MINISTER’S FOREWORD

The built environment is where Australians live and where many of us spend our working lives. Our buildings say a lot about who we are and what we value.

According to the OECD in 2003, buildings make up a big part of our environmental footprint – consuming between 30 and 50 per cent of available raw materials, and accounting for 25 to 40 per cent of final energy use.

In addition, urban water demand is significant, at 16% of Australia’s total water consumption – with up to 10% of that use in our office buildings.

The Australian Government is taking up the challenge of making buildings more sustainable. As well as having policy for energy efficiency in our own activities, the Australian Government is committed to working with industry and other stakeholders to provide concise and accurate guidance on building environmentally sustainable structures and running those assets well.

This third edition of our popular ESD Design Guide explores the opportunities that exist at the design stage for office and public buildings to make a difference on energy, water, waste, greenhouse emissions, indoor environment quality and other sustainability performance issues. The guide also includes case studies of leading Australian buildings to demonstrate that the market is already able to design and deliver these results.

This document is part of a developing suite of guides, developed with agencies and industry, including the Water efficiency guide – office and public buildings and a green leasing guide. Forthcoming publications include an ESD Operations Guide for owners, managers and tenants, which will introduce the key opportunities to improve the environmental performance of existing buildings.

In mid 2007 the Australian Government will release Your Building – a comprehensive best practice guide for commercial buildings at all phases of their life-cycles. This online guide will be a companion to the well-known guide for residential buildings called Your Home.

While the challenges of building and living sustainably are significant, this guide will help the building design and construction industry to learn from leading examples, and to help improve the environmental performance of our cities.

This is an important step in the ongoing process of improving the sustainability of our built environment.

The Hon Malcolm Turnbull MP
Minister for the Environment and Water Resources
April 2007

The Department of the Environment and Water Resources

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Graphic design by DesignInc Melbourne.

Video clips have been included in the online guide to provide additional content, context and experience (see www.sustainability.gov.au/publications). Each is preceded by a short section of the clip transcribed and edited to a print readable form. We thank Mark Thomson, Stephen Webb, Mick Pearce, David Oppenheim, Kenwyn Wilmott, Chris Barnett, Martin Osolinik, Tim Hurburgh, Paul Edwards, Paul Barnister and Sean McIrle for their participation.
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The 2006 Australian State of the Environment report found that the key issue arising from human settlements is the pressure they impose on the environment in terms of the demand for land, water, energy and other resources. According to the 2006 SoE Committee, a long-term but immediate change in materials and energy balances is needed to give more efficient urban systems, and this requires a decoupling of resource use from economic progress. Reductions in both net consumption and waste are needed for a more sustainable human environment. This will involve greater population densities than currently is the case, significant increases in building and material recycling, the capture and use of stormwater, the recycling of wastewater and biological waste, and improvements in urban form and urban structures. It also requires changes in behaviour by individuals, so education and awareness-raising are important factors. The challenge is to implement this insight.1

Buildings contribute significantly to this negative impact on our environment, consuming 32% of the world’s resources, including 12% of the world’s fresh water and up to 40% of the its energy. Buildings also produce 40% of waste going to landfill and 40% of air emissions.2 In Australia, commercial buildings produce 8.8% of the national greenhouse emissions and have a major part to play in meeting Australia’s international greenhouse targets.3

The Australian Government wishes to show leadership in minimising the environmental impacts of its buildings and operations, including leased premises. This guide provides an introduction to the key environmental issues relevant to office buildings and public buildings. It also outlines what you can do to address these issues in your building project, supporting this with evidence from case studies of leading buildings.

Relevant Australian buildings covered by this guide are: Office buildings (Building Code of Australia – BCA class 5) and public buildings such as libraries, art galleries, museums and similar cultural institutions (BCA class 9b). This is not intended to refer to schools, hospitals or correctional facilities (for information on these see the various guides developed by state departments) although many of the concepts and strategies outlined here may be relevant to those facilities.

This guide gives a basic introduction to ecological sustainability issues and specifically how the built environment affects them. It begins by outlining the Australian position on Ecologically Sustainable Development (ESD) and some key policies relevant to buildings and ESD. The next section outlines the tools that are available to help in achieving ESD in Australian offices and public buildings, specifically ABGR, NABERS and Green Star. The

ESD: Ecologically Sustainable Development – ‘using, conserving and enhancing the community’s resources so that ecological processes, on which life depends, are maintained, and the total quality of life, now and in the future, can be increased’. (NSESD, DEH 1992)

bulk of this guide outlines initiatives that can be put in place to minimise the environmental and social impacts of buildings.

Several case studies are presented to illustrate various approaches to achieving ESD in buildings:
- 8 Brindabella Circuit, Canberra - the first project to achieve 5 Star Green Star - Office Design certified rating
- 30 The Bond, Sydney - ESD in a new building using a ‘business as usual’ approach
- CH2, Melbourne - Australia’s first 6 Star Green Star - Office Design v1 project
- 743 Ann Street, Brisbane – a refurbishment of an office building in Brisbane
- Waalitj Building: Murdoch University, Perth - educational building
- SES headquarters, Melbourne
- National Museum of Australia, Canberra - ESD initiatives in a highly sensitive display environment
- 60L, Melbourne - a refurbishment of a warehouse to offices
- 40 Albert Road, Melbourne - first refurbished building to achieve 6 Star Green Star - Office Design v1
- Galleries, Museums and Libraries - various ESD opportunities in public buildings
- RAAF, Richmond NSW - 5 Green Star - Office Design v1 and Office as Built.

Figure 1. The earth, image sourced from Doncaster Hill Sustainability Guidelines, Manningham City Council.

Ecologically Sustainable Development (ESD) represents one of the greatest challenges facing Australia’s governments, industry, business and community in the coming years. In 1990, the Australian Government endorsed the following definition for ESD in Australia:

‘...using, conserving and enhancing the community’s resources so that ecological processes, on which life depends, are maintained, and the total quality of life, now and in the future, can be increased’.2

ESD is development which aims to meet the needs of Australians today, while conserving our ecosystems for the benefit of future generations. To do this, we need to develop ways of using those environmental resources that form the basis of our economy in a way which maintains and, where possible, improves their range, variety and quality. We also need to utilise those resources to develop industry and generate employment.

The Australian Government has developed several strategies and policies in response to the need to ensure ecologically sustainable development. The National Strategy for Ecologically Sustainable Development (NSES D) was launched in 1992 after extensive consultation with industry, the community, conservation groups, scientific organisations and all levels of Government. It identifies five key principles of ESD:

- integrating economic and environmental goals in policies and activities (the integration principle)
- ensuring that environmental assets are properly valued (the valuation principle)
- providing for equity within and between generations (the intergenerational principle)
- dealing cautiously with risk and irreversibility (the precautionary principle) and
- recognising the global dimension.

The Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) is the Australian Government’s major piece of environmental legislation. It protects the environment, particularly matters of National Environmental Significance. It streamlines national environmental assessment and approvals process, as well as protecting Australian biodiversity and integrating management of important natural and cultural places. It also contains requirements that Australian Government agencies report on how they are addressing the challenges of ESD. Section 516A of the EPBC Act requires Commonwealth organisations to include in their annual reports a section detailing the environmental performance of the organisation and the organisation’s contribution to ESD.6

For existing buildings, the s516A part of their annual report can record performance on water use, energy use (including greenhouse gas emissions), waste produced and any initiatives planned or in place to minimise ESD impacts. For new buildings, this report can include a record of the ESD elements taken into account in the building requirements.

This reporting should form part of the broader Section 516A ESD report on the organisation’s overall ESD performance as outlined in the document Generic ESD and Environmental Performance Indicators for Commonwealth Organisations (GPICO).7

The Australian Government has a specific policy regarding government energy use. This was originally announced in November 1997 as part of a package of measures in Safeguarding the future: Australia’s response to climate change, and was launched as the Energy Efficiency in Government Operations (EEGO) Policy in 2006. This is an updated version of the Australian Government’s 1997 policy Measures for Improving Energy Efficiency in Commonwealth Operations.

A summary of the targets the policy set are:

- energy intensity portfolio targets by the 2011-12 financial year: 7500 megajoules (MJ)/person/annum for office tenant light and power; and 400 MJ/m²/annum for office central services
- minimum energy performance standards (generally 4.5 stars on the Australian Building Greenhouse Rating (ABGR) or equivalent scheme) in contracts, leases and other relevant documentation for new buildings, major refurbishments and new leases over 2000m²
- must report on energy performance annually.

To achieve best practice of 4.5 stars ABGR in new government office buildings and major refurbishments, a maximum of 10 W/m² for lighting and 9 W/m² for general power (tenancy)
No water targets have been set by the Government but water targets can be set as part of the Energy Management Plan under the Green Lease Schedule.

Agencies and industry may wish to use the NABERS OFFICE - WATER benchmarks in their leases.


For Australian Government buildings, Australian ESD legislation and policies provide a clear direction for:

- planning buildings with a view to the long term while being feasible in the short term
- using the precautionary principle in all decision making
- taking a global approach to issues – for example approaching greenhouse gas reduction through energy efficiency
- input from users and communities on building projects
- avoiding the use of materials that have a negative effect on biodiversity
- ensuring healthy indoor environments
- reporting on performance.


THE USE OF RATING TOOLS TO IMPROVE ENVIRONMENTAL PERFORMANCE

A range of rating tools have been developed internationally and in Australia to measure various aspects of the environmental performance of buildings. There are two main approaches to ratings: (1) a design-based approach, which seeks to predict the performance of a building based on an analysis of the design features; and (2) an outcome-based approach, which measures the actual consumption of resources and environmental impacts of the building in operation. Both approaches provide useful information to building owners, managers and tenants, and have the potential to drive continuous improvement of the building stock.

