBM PC or compatible, Windows 3.1, 95, 98 or NT. 11MB disk space.

SEDA – Building Greenhouse Rating Scheme

The SEDA scheme provides a set of performance benchmarks and a promotionally oriented star rating system that provides a framework within which designers and building operators can evaluate building performance. In this sense, it provides a way for building owners and occupiers to identify the value of good design, equipment specification, commissioning and operation. Building services information for which the building owner is usually responsible, including heating, ventilation and cooling energy use, house lighting, lifts, etc, can be rated separately from tenant light and power. The rating scheme is not a design tool per se, because the rating is based on actual energy bills, not modelling or analysis of the systems within the building, and therefore can only be achieved on an existing or fully designed building. However, rating schemes such as the BREEAM scheme for offices, while built for application to existing buildings, have been increasingly used in the UK as design guidelines, because clients consider the rating as a way of indicating the level of environmental performance they are likely to receive (Yates and Hampton, 1997). SEDA is developing a ‘commitment rating’ that will allow new buildings to receive provisional ratings that can then be confirmed when the building is operating (Pears *et al*,1999).

The SEDA rating can be self administered via the internet at: www.seda.nsw.gov.au.

Inputs

- Key project details: address, postcode, etc
- dimensions of building floor area
- thermostat settings (when conducting the diagnostic assessment, but is not required for rating)
- schedules for occupancy
- energy consumption data for the past year.

Outputs

A rating certificate is provided for each building that has been rated, and the building owner, tenant or other responsible party gains the right to use the Building Greenhouse Rating logo, for promotional purposes.

Building types

Existing buildings.

Target user group

Building owners, developers, tenants, architects, and engineers.

Computer needs

PC using WINDOWS 95 and above. Mac OS2 or above.

4.0 WHEN SHOULD ENVIRONMENTAL ASSESSMENT TOOLS BE USED IN THE DESIGN PROCESS?

The process of design is an intuitive and creative exercise, normally constrained by time limits (Peshos and Hall, 2000). It is also inherently non-linear, and requires the generation of ‘satisfactory solutions’ to multi-faceted problems using many objective and subjective criteria (Owen, 2000). Environmental performance assessment tools on the other hand, provide a rational and analytical process to assist environmental design decision-making. The differences between the two processes and the structure of traditional building design processes raise a number of issues that need to be overcome in order to gain the greatest benefit from using environmental performance assessment.

An initial decision must be made as to whether to use a complex tool that provides a great amount of detail about the environmental impacts associated with a design decision, or to use a simple tool or instrument (like a checklist) that provides general guidance only. The approach chosen will depend on the time, environmental expertise and money at the designers disposal, the expectations of the client with regard to the level of environmental performance required of the building, and the level of transparency and accountability required of the design process. Complex tools provide a greater ability to assess context-sensitive environmental impact issues and obviously provide more detailed information about the predicted environmental performance of a building design choice. Simple tools and checklists provide quick references to guide the generation of environmentally beneficial (or less damaging) design solutions. However, they may not have the capacity to be altered to consider project specific issues or environmental conditions. They therefore offer far less transparency and accountability for the design process and require the design team to possess the knowledge to determine the project specific environmental issues themselves.

Two decisions must therefore be made in order to assess effectively, environmental implications of design decisions. Firstly, there needs to be a clear statement of the environmental goals of the project and secondly, there must be a commitment to allow time for environmental assessment during the design process.

4.1 Environmental performance goal setting

Perhaps the fundamental first step in any environmental design process is establishing the environmental performance scope and goals for the project. This needs to be done with the client and appropriately skilled consultants.

Project goals can be set by referring to environmental guidelines. Professional institutions, such as the RAIA, Institution of Engineers Australia and the Master Builder's Association of Victoria have published design guidelines for the environmental performance of buildings. The environmental guidelines of these organisations are also used as the foundation for industry best practice awards such as the RAIA's Ecologically Sustainable Development Award, the IEAust National Award for Sustainable Energy, and the MBAV Excellence in Construction Waste Minimisation Award.

It should be stated that the environmental performance goals set out by each of these professional organisations are very general. Best practice environmental design should also respond to specific site and surrounding contextual conditions when developing project environmental performance goals.