For assessing a range of environmental aspects of commercial buildings in Australia, Green Star - Office Design v2 assesses a project’s design while other Green Star tools assess construction and procurement environmental initiatives or existing building’s environmental assets. Green Star rating tools do not assess building occupant’s behaviour.

The National Australian Built Environment Rating System (NABERS) uses an outcome-based approach to assess the environmental performance of existing buildings (commercial office or residential home). Ratings derived from a system like NABERS that use an outcome-based approach will, to a degree, be influenced by the behaviour of occupants - i.e. by factors often not directly relevant to the building infrastructure itself. The ABGR tool is used in both Green Star and NABERS to cover energy performance. For that reason it is discussed first.

ABGR

The Australian Building Greenhouse Rating Scheme (ABGR) is administered nationally by a group of sustainable energy agencies (SEDO, SV, EPA and DEUS). To date, more than 500 buildings have been officially rated.

ABGR has broad industry support and is being used for energy rating, target development and design requirements. The ABGR scheme rates buildings from one to five stars with five stars representing exceptional greenhouse performance. ABGR can be used to rate the base building (central services), individual tenancies or a whole building.
GREEN STAR

Green Star has been developed by the Green Building Council of Australia (GBCA) with support from industry and some government agencies. Green Star rating tools relate to the various cycles of development, such as design, procurement, construction and refurbishment.

Green Star - Office Design v2
Assesses base building design for new or refurbished commercial office buildings. To be eligible to use this tool, the primary function of the building should be as an office where a minimum of 80% of the gross floor area must be Class 5 as defined by the BCA.

Green Star - Office As Built v2
Validates environmental initiatives and potential impacts of the construction stage of a Class 5 office building, and that the environmental initiatives proposed in design have been implemented.

Green Star - Office Interiors v1
Developed to assess the environmental initiatives incorporated into an office tenancy fitout once base building construction has been completed. The tool is recommended for use at the design stage of office fitouts to ensure that green initiatives are considered as early in the process as possible. The tool assesses entire tenancies after practical completion.

Green Star - Office Existing Building v1 - PILOT
Developed for the property industry to assess existing building stock and previously called Green Star Office Asset.

Green Star - Office Existing Building v1 rating tool has been withdrawn and will be launched as an extended PILOT within the first half of 2007. The new pilot tool will include revisions to the Management Efficiency Supplement and Technical Manuals to give a more robust evaluation of management practices.

Green Star - Healthcare - PILOT
Evaluates the environmental initiatives and potential environmental impact of Class 9A health facilities and Class 9C aged care facilities either at design stage or when construction is complete.

Green Star - Shopping Centre Design - PILOT
Evaluates the environmental initiatives and potential environmental impact of new or refurbished shopping centres either at design stage or when construction is complete.

Green Star - Education - PILOT
The tool will allow designers to benchmark the environmental performance of educational facilities ranging from primary schools to universities and TAFE facilities. The tool is in its last development stage and will shortly be released for piloting.

Green Building Council Australia
For case studies on Green Star accredited buildings see Appendix 2 and www.gbcaus.org/gbc.asp?sectionid=108&docid=969

“The client came to us with Green Star - Office Design v1 after documentation …so we developed two A4 pages …of ESD initiatives that we could take on for free.”

Martin Osolnik, Associate, Daryl Jackson
Alastair Swayn

5 Star, Green Star - Office Design v1 implementation at Brindabella
RATING TOOLS AND
environmental performance

NABERS
NABERS was developed by the Australian Government in consultation with industry and stakeholders. It is a national initiative managed by the NSW Government Department of Energy, Utilities and Sustainability (DEUS) and provides ratings for office buildings, office tenancies and homes.

NABERS OFFICE is a performance-based tool used to assess the measured operational impacts of existing buildings. Environmental performance is assessed against a comprehensive set of key impact categories. ABGR is used to assess energy efficiency while a new tool, NABERS OFFICE WATER, was released in April 2006. This tool measures water consumption on a scale of 1 to 5 stars, reflecting the performance of the building relative to the market, from least efficient (one star) to best practice (five stars). The current market average is two and a half stars.

Further tools are being developed to measure comprehensively the full range of environmental impacts including: refrigerants (greenhouse and ozone depletion potential), stormwater runoff and pollution, sewage, landscape diversity, transport, indoor air quality, occupant satisfaction, waste and presence of toxic materials.

The NABERS web site features case studies for general performance and energy. Water case studies are being developed. Below is an example of the rating for water.

<table>
<thead>
<tr>
<th>Star</th>
<th>Description</th>
</tr>
</thead>
</table>
| 1 star | Poor water management or systems  
The building is consuming a lot of unnecessary water. There are significant opportunities that can be implemented to reduce water consumption, operating costs and the burden on our water supplies. |
| 2 stars | Below average building performance  
The building is below current market average performance. There are opportunities that can be implemented to reduce water consumption, operating costs and the burden on our water supplies. |
| 3 stars | Above average performance  
The building is performing better than the current market average. Water efficiency is a priority in this building. There are still opportunities for reducing water consumption. |
| 4 stars | Strong performance  
The building demonstrates excellent water performance due to design and management practices, and high efficiency systems and equipment. |
| 5 stars | Best building performance  
The building is leading the market in water efficiency due to integrated design, operation, management and water source choice. |

National Australian Built Environmental Rating System  
www.nabers.com.au
### Table 1. Comparison of the information required by Green Star and NABERS

<table>
<thead>
<tr>
<th>Information required for Green Star - Office Design v2&lt;sup&gt;8&lt;/sup&gt;</th>
<th>Green Star category</th>
<th>NABERS category</th>
<th>Information required for NABERS&lt;sup&gt;9&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commissioning waste and environmental management plans</td>
<td>Management</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Predicted ventilation, light, views, user control, VOCs, noise and asbestos</td>
<td>IEQ</td>
<td>Indoor Environment</td>
<td>To be updated first half 2007</td>
</tr>
<tr>
<td>ABGR rating with a minimum of 4 stars, metering, peak demand reduction, zoning</td>
<td>Energy</td>
<td>Energy use and Greenhouse Emissions</td>
<td>Enter ABGR score 0-5 stars,</td>
</tr>
<tr>
<td>Proximity to public transport and car parking minimisation</td>
<td>Transport</td>
<td>Transport</td>
<td>Transport type, engine size, km and number of trips</td>
</tr>
<tr>
<td>Water efficient fixtures, metering, cooling tower, irrigation, water collection and reuse</td>
<td>Water</td>
<td>Water Use</td>
<td>Actual m&lt;sup&gt;3&lt;/sup&gt; of water used</td>
</tr>
<tr>
<td>Water (see water)</td>
<td>Stormwater Runoff</td>
<td>Rainwater captured and used, permeable and non permeable surfaces, rainfall, evaporation</td>
<td></td>
</tr>
<tr>
<td>(see emissions)</td>
<td>Sewage Outfall Volume</td>
<td>Actual m&lt;sup&gt;3&lt;/sup&gt; of water sent to sewer and reused</td>
<td></td>
</tr>
<tr>
<td>Reuse, recycled content, PVC minimisation, sustainable timber</td>
<td>Materials</td>
<td>Toxic Materials</td>
<td>Presence, storage and disposal per type</td>
</tr>
<tr>
<td>Existing building system (façade/structure) reuse</td>
<td>(see materials)</td>
<td>Waste</td>
<td>To be updated first half 2007</td>
</tr>
<tr>
<td>Soil reuse, adding ecological value and quality through remediation to land decommissioning</td>
<td>Land use</td>
<td>Landscape Diversity</td>
<td>Landscape types and m&lt;sup&gt;2&lt;/sup&gt;</td>
</tr>
<tr>
<td>Refrigerant capture, water pollution minimisation, sewage minimisation, light pollution, cooling tower</td>
<td>Emissions</td>
<td>Stormwater Pollution</td>
<td>Actual m&lt;sup&gt;2&lt;/sup&gt; of different surfaces on which storm water falls e.g. garden with fertiliser</td>
</tr>
<tr>
<td>(see emissions)</td>
<td>Refrigerant use (GWP and ODP)</td>
<td>Type, amount and actual leakage (by top up required)</td>
<td></td>
</tr>
<tr>
<td>New innovative technologies, techniques and approaches</td>
<td>Innovation</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

8 Green Star - Office Design v2 [www.gbcaus.org](http://www.gbcaus.org)
CLIENT COMMITMENT
The single most important principle for achieving an ecologically sustainable building design is client commitment. As shown above the Australian Government is committed to ESD and has developed some specific targets in the area of energy, with others to follow in the near future. In developing the new or existing building brief, ESD needs to be built in along with functional and technical requirements. A base building brief being developed by the Australian Government will support the development of this commitment into an effective functional brief. Available from: www.greenhouse.gov.au/government/index.html.

WHOLE OF LIFE THINKING
Buildings are complex and have many impacts. It is important when addressing these impacts that each project team member does not work in isolation, without considering the consequences of any other particular initiative. One of the main ways of looking at a building’s impact is to think about the life cycle of the building; that is, its design, construction, use, refurbishment and demolition (see Figure 5).

DESIGN INFLUENCE
As many projects have shown, it is at the design stage that many of the impacts of a building are locked in (see Figure 7). The greatest chance to reduce the environmental impact of a building is to tackle the minimisation of impacts at the design stage, through good guidance with a building brief that clearly outlines targets and ESD requirements. It is also recommended that an integrated design process be used to minimise silo initiatives and unintended consequences. For example, for improved Indoor Environment Quality (IEQ) levels, it is good to have higher levels of ventilation than is required under Australian Standards, but this can have an adverse effect of increasing the energy used by the building for heating and/or cooling this air.

‘It is important to develop… an environmental brief ‘to … share the vision with the client of what is possible, …show them… that they can achieve quite a lot more which is beneficial to them in the long term in terms of operational savings…’

Client commitment
743 Ann Street
Mark Thomson, Director, TVS Partnership

Figure 5. Life cycle of a building.