Goals can also be relative, absolute or a combination of both. A project might aim for a reduction in operational energy consumption of say 10%, relative to a 'standard' building of the same type in the same climate. The project might also set an absolute target of generating 10% of its own energy from renewable sources. In any case, goals must be measurable in some way so that compliance can be determined.

4.2 Creating the space and time for environmental assessment

The process of design is an iterative and dynamic process in which building designers are very often limited in the time they have to complete a building design. Given that the emphasis of design has been on meeting the traditional client goals of cost and quality, how can designers find more time in their practice to address the complicated issues of a building's environmental performance – even when it is not explicitly a client's goal?

The decision to conduct environmental assessment is a decision to broaden the scope of design problem investigation and solution generation. Although this may equally be seen as an advantage, environmental performance assessments may increase the time and cost of design and may require the inclusion of consulting engineers and environmental consultants who would not normally become involved until the design development phase.

"A successful project also typically requires advocacy by the owner, and the leader of the design team (typically the architect), along with a "buy-in" at minimum from other key project participants such as the mechanical engineer if green design concepts are to be incorporated" (Bobenhausen and Witner, 1998).

Researchers argue that unless the process is changed to incorporate environmental assessment as an integral part of conceptual design, then there will only ever be a marginal use of environmental assessment tools by practitioners (Soebarto and Williamson, 1999). Owen (2000) for example, calls for a systematic approach to design that incorporates the consideration of environmental performance using Life Cycle Design Thinking. She proposes a conceptual design process that clarifies the role of environmental assessments as tools for interpreting the various iterations of solutions. Used in this context, assessment tools provide information that helps the design team learn more about the problems associated with design decisions, as well as helping identify possible solutions.

Owen (2000) also argues that Life Cycle Design Thinking assists in the development of more suitable designs at the inception stage, rather than simply identifying problems with substantially finished designs and identifying possible last minute solutions. Tools such as NatHERS already do this by suggesting ways to improve the star rating of a building which has been assessed.

Peshos and Hall (2000) argue that a successful environmental design process is different from a traditional design process in that it must provide the opportunity for the input of consulting engineers and environmental consultants during the conceptual design phase. It therefore follows that changes to the design process itself are required in order to gain the maximum benefit from using environmental performance assessment tools, and avoid time or financial penalties.

Bunting Coady Architects of Canada have also developed an integrated environmental design process for application on public works projects in British Columbia. The Design Facilitation Process brings building and services design teams together with the client and is said to produce integrated environmental solutions that make the best use of available environmental expertise and design tools, and optimises building performance. Facilitators provide support and information on advanced building design and extensive computer modelling is carried out to ensure the design stages dovetail with one another. The team objective is integrating the stages into a conceptual whole, where the building form supports the envelope design, which in turn supports the system design (Coady *et al*, 1998).

In any case, it has been well established that the environmental performance of building projects are improved if environmental performance is embedded as a key philosophy of the project, rather than something to be considered once the cost and quality aspects of the project have been established[2].

4.3 Conceptual design

It has been argued that the major environmental impacts of a building are determined at the conceptual design phase, particularly when deciding on building plan shape, form and envelope characteristics (Coady and Zimmerman, 1998). Moreover, decisions made during conceptual design can have the greatest influence on project performance and have the least associated cost (Marsh, 1999). Therefore, it is important that environmental design tools be applied at this stage in order that the environmental implications of different iterations of design may be monitored progressively. Unfortunately, until recently many environmental assessment tools required a developed design in order to predict the overall environmental impact. Tool developers are now reorganising their programs to cater to this need and new environmental design tools specifically catering for conceptual design are being developed (Hyde and Pedrini, 1999).

Both ENER-Rate and Eco-Tect are described by their developers as conceptual environmental design tools. The Eco-Tect program is purpose-built for conceptual design and provides a graphical interface so that designers can sketch in design solutions and run simulations on ambient environmental impacts such as shadow effects, acoustics and sun penetration. The program can be linked to the LCAid program administered by the Department of Public Works and Services NSW to also provide predicted life cycle ecological impact profiles for different solutions.

The ENER-Rate program emphasises transparency in the input of data and the databases used to generate environmental impact profiles. The user has a great amount of flexibility in defining the attributes of the project at the conceptual phase. The program automatically generates a reference building so that environmental performance of a design option can be immediately compared with a benchmark. The program also acknowledges the importance of addressing environmental issues arising from the site and surrounding context by providing an opportunity for the designer to weight environmental issues assessed by the program (Williamson and Soebarto, 1999).