Figure 6. Trees, image sourced from Doncaster Hill Sustainability Guidelines, Manningham City Council.
environmentally sustainable building design

LIFE CYCLE ASSESSMENT
Building owners already try to determine the costs and benefits over the life of their assets (sometimes referred to as the total cost of ownership), balancing the upfront capital costs with the ongoing operating expenses. Similar approaches exist for evaluating the overall environmental performance of a building. One of the main techniques for determining the relative merit of any one initiative is through Life Cycle Assessment (LCA). LCA is the assessment of the whole of life impact of various initiatives on the environment (including all of the impacts listed in this report). LCA methodology uses actual figures, such as for energy use, emissions to the environment, and materials used rather than predicted figures.

Currently LCAs are mainly used in commercial buildings to make decisions concerning various options for particular elements (i.e. wool carpet versus nylon carpet) rather than the entire building, since the use of LCA is both time and resource intensive. There are, however, tools being developed currently to make this more streamlined, such as LCAid. The CRC for Construction Innovation developed LCADesign, which is an automated Life Cycle Assessment tool for commercial buildings. The tool is being trialled by a number of government and industry users prior to its commercial availability in 2007.

Any enquires should be directed to enquiries@construction-innovation.info

Online Resources

LCA
Department of the Environment and Water Resources
www.environment.gov.au/industry/corporate/lca

Greening the Building Life Cycle
buildlca.rmit.edu.au provides case studies, links to LCA tools and a guide to LCA use for building design

Canadian Architect

‘Everyone was brought on board at least 3 years prior to Bond being built. We had a blue sky workshop with our staff before we started the process. Then we took on a taskforce approach with about 8 different taskforces. Those taskforces pretty much wrote the brief.’

Engaging stakeholders in the creation process
30 the Bond
Paul Edwards, General Manager, Environment Sustainability Initiatives, Lend Lease Australia Pacific

Figure 7. Ability to influence green innovation in design.
<table>
<thead>
<tr>
<th>OPPORTUNITIES</th>
<th>PRE DESIGN</th>
<th>DESIGN</th>
<th>CONSTRUCTION DOCUMENTATION</th>
<th>CONSTRUCTION</th>
<th>OCCUPANCY</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. INTEGRATED DESIGN and PROCESS MANAGEMENT</td>
<td>Establish design values of project. Set environmental performance targets. Consider collaborative design workshops.</td>
<td>Consider thermal modelling. Assess design against benchmarks and targets. Consider environmental cost-benefit analysis.</td>
<td>Peer reviews to confirm innovative technology.</td>
<td>Use environmental performance ratings, on-site monitoring and user feedback.</td>
<td>Use environmental performance ratings, on-site monitoring and user feedback.</td>
</tr>
<tr>
<td>2. SOCIAL SUSTAINABILITY AND OCCUPANT SATISFACTION</td>
<td>Consider the broader urban environment.</td>
<td>Design for access and mobility. Maintain site biodiversity.</td>
<td>Minimise disturbance to offsite areas.</td>
<td>Inform occupants of the ESD features of the building.</td>
<td>Inform occupants of the ESD features of the building.</td>
</tr>
<tr>
<td>5. TRANSPORT</td>
<td>Consider location in relation to use. Are there alternative transport options to the site?</td>
<td>Include shower and locker facilities and adequate bicycle parking.</td>
<td>Consider car parking spaces that are adaptable for other uses.</td>
<td>Make parking provisions for contractors.</td>
<td>Occupant education to promote use of public transport, cycling and walking.</td>
</tr>
<tr>
<td>6. OZONE LAYER DEPLETION</td>
<td>Specify use of refrigerants with a zero ODP and a maximum of 10 GWP.</td>
<td></td>
<td></td>
<td></td>
<td>Audit regularly for leaks, minimise where possible.</td>
</tr>
<tr>
<td>7. CHOOSING MATERIALS (incl. minimising toxicity)</td>
<td>Use material selection rules of thumb. Choose materials which minimise toxicity.</td>
<td>Further research information on material maintenance, reuse and recycling. Environmental criteria included in final specifications.</td>
<td>Review material certification and installation. Provide method for contractors to use in material substitution.</td>
<td>Building use material selection guideline, particularly for cleaning.</td>
<td>Building use material selection guideline, particularly for cleaning.</td>
</tr>
<tr>
<td>9. WATER USE REDUCTION</td>
<td>Contact local water authority (re approvals).</td>
<td>Investigate site water collection and re-use options. Investigate waste water treatment options.</td>
<td>Specify minimum AAA rated fittings. Specify use of water wise landscaping.</td>
<td>Ensure stormwater runoff is contained and sediment removed prior to leaving site.</td>
<td>Ensure stormwater runoff is contained and sediment removed prior to leaving site.</td>
</tr>
</tbody>
</table>

Table 2. Whole of life opportunities in Government buildings. Adapted from the Doncaster Hill Sustainability Guidelines, City of Manningham, Victoria 2004.
An integrated design process brings together all of the parties that will work on a building at the beginning of the project – clients, consultants, financiers, builders, tenants etc. One technique to support the integrated design process is to run a charrette. The benefit of this is that after a period of between say 2 days to 2 weeks (depending on the size of the project) the entire design team can resolve most of the building design elements and optimise how the building systems can work together.

**IMPORTANCE OF INTEGRATED DESIGN**

The best way to reduce all of the environmental impacts of a commercial building is to ensure that decisions are made holistically. In any project where a new building or refurbishment is being considered, it is best achieved through an integrated design process that includes environmental management in construction and during operation.

**OPTIMISING INTEGRATED DESIGN**

A charrette type workshop is an effective method for beginning the integrated design process. One option for structuring the charrette is to use Green Star as the framework for decision-making. This gives a coherent way to think through the design.

In general, the best way to start the process that minimises a building’s impact on the environment is to ensure that the design responds to the climate in which it will be built. The ESD opportunities identified in the charrette process need to be integrated into the design and documentation process.

The construction phase is also crucial for the successful completion of a building aiming to reduce its impacts on the environment. The main construction impacts are related to waste and pollution. These can be minimised by a good Environmental Management Plan (EMP) and Waste Management Plan (WMP). An Environmental Management System (EMS) can be certified to ISO14001 and tends to be written at a company level, while the EMP and WMP are often site specific.

After construction, and during the handover period, there should be a thorough commissioning stage to prove that the building has been built as designed and is functioning as intended. Depending on the size of the building the following steps need to be taken during this process:

- Step 1 – ensure that the construction documentation
OPPORTUNITY 1

integrated design

includes requirements for pre-commissioning, commissioning and quality processes

- Step 2 – ensure that knowledge transfer is facilitated by documenting the design intent and outcomes, and communicating these with the design and construction teams and the client
- Step 3 – ensure that a user manual is written – both for tenants and for the owner/building manager
- Step 4 – plan for a 12 month commissioning period to ensure that there is time for fine-tuning and assessment of performance over the differing seasons, and
- Step 5 – for those larger projects or those trying to attain the highest Green Star - Office Design rating, plan for the appointment of an independent commissioning agent to support the contractor commissioning process and to audit the process and outcomes.

Introduction to green leases

To help government meet its energy targets, green lease schedules have been developed where the rent is gross and the net lettable area of the premises is 2000 square metres or more. There are slightly different schedules depending on the percentage of occupancy:

- Schedule A1 (tenant occupies 100% of the building)
- Schedule B1 (tenant occupies 50-99% of the building)
- Schedule C1 (tenant occupies 49% or less of the building)

To download copies of these schedules see www.greenhouse.gov.au/government/index.html

The 2006 policy acknowledges the need for cooperation between building owners and tenants (and any relevant service providers and contractors). It addresses traditional structural barriers to implementation, such as split incentives between developers, building owners and tenants, by ensuring that the parties with influence over key aspects of energy performance obtain some benefit from implementing the improvements. It provides a transparent legal and management framework in the Green Lease Schedule (GLS) to ensure that the parties identify and address problems promptly and efficiently.

Attaching a GLS to a lease for a commercial building obliges both the tenant and building owner to work towards achieving the operational ABGR requirement. The emphasis is on prevention and rectification, rather than retribution. The GLS and Energy Management Plan (EMP) templates make it easier to identify problems, work out who is responsible and ensure that appropriate steps are taken to remedy the situation promptly (EEGO 2006:6).
A building can make a contribution to social sustainability by how it responds to its surroundings (does it fit in, address and if possible enhance the surrounding contexts?) and how it meets the social needs of the people who will be using the building (access and usability).

**IMPORTANCE OF SOCIAL SUSTAINABILITY AND OCCUPANT SATISFACTION**

This is important because buildings are social spaces driven by the needs of organisations that work in them. If a green building does not provide the functionality that the users need, or looks out of place with its context, it will either be removed or significantly renovated, which is not sustainable.

**OPTIMISING SOCIAL SUSTAINABILITY AND OCCUPANT SATISFACTION**

Though this guide is mainly an introduction to the potential to minimise the environmental impact of buildings, it is important to outline the social opportunities of a new building or refurbishment. Some social considerations include:

- **Accessibility** – ensuring that the building can be accessed by all of the community particularly the less able.
- **Usability** – ensuring that input from the building users into the design and choices of systems in the building meets their social and functional needs (including encouraging the kinds of collegiality and team-building desired).
- **Education** – ensuring that government buildings, particularly public buildings, can have an educative role. Thus, for any buildings that have embraced sustainability, resources should be factored into the budget to demonstrate these features – information kiosks, signage, online fact sheets, ongoing monitoring and reporting.
- **Indigenous cultural input** – ensuring that Indigenous cultural and spiritual aspects of sites are considered in the construction of any new buildings, as places often have meanings that should be acknowledged and, if possible, be part of the design inspiration.
- **Public space** – ensuring that the outdoor public spaces of the building are designed and located as functional areas, with access to sunlight, able to support activities and considerate of adjoining properties.
- **Context** – ensuring that the building fits into its context (such as the urban fabric) within which it is being built. This may include cultural heritage considerations.

Apart from the above general considerations, there are also separate requirements for accessibility that should be consulted, for example the Disability Discrimination Act (DDA).

**Online Resources**

- **Social Sustainability and Occupant Satisfaction**
  - Occupant satisfaction probe studies: [www.usablebuildings.co.uk](http://www.usablebuildings.co.uk)
OPPORTUNITY 3
optimising indoor environment quality

Indoor Environment Quality (IEQ) is mainly assessed by how the environment in the building is perceived by its users, as well as some empirical measurements of air flow and temperature. It is made up of various elements:

- Indoor Air Quality (IAQ), assessed by the levels of pollutants in the air, odour etc.
- ventilation
- thermal comfort
- lighting (including provision of natural light)
- noise and
- visual amenity.

IMPORTANCE OF IEQ
IEQ is important because people spend around 90% of their time indoors. Minimising the toxicity of their indoor environment is therefore a priority, particularly when indoor air is shown to be more toxic than outdoor air. The US EPA estimates that 20 to 35% of all workers in modern mechanically ventilated buildings may experience negative air-quality related signs and symptoms. Furthermore, it declares that indoor pollution is estimated to cause thousands of cancer deaths and hundreds of thousands of respiratory health problems each year.

A 1984 World Health Organization Committee report suggested that up to 30% of new and remodelled buildings worldwide may be the subject of complaints related to indoor air quality.

Several studies have established links between increased productivity and improved IEQ. Some of these studies are shown in Table 3.

General rules of thumb for fit-out ESD:
- specify that all furniture give off no or minimal VOC emissions
- specify that fit-out is designed for longevity – i.e. with minimal parts that are easily retrofitted
- use renewable, sustainably harvested natural materials, recycled or recyclable materials and consider biodiversity protection
- use modular reusable and recyclable carpet
- use water based paints, glues and caulking
- provide recycling bins at desks, do not provide individual rubbish bins;
- provide adequate recycling storage space
- provide task lighting
- require that all fit-out furniture and products come in recyclable packaging that is taken away by the supplier for reuse or recycling and
- provide individual control of airflow.

See also the sustainable fit-out guide developed by the New Zealand Ministry of the Environment.

### Table 3. Summaries of several productivity studies.

<table>
<thead>
<tr>
<th>PROJECT</th>
<th>PRODUCTIVITY INCREASES</th>
<th>REASON</th>
</tr>
</thead>
<tbody>
<tr>
<td>ING bank (Netherlands)</td>
<td>15%</td>
<td>IEQ</td>
</tr>
<tr>
<td>San Fran Sustainable Development Committee studies (US)</td>
<td>3% to 15%</td>
<td>IEQ</td>
</tr>
<tr>
<td>Nevada Post office (US)</td>
<td>6%</td>
<td>Better lighting and use of natural light.</td>
</tr>
<tr>
<td>Verifone Corporation (US)</td>
<td>45% decrease in absenteeism</td>
<td>Daylighting, air filtration and low toxicity material specification.</td>
</tr>
<tr>
<td>Twelve Public Offices (US)</td>
<td></td>
<td>Mechanically ventilated buildings had significantly more people with symptoms of sick building syndrome than occupants of naturally ventilated buildings, after adjustment for confounding factors.</td>
</tr>
</tbody>
</table>

12 ibid p. 8
13 ibid p. 9
15 ibid p. 10
17 ibid p. 10
OPTIMISING IEQ
Design strategies for optimising IEQ are:

**Light**
Optimise the amount of natural light entering the working environment while minimising glare, ensuring employees have access to views. Provide adequate artificial lighting for the tasks building users need to perform.

**Ventilation**
Optimise the amount of ventilation and fresh air provision to ensure air change effectiveness (no sections of the building to have stale air build up because of inadequate air flow). AS1668.2-1991 sets a minimum rate (dependent on the project) between 5 and 10 litres per second per person (l/s/person). The Australian Institute of Refrigeration, Heating and Air Conditioning (AIRAH) recommends 10l/s/person and CH2 is aiming for 22.5l/s/person. Another useful tool is the CO₂ sensor which controls ventilation systems, activating them only when required. In addition ensure that air supply ductwork is maintained to avoid/eliminate mould and other contaminants developing.

**Thermal comfort**
Avoid the simplistic ‘air temperature’ definition of acceptable comfort. Rather, consider the concept of ‘adaptive comfort’ that uses holistic measures including radiant temperature, symmetry, internal air temperature ranges related to external ambient conditions, air movement, activity levels and occupant clothing. Carry out thermal modelling to design for appropriate comfort levels (see Figure 14 showing thermal modelling of night purge thermal mass cooling). Provide individual controls to allow building users to tailor the environmental conditions of their working space. The International standard for thermal comfort is ISO 7730.

**Noise**
Ensure noise is kept to appropriate levels. For example Green Star – Office Design v2 defines appropriate levels as:
- ‘the design of building services building services noise meets the recommended design sound levels provided in Table 1 of ASINZS 2107:2000’
- ‘design sound level between 40-45 dB LAeqT (decibels equivalent sound levels – a complicated acoustic logarithmic formulae) in general offices and 35-40dB LAeqT in private offices’

**Pollutants**

**Material selection**
Ensure asbestos and other mineral fibres are eliminated from the occupied space. Minimise materials that emit volatile organic compounds (VOCs) including formaldehyde emissions. Ensure that spaces containing equipment such as printers and photocopiers are isolated and well ventilated. Ensure any combustion plants are maintained to minimise pollution and greenhouse gas emissions. Ensure cooling plant is maintained to eliminate water borne atmospheric pathogens and that the plant refrigerant has zero Ozone Depleting Potential (ODP) and a Global Warming Potential (GWP) of below 10.

**IEQ and construction**
To protect the health of construction workers ensure that the cutting of MDF is avoided or minimised with appropriate safety equipment, ensure the removal of asbestos and minimise emissions from volatile organic compounds.

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**Online Resources**

IEQ


The use of energy from non-renewable sources, such as coal and gas, is not sustainable because of the finite amount of these sources as well as the environmental impacts, such as climate change, they create by their use for energy production.

**IMPORTANCE OF ENERGY USE MINIMISATION**

The reason that greenhouse gas emissions are an environmental problem is that their build up in the atmosphere will lead to the enhanced greenhouse effect and a change in the earth’s climate (this is also referred to as climate change or global warming). The consequences of a rise in the earth’s temperature, which is predicted to be between 1.4 to 5.8 degrees within the next century\(^{21}\), includes a rise in sea levels due to ice caps melting and complicated changes to weather patterns.

Commercial buildings are said to contribute 8.8% of the total Australian greenhouse emissions.\(^{22}\)

Greenhouse gases are measured by greenhouse gas equivalents relating to Global Warming Potential (GWP). \(\text{CO}_2\) is set as a GWP of 1. All other gases are given a relative score – eg if a gas has twice the global warming potential when compared to \(\text{CO}_2\), it gets a GWP of 2.\(^{23}\)

**OPTIMISING ENERGY USE MINIMISATION**

One approach to achieving greenhouse targets is to ensure that buildings use minimal amounts of ‘fossil based’ energy. The energy consumption of a building is largely determined at the design stage. It is here that energy efficient features affecting air conditioning and lighting (the main contributors to energy consumption) can be incorporated.

Having integrated as many of the energy efficiency opportunities as possible in the design stage, consider carrying out an ABGR commitment rating. A minimum of 4.5 stars ABGR should be required, as this is quite achievable in a well-designed building without significant cost. At the design stage, the ABGR will require modelling of the building’s energy performance.\(^{24}\)

During operation, energy use can be minimised through building management techniques such as provision of a Building User Guide and encouraging the purchase by tenants of energy efficient equipment and appliances (guides at differing levels of complexity should be developed for the users, owners and building managers).

The main techniques for the minimisation of energy consumption in the design stage are:

- passive design – use of thermal mass, natural light, natural cooling and heating potential
- appropriate sizing of lighting, heating and cooling systems by working with the engineers
- appropriate zoning and sensors
- appropriate building management including equipment purchasing
- use of renewable energy
- minimising embodied energy in materials.


\(^{23}\) Emissions credits Emi-1 Emissions ‘Refrigerant ODP’ and Emi-2 ‘Refrigerant GWP’ www.gbcaus.org

\(^{24}\) Simulation package must either: have passed the BESTEST validation test; be certified in accordance with ANSI/ASHRAE Standard 140-2001 “Standard Method of Test for Evaluation of Building Energy Analysis Computer Programs” or European Union draft standard EN13791 July 2000.
**PASSIVE DESIGN**

Passive design is the name given to any design technique that requires no active (energy using) intervention.

The following are some examples of passive design techniques.

**Orientation**

In areas where the sun can be used effectively for space heating the building should be designed with windows facing north, with care taken to ensure overheating and glare will not occur. Orientation also takes into account an understanding of the directions of the prevailing winds and breezes in an area.

**Thermal cooling**

Thermal mass can be used to absorb excessive day time air temperature. This excessive heat can be ‘stripped out’ at night time by passing cool night air over it in order to cool the mass so it is ready for use the next day (this is also called charging the thermal mass). Types of thermal mass approaches are the use of exposed concrete, stone, labyrinths, water (for energy storage) and rock stores. This only works if there is a significant difference between day and night temperatures and the sun can shine directly onto the mass.

**Thermal heating**

Thermal mass will absorb heat from any source, for example the sun, and then radiate that into a space if the air in that space is cooler than the mass. This is a particularly good technique where a lot of heating is needed.

**Thermal resistance**

Thermal resistance is the R value of a material, how well it keeps heat from transferring through it. The higher the R value the better the insulator.