Following the experience of the implementation of BREEAM in the UK (Yates and Hampton, 1997), Australian rating schemes might become recognised as setting industry benchmarks, to be used during conceptual design as a means of identifying project environmental goals and performance targets. Modelling programs such as Doe 2.2 are also used during conceptual design. However, they offer no means for determining the environmental impacts of energy performance associated with a design concept.

4.4 Design development

The specification of materials and equipment for a project can obviously cause wide-ranging environmental impacts. Designers wishing to mitigate a project's damage to the environment would therefore seek specific information on the environmental impact of materials and systems. LCA based material checklists could be consulted if they existed in Australia. While these checklists are presently under development in Australia, there are none yet commercially available. Projects like the Sydney Olympic Village developed their own rating system to help make material and product selections. It is unlikely that average projects will have the budget for this exercise. Guidance is available, however, in the form of a number of purchasing guides, checklists and reference texts. Some useful resources are listed at the end of this note.

Once major decisions such as the building form, the envelope design and the heating and cooling system design have been made, rating schemes might be applied to determine the energy or greenhouse performance rating of a project. Unfortunately, at this stage of design, the range of options available for redesigning to optimise energy or greenhouse performance is limited.

5.0 LIMITATIONS OF AUSTRALIAN ENVIRONMENTAL PERFORMANCE ASSESSMENT TOOLS

Australian environmental assessment tools are limited in the data and scope of assessments that they offer. While some clients may have wide ranging environmental performance criteria, covering everything from energy performance to impacts on regional biodiversity, tools currently available in Australia do not go far beyond energy related environmental impacts, such as greenhouse gas emissions and pollution associated with different fuel types, and initial embodied energy. This is due principally to a lack of available Australian life cycle assessment data.

There are those that argue that environmental performance assessment tools are becoming overly complex and, as a consequence, the robustness of the information that they provide suffers. The alternative is to offer building designers a range of tools that focus on a detailed and robust analysis of specific building components or sub-systems that most affect the life cycle environmental impact of a building. Tools have

2 The RAIA is currently re-writing the existing RAIA Environment Policy, which will provide greater guidance on the overall process of ESD design. Once complete, it will be published in the *BDP Environment Design Guide*.

therefore been developed in Australia for example, to model the energy-efficiency of windows and lighting systems (Bell *et al*, 2000). If the choice is made to use component or system specific assessment tools, the design team must have the time to conduct a range of elemental analyses and be able to determine how the integration of different building elements affects the environmental performance of the building as a whole. This is, of course, not as simple as summing the parts.

It should also be noted that environmental impact assessment is in many ways a relative science that is evolving towards providing absolute levels of performance against industry benchmarks and the carrying capacity of ecosystems. Environmental assessment tools quite often provide objective data concerning the environmental loading of a building (e.g. tonnes of CO_2 emissions during building operation, potable water consumption, area of physical disturbance on-site) but rarely give any indication of how important each impact is in determining the overall environmental performance of a building.

All of the environmental design tools available in Australia provide environmental performance indicators for various impacts. Most of them provide indicators of the relative embodied energy and CO_2 emissions associated with a design decision. These tools allow the designer to anticipate the impact of a design decision on a range of indicators, most commonly energy and emissions. The data are provided in relative scores, that is the environmental impact of a building is presented relative to a 'standard' or 'reference' building of the same type. The greater the score relative to the benchmark building, the better the design decision is for the environment.

The Department of Public Works and Services in NSW uses the LCAid – ECOTECT combination to provide LCA based environmental impact profiles for design decisions. At present, the LCAid tool is the only Australian tool that includes consideration of a wide range of non-energy related environmental impacts by virtue of its use of the Boustead Life Cycle Assessment method. The Centre for Design at RMIT is currently working to integrate Australian Life Cycle Assessment databases with the SimaPro program, developed in the Netherlands.

Once the impacts have been identified, the issues need to be weighted in order to provide an indication of the importance of each impact with regard to the environmental goals of the client, the designer, society or the ecological limitations of the site. Weighting of environmental impacts is not included as a core component of design tools currently available in Australia. Tools such as ENER-RATE and Eco-Tect provide a range of impact profiles and scores related to standard practice for a range of buildings. It is therefore up to the designer to determine the relative importance of one environmental impact over another.