**Night purge**

Night purge is where cool night air is used to cool a space. This will only work if the night-time air temperature is significantly less than during the day (this is referred to as the diurnal range) and this is generally preferred to be about 15°C. Issues to be considered are the diurnal range, security (windows open at night may not be the best solution in some areas) and design of spaces to allow air to move freely through it.

**Natural ventilation**

Natural ventilation is the use of windows and the natural conditions around the building, to ventilate the building. This requires knowledge of the beneficial and detrimental winds in the area, temperature ranges, humidity and the function of the building. Usually buildings will require some kind of additional heating and cooling, as well as natural ventilation (see Figures 16 and 17 for how to capture natural ventilation).

**Natural lighting - effective glazing use (including use of atria)**

Glazing is an integral part of a greener building. It allows in natural light as well as access to outside views, which are important for user health and effectiveness. A balance needs to be struck between the size of the windows and the benefits and additional heat loads they create. The mechanical ESD engineers can help with this. Consider glazing types, reflective films, shading, and particularly rationalising the amount of glazing required. In Victoria for example, a 50% glazing ratio has been shown to be most effective for office buildings (this will differ from state to state).

**Minimisation of infiltration**

This issue offers significant cost reductions and is easily integrated into the building process by good detailing and construction. Consider good seals, effective airlocks, effective HVAC ductwork installation and good quality facades.

**Effective external shading**

External shading is very important if glazing is being used. It is important because it can reduce heat load while providing natural light and views.

**Effective use of insulation**

Use appropriate insulation for the climate and building type. Ensure ducts and pipes are well insulated if required.
Effective use of thermal stacks
A thermal stack is a large chimney like structure that draws hot air out of the building by means of the natural buoyancy of air. This can be aided by using dark colours at the top of the stack, or using fans, and/or wind turbines if the conditions are favourable.

Design of office floor plates
If passive design is being used, then the design of the office floor plates is crucial. Natural ventilation needs to be able to travel through the building and if closed offices are being proposed they need to be planned to allow air to flow in and flow out. In general, partitions should be limited to 1200mm in height, or if full height to be located perpendicular to the air flow (refer Figures 19 and 20).

Due to the increased solar load on northern facades, it can be advantageous to have the density of persons on the north façade lower than that of the south façade. Heavily polluting equipment should be put in rooms with mechanical extract on the east or west façades where solar gain is hard to control (refer Figure 19).

Climatic design
Passive design techniques vary according to different climate zones. What works in a temperate climate like Sydney may not work in a more humid environment like Darwin. In order to carry out effective passive design, ensure that the project has a thorough site analysis with information on:
- site
- solar access
- wind direction and speed over an entire year and
- climate type.

This will help the designers to choose which passive design techniques are used.

Most commercial buildings in Australia will not be able to be completely passively designed and will need some mechanical heating and cooling. Notwithstanding this, using appropriate passive techniques will minimise any additional energy needed.
Radiant cooling/heating
Radiant cooling/heating is the feeling of heat or ‘coolth’ radiating from a nearby element (such as brick wall that has been in sun). A large percentage of an individual’s sensation of thermal comfort is from radiant heating or cooling.

Mechanical plant size
Taking passive design elements into account means that in many cases the size of the mechanical plant can be reduced. Setting realistic building energy needs is also important. This requires an understanding of how the building will be used, how many people will be using it, and for how many hours.

For example the energy needs for a 24 hour building that houses a call centre, with their people and equipment intensive workspaces, will be different to a nine-to-five office housing maintenance staff for Canberra parks. They may only be in their office half of the time and spend most of their time in the field.

Lighting
Lighting needs to be optimised for the tasks that will be performed. The simplest ways of minimising energy consumption from lighting are to consider:

• energy efficiency fluorescent tubes (T5 or T8 depending on sitting and use of light)
• use of natural light
• use of electronic ballasts (7% more efficient)
• user controls
• task lighting.

Comfort
Comfort is a term about the perception of people in a space. The Predicted Mean Vote (PMV ISO 7730-1984) and Adaptive comfort (ASHRAE-5525) systems provide appropriate measures of comfort. Together they both consider factors such as radiant temperature, humidity, radiant symmetry, air movement, occupant clothing and activity levels and external ambient temperatures.

Adaptive comfort
Adaptive comfort assessment methods allows the designer to produce a more efficient and smaller HVAC system.

‘One of the problems with air based systems is that they don’t turn down very well. And when they get to this low load situation... they perform badly and get into all sorts of problems ... yet this is the situation for 80% of the year.’

Appropriate sizing of building systems
Dr Paul Bannister, Managing Director, Exergy Australia

The Council House 2 project (CH2) carried out an assessment of all of its systems to determine the risks and opportunities for lowering energy use. This was done to assist in the sizing of the chilled water panels, the sizing of the chillers and the sizing of the phase change material plant. The graph in Figure 21 is an example of the analysis and its implications on cooling load for one section of CH2. This was repeated to optimise the entire building.

**Note:** The result of this analysis showed that a 95% coverage of cooling loads would reduce load by 42% saving around $600 000 in plant.

**Figure 21.** Risk assessment CH2 for cooling load (AEC, City of Melbourne report).

The assessment shown in Figure 21 was only possible through the active collaboration of the whole design team, including the engineers, from the beginning of the design process. Where a process such as this is not possible, then it is important to ensure that the engineers understand the relative loads of the building (how many people, what hours, how much equipment, glazing, orientation etc.) and that they use this knowledge to work effectively with the designers and the client to optimise comfort and minimise cost.

**EFFECTIVE ZONING, SENSORS AND CONTROLS**

**Zoning**

Effective zoning means that heating, cooling and lighting are provided only when and where needed. This should form part of the mechanical engineer’s brief, though it needs input from the design team, as effective zoning requires accurate information on internal layout and fit-out. Sensors can also be effectively used with an integrated building management system in order to turn off or adjust lights, ventilation, heating and cooling.

**Sensors**

**Light lux level sensors**

Adjust lighting to compensate for the amount of natural light entering the space. These sensors are also called photoelectric (PE) sensors.

**Timers**

Switch off lights and other systems at certain times.

**Movement sensors**

Turn on lighting and ventilation systems when movement is detected.

**Carbon Dioxide sensors**

Adjust ventilation rates so that enough fresh air is supplied.

**Temperature sensors**

Adjust ventilation, heating and cooling systems to maintain a specified temperature range.

‘The mechanical system was something very easy to do. The lighting and lighting controls as well....we can find out if there is a leak in the system, or if something is not working, they’re all alarmed so we set our alarms to any slight variations, which immediately draws attention.’

**Metering, lighting and building management**

Brindabella Park’s central plant

Martin Osolnik, Associate, Daryl Jackson

Alastair Swayn
Control
Like comfort, a decision needs to be made at an early stage as to the amount of control individuals will have. Studies have shown that having control over light, ventilation, heating and cooling will improve a person’s perception of comfort, but these need to be weighed against the increased use of energy if one person is turning up the heat while the other is turning it down. An example of a compromise design approach (which aims for maximum control and efficiency) is to have standard background lighting, heating and cooling levels, while allowing individuals to control ventilation direction and providing task lighting.

BUILDING MANAGEMENT SYSTEMS AND EQUIPMENT PURCHASING
It is often said that ‘if you can’t measure it you can’t manage it’ - this holds true for buildings also. Measuring energy performance using sub meters on separate floors and high energy usage areas such as server rooms, allows for the early detection of problems and the optimisation of performance.

Figure 22. Comparable energy savings between monitor types and client, CH2 (AEC, City of Melbourne report).

Efficient office equipment specification (i.e. for photocopiers, computers, etc.) is one method to minimise operational energy use. This guide does not provide detailed advice in this area, but an effective purchasing

Liquid Crystalline Display (LCD) computer monitors consume 77% less energy than older cathode ray tube (CRT) computer monitors. The adoption of the LCD monitors and the thin client technology for the computing requirements will reduce the internal heat load and therefore, the amount of cooling which needs to be provided. The thin client eliminates the need for a Central Processing Unit (CPU) using 85W at each desk. Combined with a LCD screen, at 30W, instead of the 80W CRT screen, this saves 127W per desk.

Note: savings may vary with equipment, design of the offices and the type of cooling provided.

The greatest life-time energy impact of a building is its operational energy consumption and therefore having a good building management system, with periodic auditing and improvement, will optimise performance. Having said this, the more complex a building and its systems, the more difficult it is to manage. As a general rule try to keep a building and its systems as simple as possible to carry out the functions it is required to do.

Another tool for minimising energy consumption during operation is to have tenant initiatives such as tenant EMS, green leases and tenant building user manuals. This can ensure that the building tenants know how to use the building effectively and energy efficiently. Tenant specific lighting and environmental controls and metering are particularly effective in supporting this strategy.

AGO capital cost reductions
David Oppenheim, Director, Sustainable Built Environments

‘We adopted realistic accommodation sizing, which reduced the capital cost of the plant by $35 000. We adopted realistic lighting power densities, which reduced the capital cost of the plant by $30 000 and we adopted realistic plug-in load density and that saved $70 000.’
minimising energy use

**Effectiveness of hot water and PV systems**

Domestic hot water cost payback: 6-7 years\(^{26}\)
Embodied energy payback: 0.5-2 yrs\(^{27}\)

Domestic and commercial photovoltaic systems cost payback: Greater than 10 years\(^{28}\)
Embodied energy payback: 2.5-3 yrs\(^{29}\)

**RENEWABLE ENERGY**

**Green Power, Solar Hot Water and Photovoltaic systems**

One main technique for minimising the greenhouse intensity of the energy used in a building is to use green power (electricity which comes from wind, water or solar sources) and/or to use a cogeneration system.

Using solar energy for the provision of hot water is another method for using renewable energy and reducing the greenhouse impact of a building. Solar hot water systems involve pumping water through pipes that are laid on an absorber plate. Both of those are coated with heat absorbing material. The pipes and plate are mounted in the sun’s direction to maximise heat absorbance. The water absorbs heat and transfers this heat to a storage tank where it is collected and ready for use when required. Optimum positioning for panels is within 30° of true north and tilted at an angle of latitude plus 15°.

A photovoltaic system (PV) uses solar energy to generate electricity. PV panels are made with a positive and a negative layer of silicon. When light falls on these layers, it produces a potential difference (photovoltage) between the layers by causing electrons within the layers to move. If an external circuit is present, this voltage can drive a current through it. This current is then converted to AC current (the type of current used in the office) via an inverter. This can then power normal office appliances and lights. If the office is connected to the mains electricity, excess energy can be redirected to the grid, reducing energy costs.

**EMBODIED ENERGY MINIMISATION**

Embodied energy is discussed in Opportunity 7 Choosing materials.

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**Online Resources**

- **Passive Design Techniques**
  - Square One [www.sq1.com](http://www.sq1.com)
- **Sustainable Building Sourcebook**
  - [www.greenbuildingsourcebook.com](http://www.greenbuildingsourcebook.com)
- **Renewable Energy**
- **Solar Power**
  - ATA (Alternative Technology Association) [www.ata.org.au](http://www.ata.org.au)
- **Energy Efficient Fittings and Equipment**
Buildings have a role to play in minimising the environmental impact caused by transport. If there is a choice of locations, choose the site with the best access to public transport and amenities such as child care, shops, etc. This will minimise car use. Smaller cars can also be encouraged by designing in car parking spaces that are 2.3 x 5m.

Day-to-day travel by individuals in cars can also be reduced by supporting car pooling, integrating green travel plans and providing adequate numbers of cycling facilities. If cycling is to be encouraged, the building design needs to include enough space for secure bicycle parking, clothes storage, changing facilities and showers (a provision for 5% of the staff is common practice).

In addition, by choosing local materials you will minimise the transport impact of bringing these materials to the building, during both its construction and operational phases.

In the staff how many people would be making use of the facilities they found that they needed much more space for change rooms and lockers than they had initially anticipated. For this reason a hierarchy of lockers has been devised depending on whether people needed the lockers as part of their day-to-day activities such as parking inspectors or were just using the facilities occasionally.

30 The Bond, the Bovis Lend Lease headquarters building in Sydney included infrastructure for their staff for cycling and changing. Another tenant that has moved into the building saw this and was inspired to convert car parking into 13 bicycle parks and install showers in their tenancy.

The Council House 2 project (CH2) includes bicycle parking and changing facilities, but on asking

Online Resources
Minimising Transport Impacts
Travel Smart Australia
www.travelsmart.gov.au
GreenFleet
www.greenfleet.com.au

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30  
Green Star - Office Design transport credit Tra-3
Cyclist Facilities: www.gbcaus.org

Figure 25. Public transport, DesignInc.
Figure 26. Bicycles, freefoto.
Figure 27. Runners, Doncaster Hill Sustainability Guidelines, Manningham City Council.
HFCs are not genuinely ozone friendly. The production of HFCs uses the very same halogenated CFCs and HCFCs, which they were intended to replace, as emissions during the manufacturing process are inevitable. Better options include using ammonia and hydrocarbon refrigerants.

**OPPORTUNITY 6**

**minimising ozone layer depletion**

To minimise impact on the ozone layer during the maintenance and top-up of refrigerants, use an automatic pump-down to either a separate storage tank or into the heat exchanger with isolation valves fitted to contain refrigerant once fully pumped down.

**IMPORTANCE OF MINIMISING OZONE LAYER DEPLETION**

The ozone layer is a layer of ozone (O³) situated far above the build up of greenhouse gases and it protects the earth from harmful (to humans) solar radiation. Research has shown a thinning of the ozone layer all over the globe. However due to specific meteorological conditions the most dramatic depletion is over Antarctica. Its absence results in increased exposure to solar radiation and its detrimental effects – such as skin cancer, cataracts and disruption of normal function of micro-organisms.

Chlorofluorocarbons (CFCs), halons, methyl chloroform, carbon tetrachloride, HCFCs, hydrobromofluorocarbons and methyl bromide are responsible for the ozone layer depletion. The impact on the ozone layer is measured by the Ozone Depletion Potential with CFC-11 set as 1 and all other gases given a relative score.

Ozone depleting substances used in buildings include chemical refrigerants used in air-conditioning systems and fridges, and expanded materials such as polystyrene.

**OPTIMISING MINIMISATION OF OZONE LAYER DEPLETION**

Minimising emissions that affect the ozone layer can be done by choosing non-ozone depleting refrigerants (such as water, air, CO₂, ammonium and hydrocarbons) and ensuring there are systems in place to minimise or eliminate refrigerant leaks.³¹

Refrigerant leaks can make up to 15% of the volume of refrigerants required per year. This not only affects the ozone layer, but also adds to the greenhouse effect. The global warming caused by cooling system refrigerant leakage can be as much as that caused by the electricity consumed by the cooling plant. As an example, Green Star – Office Design v2 specifies that to achieve the relevant credits, refrigerants need to have an Ozone Depleting Potential (ODP) of zero and a Global Warming Potential (GWP) of ten or less.

³¹ Green Star - Office Design v2 Emissions credits Em-1 ‘Refrigerant ODP’ and Em-2 ‘Refrigerant GWP’ www.gbcaus.org

Australian Government building responsibilities are invoked because Australia is a signatory to the Montreal Protocol on substances that deplete the ozone layer. The manufacture, import, and export of CFCs, halon, methyl chloroform and carbon tetrachloride has been controlled in Australia since 1989. These activities were banned for halon from 31 December 1992, one year ahead of the Montreal Protocol requirements. For the other chemicals, these activities have been banned since 1 January 1996, except for a small range of essential uses. Australia banned importation and manufacture of CFCs from 31 December 1995. HCFCs are ozone depleting, but have a much lower ozone depletion potential than CFCs, and are considered a transitional chemical to assist in the phasing out of CFCs. They are commonly used as refrigerants, solvents, and blowing agents for plastic foam manufacture, and are scheduled to be phased out by 2020.

HFCs are not genuinely ozone friendly. The production of HFCs uses the very same halogenated CFCs and HCFCs, which they were intended to replace, as emissions during the manufacturing process are inevitable. Better options include using ammonia and hydrocarbon refrigerants.

**Online Resources**

**Ozone Layer Depletion**


US EPA [www.epa.gov/ozone/ods.html](http://www.epa.gov/ozone/ods.html) a list of class 1 ozone depleting substances


Standards Australia - (HB 40.1-2001): Appendix 3 and 4 summarise ODP potential for most common types of refrigerants [www.standards.org.au](http://www.standards.org.au)

IMPORTANCE OF CHOOSING MATERIALS
The choice of materials in a new or refurbished building has an impact on the environment. This impact is not as large as that of the operation of the building, but it is still considerable. Materials impact the environment in the following ways (they are discussed in more detail below):

• consuming energy in manufacture and transport (embodied energy)
• potentially having an impact on toxicity in manufacture and in use
• using water in manufacture (called embodied water) and
• consuming other materials that have their own impacts (e.g. mining, land clearing, etc.)

OPTIMISING MATERIAL SELECTION
Choose materials that have a minimal impact and ensure that they are used for the maximum amount of time and are not wasted (waste is discussed elsewhere).

Choosing a material with minimal impact is difficult. Often you are comparing completely different products and impacts; for example, timber (biodiversity impacts, energy efficiency and high maintenance) versus aluminium windows (high embodied energy and low maintenance). The best methodology for comparing materials holistically is to use Life Cycle Analysis (LCA). The problem though is that material decisions tend to be made quickly and may not be able to wait for an LCA, and there are also many other factors that need to be considered: costs, functionality, aesthetics, etc. For this reason, simplified methods, guides and rules of thumb are often used for choosing materials.

For example, choose materials:
• with a high recycled content
• with low toxic emissions
• with low embodied energy and embodied water
• with an ability to be easily recycled
• independently certified by a third party – i.e. the Australian Environmental Labelling Association.

Embodied energy
Embodied energy is a term used to describe the inherent amount of energy in all the materials used to make a building. This is the sum of energy expended to make the bricks, windows, steel beams etc. To minimise embodied energy, less energy intensive products that perform the same function should be chosen. One way of minimising the embodied energy in products is to use those with recycled content. Many products use much less energy to be recycled than to make them in the first place; for example, only 10% of the energy used to make aluminium is needed to make recycled aluminium. Embodied energy impacts can be justified in a building designed for longevity.

Toxicity in manufacture and use
Toxicity is the release of substances into the environment (water, air, soil, etc.) that are detrimental to its normal functioning. Its effects are often talked about in human life year equivalents (i.e. the number of years earlier that the average person will die because of an emission) or human disability equivalents (the amount of impairment to normal function because of an emission). Toxicity has a much broader impact to animals and plants. This is too broad a topic to be fully explained in this guide but the strategies for minimising human toxicity are linked to reduction in other toxic impacts.
Toxicity, as it pertains to a government building, falls into two areas: the first is toxicity to the users of the building; the second is toxicity to the environment through the production of materials and electricity.

Toxicity to building users is covered under Indoor Environment Quality (IEQ) section and the guide to volatile organic compounds (VOC) limits in Green Star - Office Design. VOC emissions are a problem because some (such as formaldehyde) have been shown to be carcinogenic. VOCs also have an impact on concentration, and cause (to a varying degree) headaches, nausea etc. in sensitive people.

Minimising the impact on the environment from the production of particular materials can be achieved by specifying substances that avoid or minimise toxicity. Toxic substances are listed in the National Pollutant Inventory (NPI). Minimising the impact of the production of pollution from power stations can be achieved by using green power.

**Embodied water**

Like embodied energy, embodied water is the amount of water needed to produce a product. Currently there are no Australian guides and databases on embodied water, though these are being developed by organisations such as Deakin University.