Weighting is used to a certain degree within rating schemes in order to convert environmental performance attributes of building designs into points or stars. In this case, characteristics of buildings, rather than different environmental impacts, are weighted by their potential to enhance the performance characteristic that the rating scheme is designed to promote.

Some overseas tools such as the BRE's Envest (BRE, 2000), normalise the environmental impact profiles into a common indicator, using weightings based on surveys of industry and the general public in Britain. In the Envest program, design decisions are given 'eco-points' representing the average daily environmental impact of a British citizen. The Envest program scores a conceptual design decision using eco-points, the most environmentally beneficial decision being the one that attracts the least amount of points.

6.0 CONCLUSION

There is a lot to know about the environmental assessment of buildings, and there is still much work to be done both in Australia and internationally on methodologies and tool development, and in collecting base life cycle inventory data on building materials. Australian environmental assessment and rating tools presently provide more detail on the energy related environmental impacts of design decisions. Further development of life cycle assessment tools is necessary in order that the ecological and human health impacts of design decisions may be assessed. The tools available in Australia at present do provide pragmatic approaches to integrating the assessment of environmental performance into design decision-making processes and predicting the environmental performance of designs.

The application of environmental assessment tools at present provides quantitative relative performance predictions for energy related environmental impacts of design. In the future, tools are likely to have the potential to provide absolute predictions of a wide range of environmental performance criteria. Tools developed overseas are more advanced and comprehensive in the scope of environmental issues assessed and in their use of life cycle assessment data. Unfortunately, international tools are not directly transferable to Australia because they do not reflect local environmental conditions, pressures or impacts. Work is in progress to adapt some of these tools for Australia. The only international LCA tool available in Australia to date, is the Dutch program SIMAPRO, however its databases are not yet comprehensive for all building materials.

Environmental performance assessment tools provide systematic approaches to more rigorously examine the environmental implications of building design decisions, and provide systematic approaches to identifying, learning about and reducing the environmental damage of the construction and operation of buildings. Given the increasing requirements from government and the private sector for better environmental performance, the use of these tools will also provide a basis for establishing accountability for, and demonstrating compliance with, emerging environmental performance standards.

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MORE INFORMATION ON TOOLS AND RESOURCES

LCA tools

LCAid

Zig Peshos or Karen Duncan – NSW Department of Public Works and Services, Environmental and Energy Services
ph: (02) 9372 8227
Email: zig.peshos@dpws.nsw.gov.au.

Energy modelling tools

BUNYIP

CSIRO – Steve Moller
Steven.Moller@dbce.csiro.au

BEAVER/ ESPII

ACADS-BSG
acadsbsg@ozemail.com.au

DOE 2.2

More Information
http://doe2.com/

GSL - Giselle

Assoc. Professor John Bell – School of MMME
j.bell@qut.edu.au

Hybrid tools

ECOTECT

Dr Andrew Marsh – University of Western Australia
Andrew.Marsh@uwa.edu.au

ENER-RATE

Dr Terry Williamson - School of Architecture, Landscape Architecture and Urban Design
twilliam@arch.adelaide.edu.au

Rating schemes

NatHERS – Nationwide House Energy Rating Software

CSIRO
http://www.dbce.csiro.au/ind-serv/brochures/nathers/nathers.htm

SEDA – Building Greenhouse Rating Scheme

SEDA NSW
www.seda.nsw.gov.au

Instruments

One-Stop Timber Shop
http://www.timbershop.wilderness.org.au/

The Eco-specifier guide
http://ecospecifier.rmit.edu.au

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BIOGRAPHY

Peter Graham is Lecturer in Sustainable Construction in the Department of Building and Construction Economics at RMIT University. In 1997, he Completed his Master of Applied Science (building) researching methods for assessing the sustainability of buildings. He has also been a contributor to the International Energy Agency Annex 31 (Assessing the energy related environmental impacts of buildings) and is a member of the Australian Green Building Challenge (GBC) Team, and the GBC International Framework Committee for developing building performance assessment frameworks. He is currently co-convening the Victorian Chapter of Urban Ecology, and surfing in his spare-time.