**Knock-on impacts (e.g. in mining, land clearing, etc.)**

This refers to being efficient with materials use, and careful in the choice of materials that may affect the environment and biodiversity. There are two elements to minimising these impacts: firstly, choose materials with high recycled content and which can be recycled at the end of life; and secondly, choose materials that have third party certification indicating that sustainable management strategies are in place.

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32 Green Star - Office Design v2 Indoor Environment Quality credits IEQ-13 ‘Volatile Organic Compounds’ [www.gbcaus.org](http://www.gbcaus.org)

IMPORTANCE OF MINIMISING WASTE
Waste is a major environmental issue in the built environment with more than 40% of landfill resulting from building-related waste. One of the major imperatives of sustainable design is to use the waste hierarchy of avoid, reduce, reuse and recycle (see Figure 33). That is, do not order it if you do not need it; plan use so as to optimise material efficiency (e.g. design height for plasterboard size); put aside cut offs for later reuse; etc.

OPTIMISING WASTE MINIMISATION
Waste minimisation involves a diligent approach to documentation and project management in order to minimise the amount of waste produced on site during demolition and construction. It also recognises the potential of some materials to be reused or recycled rather than allowing them to contribute to waste volumes going to landfill. The focus of this should be a more efficient use of finite resources.

The environmental opportunities of waste management include the reduction of demolition and construction waste streams, as well as those resulting from ongoing operational waste during the life-cycle of the building. The key when thinking about minimising waste is to go through each decision using the waste minimisation hierarchy outlined in Figure 33.

Design stage
The design stage produces comparatively very little waste. Yet this is the stage where many of the waste opportunities can be minimised. Some strategies are outlined in the next column:

| Design for materials and design for standard sizes | Design ceiling dimensions to make best use of materials – for example if plasterboard comes in 1200mm don’t design ceiling heights to be 2700mm, since 2400mm would make better use of the material and minimise waste. |
| Design for flexibility | Design spaces and systems that can be easily adapted to changes in management and company structures. |
| Design of assembly and disassembly | More and more systems are being developed that allow buildings to be built in a way that allows them to be disassembled and reused. This is not mainstream in Australia yet but the trend in Europe is towards this type of construction. |
| Design using prefabricated components | Linked to the above, use systems that can be prefabricated off site and then assembled on site saving waste and time. |
| Design for ease of recycling | Design waste areas with easy access and spaces on each floor that encourage staff to recycle. |

Documentation stage
In preparing the specifications and contracts for a new building or refurbishment, ensure that there are requirements for waste minimisation. Require a waste management plan with periodic reporting, set minimum performance targets, ensure an effective induction programme has been planned for people working on site, and negotiate with the contractors that they minimise over-ordering.

Construction stage
Construction and demolition waste makes up 33% of the landfill space in Australia. This can be reduced in many cases by 80-90% through better waste management procedures.
Encourage contractors to have a plan of what waste they expect to be generated by the project, how they will divert it from landfill, and where it will be sent for reuse or recycling. One method for ensuring that the contractor has the basic understanding of waste minimisation requirements is to ask for ISO 14001 certification. This certification is for all environmental impacts, not just waste. It provides assurance that the contractor understands how to carry out an environmental plan and its associated waste management plan. Having an ISO 14001 certification is not enough to ensure performance though; it just demonstrates they understand the procedures. It is still important to have regular reports and reviews on performance.

**Operation stage**

During the life of the building, waste minimisation is a building management and tenancy issue. There is a real opportunity for savings by implementing a waste and recycling reporting, auditing and management programme as part of the everyday management of the building (see PCA’s building EMS). Particularly important is measuring the actual waste leaving the building and where it is taken – recycling, landfill, composting as this allows for active management of the waste streams.

Tenant management is another area of opportunity for waste reduction. There is an opportunity to influence tenant behaviour by ensuring easy access to recycling facilities, describing what happens to the recycling and waste streams from the building and including reports to the tenants on performance. This can also be integrated, from the tenant’s perspective, into a green lease requiring the building owner to provide reporting of waste and facilities for recycling.

**End-of-life stage**

At the end of a building’s useful life there are several choices: reuse the building, reuse part of the building, recycle the building, or demolish and send the materials to recycling or landfill. The first thing to consider is if it is possible to reuse the building. This will require a series of inspections and assessments of the potential of the building. It may be also that just the structure can be reused and everything else needs to be replaced. This is still environmentally preferable in most cases to complete demolition. When recycling the building, carry out an existing building audit and plan what will happen to all of the materials – who will take them, where they will be used etc. It is useful to note that about one half of the embodied energy in a building is contained in the structure and the roof.

**Online Resources**

**Waste**

Sustainability Victoria (SV) waste minimisation plan


SV clauses for waste management contracts and designing-in waste minimisation


Clean Up Australia

www.cleanup.com.au

**Construction and Demolition**

Sustainability Victoria resources


Resource NSW Construction and Demolition Section


Department of the Environment and Water Resources

Two topics are covered here: potable water use reduction and storm water management.

**IMPORTANCE OF WATER CONSERVATION**

Water scarcity is a major issue for Australia. While buildings, including residential ones, only consume 8-10% of water in Australia (the major users being agriculture at 70% and manufacturing at 20%)\(^35\), it is easy to get 20-50% reductions in building use through simple measures.

The main driver for water efficiency in Australian Government buildings comes from restrictions that are being placed on water usage. These restrictions are in place in cities because of the limited supply of water. The main uses of water in a commercial building are toilet flushing, cooling towers (if present), leakage, sprinkler testing\(^36\) (if present) and irrigation (if present).

*‘In Sydney, the commercial building sector in Sydney Water’s area of operations uses around 100 million litres of water daily and cooling towers account for around 30% of this.’*\(^37\)

**AUSTRALIAN GOVERNMENT WATER USE**

Data collected from a desktop study, and from site assessments of a variety of government buildings, has allowed the Institute for Sustainable Futures at the University of Technology in Sydney\(^38\) to formulate a model to estimate the total water consumption in Australian Government buildings and operations.

The results of the model indicate that total Australian Government water consumption is approximately 19 100 ML/year (equivalent to 73 000 Australian households). An average water consumption intensity of 3.34 kL/m\(^2\) per annum and a best practice target of 2 kL/m\(^2\) per annum have been identified based on the data.\(^39\)

**NATIONAL WATER INTENSITY BENCHMARKS**

National benchmarks for water consumption in office buildings have recently been developed based on ABGR methodology. As indicated in the table below, a score of 2.5 is Australian average practice, with a score of 5 representing possible best practice.

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<th>Syd</th>
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<th>Adel</th>
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<td>0.35</td>
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</table>


…studies show that reductions of up to 80% of potable water demand and 90% of sewage discharge can be achieved in a sustainable commercial building compared to a conventional building, through the integration of innovative water efficiency measures, rainfall capture and use, treated effluent reuse and evapotranspiration through roof gardens.\(^34\)


36 Research done for the CH 2 building showed that sprinkler water testing uses about 10KL of water per week for the average 10 storey building, this is potable water that can be used for other purposes.


**OPPORTUNITY 9**

**water conservation**

**OPTIMISING WATER CONSERVATION**

* Potable water reduction opportunities

Many opportunities can be implemented quickly and cheaply to reduce water consumption. Opportunities for water reduction are as follows (these are discussed in greater detail below):

- management and monitoring
- leak avoidance
- efficient fixtures and fittings
- water sensitive landscaping and
- source substitution.

**Management and monitoring**

Regular monitoring of meters and sub-meters, either manually or by connection to the Building Management System is particularly useful in establishing base flow rates and then identifying leaks when water use exceeds normal variability ranges.

**Leak avoidance**

- Report of leaks to building management - building occupants should be made aware of where and to whom they can report any leaks. It is important to promptly fix any reported leakages to ensure positive feedback.
- Regular inspections of toilets, urinals, taps and showers.

**Efficient fixtures and fittings**

Water efficiency labels are being introduced for many water-using appliances. Specification of efficient fixtures and fittings (as noted below) can reduce water wastage.

**Toilets and urinals**

- Toilet and urinal adjustment – adjust floaters to use minimal water
- 3 / 4 L or dual flush toilets
- Urinal flush controls – sensors
- Waterless Urinals.

A dual flush toilet replacing a single flush unit in an office building will save approximately 360 litres each working day (90 kL per year) in a female toilet, an annual financial saving from potable water alone of about $90 or more. For a male toilet the saving will be about 40 kL/year. For the Edmund Barton building in Canberra, with approximately 2800 staff, this would mean an annual saving of more than 9 ML, or $11,000 for a cost of about $40,000, a payback of under four years.

In a busy public building, the saving from a dual flush toilet retrofit could be more than 1 kL per day per toilet, or about 400 kL/year for a building open every day of the year. The cost of retrofitting dual flush toilets depends upon the plumbing changes and redecorating that would be required. It can range from $250 to $500 or more per toilet.
Stormwater recycling can be encouraged at minimum cost to Government. Rainwater tanks connected to roofs provide a valuable source of water for gardens, toilet flushing, washing and hot water. Stormwater storage underground, which could form part of an on-site stormwater retention/detention system, can also be incorporated into buildings.  

Shower heads – need good advice on type as some may result in an inadequate shower

AAA or AAAA showerheads – made to increase pressure so as to still provide a good shower.

Taps

Flow restrictors or tap aerators
Automatic cut-off and sensor operated taps.

Cooling towers

Making sure float valves are set correctly
Installing a conductivity meter and automating the blow-down system to a pre-set conductivity level (Total Dissolved Solids concentration) of the re-circulating water
Implementing ‘performance-based’ maintenance
Reducing heat loads by improving the energy efficiency of the building and energy services, which will also reduce the heat load on chillers and cooling towers

Further options for improving efficiency in cooling towers can be found in Sydney Water’s Best Practice Guidelines for Cooling Towers in Commercial Buildings

Sprinkler water testing

Ensure sprinkler testing water can be captured for reuse
Preferably, use captured water for potable uses

Water sensitive landscaping (Keriscape)

Use native and indigenous plants for the garden as they require less water compared to exotic varieties
Use mulch in the landscape to minimise the loss of water from the soil by evaporation
Schedule the irrigation time using timer controls so that irrigation is done after sunset, to minimise loss of water to evaporation
Install soil moisture sensors

Source substitution

Other than water efficiency measures, there are three additional options for reducing water use from mains: the first is to collect and use rainwater, the second to reuse grey water and the last to recycle all waste water.

Rainwater

Water collected off the roof of a building is dependent on collection area, rainfall and amount of space available for water storage tanks.

Grey water

Grey water is from showers, clothes washing and non-kitchen sinks. For most commercial and other government buildings the amount of grey water is not significant since there is little water generated from these sources. Local regulations will need to be investigated to see the classification of grey water. In some states treated grey water is seen as waste (or black) water and therefore such systems need the appropriate authorities to approve its reuse. In Canberra, the John Gorton building has been recycling grey water since the late 1990s.

Waste or Black water

This is water from kitchens and toilets and recycling and recycling is possible with current technology but requires appropriate permits and a thorough system of maintenance and monitoring. There are two types of recycling – biological (using bacteria and worms) and mechanical (using filters). Some examples include the 60L building in Melbourne that uses a biological system and CH2 that uses a mechanical system.
OPPORTUNITY 9
water conservation

STORMWATER

Stormwater is the rainwater that runs off surfaces such as roads and roofs into the stormwater system. This water is a potential resource, but currently it is mainly collected and run off into rivers, lakes and the ocean.

Stormwater opportunities

For government buildings the main issues with stormwater (adapted from DEW stormwater guidelines see link below) are stormwater effective landscaping, on-site retention, roof gardens and aquifer storage.

Stormwater effective landscaping

- Using landscaping to absorb stormwater runoff from paths
- Using semipermeable surfaces

On-site stormwater detention (OSD)

Best practice on-site stormwater detention involves:

- Increasing the quality of the water captured by separation of first-flushes from later flows. First-flush water can be contaminated by dust on roofs, oil on roads and other pollutants. These can be diverted to landscaping or can be treated.
- Using screened outlets to closely control flow rates and capture litter, debris and sediment.
- Using frequency-staged storage systems that employ ‘storage’ in lawns and garden soils, depressions in public open spaces, and open and covered pavements such as car parks, but designed in a staged fashion, so that each storage comes into operation only when the preceding one is full.
- Using tailwater compensation to control discharge when the bed of the water storage facility lies below the water surface in the receiving drain.
- Using pump discharge regulation for controlling pumping from basement tanks in buildings.

The benefits of OSD are:

- it can be funded immediately (i.e. by the developer) and does not require capital outlays from stormwater management authorities
- it protects downstream properties against increases in flooding resulting from new developments.

Roof gardens

In cities, roofs cover 40-80% of built areas leading to problems including higher volumes of stormwater runoff. A number of countries in Europe have acknowledged this problem and have legislated that all public buildings should be covered with a roof garden. The German government contributes 50% to the cost of building a roof garden on either private or public buildings. Roof gardens absorb about 76 litres of water per square metre of garden space. Super-imposed loads on the roof structure, plus retained rainwater, means that the roof needs to be designed for the extra loading.46

47 Gerges, N.Z. Aquifer storage and recovery: type and selection of aquifer. Primary Industry and Resources, Canberra.

Green roofs are an example of one initiative that affects several impacts – stormwater run off, increase insulation of the roof, and importantly reduction of the urban heat island effect (the significant increase in air temperature in built up areas).

Aquifer storage and recovery (ASR)

This involves the harvesting of surplus stormwater from a variety of sources. Stormwater can be temporarily stored in a suitable aquifer, and then retrieved for potable, irrigation or industrial applications.47

Online Resources

Water

Stormwater

Savewater.com.au
www.savewater.com.au

Water management plan

Clearwater
www.clearwater.asn.au/

Water Efficiency Labelling

Yarra Valley Water

ESD DESIGN GUIDE - OFFICE AND PUBLIC BUILDINGS

034
**IMPORTANCE OF LAND USE AND PROTECTION OF ECOLOGY**

The main issues with the choice of land are: efficiency in its use and avoiding potential biodiversity impacts. Biodiversity is the richness of animals and plants that live in an area. The value of considering biodiversity is that over 40% of nationally listed threatened ecological communities, and more than 50% of threatened species, occur in urban fringe areas. The impact of the loss of biodiversity ranges from not having that animal or plant present, to systemic chain reactions that go beyond the scope of this guide to explain. Preserving and enhancing levels of biodiversity is one of the three key objectives of the National Strategy for Ecologically Sustainable Development.

**OPTIMISING LAND USE AND PROTECTION OF ECOLOGY**

The main issue for Australian Government buildings is in the land chosen for a new building and in the materials chosen for that building. The main way of minimising this impact is by choosing a site which is a ‘brownfield’ site, that has had buildings or other industrial uses on it before. This is opposed to a ‘greenfield’ site, which is land that has previously been undeveloped – park, farm, bush, etc. The second way to ensure that the ecological value of the site is maintained or increased is to choose native landscaping and to remediate land if possible.

Green Star and NABERS criteria can be used for minimising these impacts:

- **NABERS** looks at the percentage of native plant cover and the complexity of that cover.
- **Green Star - Office Design** looks at whether the site is a brownfield or contaminated site, and whether the ecological value of the site has been increased by the use of native plants, wetlands, etc. The Green Star - Office Design technical manual is a good resource for this area of decision making.


50 Green Star - Office Design v2 Land use and Ecology (Eco) set of credits [www.gbcaus.org](http://www.gbcaus.org)

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**Online Resources**

**Land use and Ecology**

Department of the Environment and Water Resources

Australian Museum

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Figure 44. Queenscliff Ecocentre, DPI Victoria.

Figure 45. Native grasses use in the Reservoir Civic Centre, Darebin City Council.
Eight Brindabella Circuit has achieved a 5 Star Green Star - Office Design v1 certified rating. Brindabella Business Park has been designed and built incorporating sustainable principles.

**BUILDING OUTPUTS**

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<tr>
<td>Water</td>
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<tr>
<td>Greenhouse Gas Emissions</td>
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<td>Capital cost</td>
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<td>$30,103 per year on energy costs</td>
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<td>Payback</td>
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**KEY AREAS OF ACHIEVEMENT**

- Active chilled beams used to circulate air inside the building.
- Energy efficient light ballasts and zoned lighting used to reduce energy consumption, including an advanced control system that automatically dims the luminaires around the perimeter of the building when daylight is sufficient.
- Extensive research was undertaken to ensure that all materials used have either no or extremely low VOC levels.
- High levels of recycled content was achieved in concrete, steel and timber.
- Solar hot water panels preheat 100% of all hot water, and provide approximately 70% of the total heat energy.

**PROJECT BACKGROUND**

Eight Brindabella Circuit was designed as a speculative office building with some retail spaces. The client was keen to achieve a 5 Star Green Star building to provide a ‘green’ alternative in the market, which was also commercially viable. The building forms part of the Brindabella Office Park and reflects the progression of various initiatives introduced to the suite of buildings within the park.

**ESD CONSIDERATIONS**

**MANAGEMENT**

This building was constructed in accordance with a site specific environmental management plan, which exceeds both best practice NSW Environment Management System Guidelines (1998), and best practice Australian Government guidelines.

All the key decision makers involved in the design phase have undergone training by the Green Building Council of Australia and some have progressed to become Accredited Green Star Professionals. All workers are inducted in green construction techniques, including material (particularly adhesives and solvents) selection and recycling. All airport management and staff have also undergone green management, safety, and emergency spill training.

An independent commissioning agent appointed to the project will return to 8 Brindabella Circuit every three months for one year to ensure absolute compliance with Green Star specifications. This ensures systems continue to run as specified and re-tunes the system to provide ongoing energy savings.

A Building User Guide has been prepared to help the building manager and occupants understand the innovative systems installed in the building, which ensures the systems are used efficiently.

Solvents used in the cleaning of all Business Park buildings have been tested for any impact they may have on the environment. Occupants and cleaning staff are required to separate recyclable and non-recyclable waste.
ENERGY

Cooling, heating and supplementary air conditioning water is reticulated from a Central Services Building, which in turn serves all the new buildings in the Brindabella Business Park. This means the building is more energy efficient than a building of similar size. These economies of scale allow considerable redundant capacity to be provided, ensuring a consistent supply of conditioned air and heated water to the building.

The building uses active chilled beams to circulate and control the air temperature. This significantly reduces the quantity of air moved from the plantroom, reducing fanpower and energy consumption. The building also features passive in-slab heating and cooling around its perimeter, ensuring efficient and more constant temperatures across the tenancy to improve occupant comfort.

Every substantive energy use within the building and in the plantroom is individually monitored and is connected to a Building Management System, centrally monitored and controlled across the park. This allows detailed analysis of the energy use of each of the key users of electricity and, hence, provides for future energy savings through proper management. Similarly, sub metering is provided for lighting and small power uses in each of the tenancies, and individual tenant meters can be connected to the Building Management System.

Artificial light is supplied by high-efficiency single tube 54 W T5 fittings for all tenant lighting, reducing the lighting load to approximately 9 W/m² (ordinarily 15 W/m² in a conventionally lit commercial building). The building’s perimeter lighting features a system that automatically senses when it can dim the lights to optimise use of the daylight, while motion sensors turn lights off when nobody is around.

Lighting zone flexibility ensures that only occupied areas are lit. This flexibility is achieved by separate switches for individual and enclosed spaces with the size of individually switched zones not exceeding 100 m², and clearly labelled.

Roof top solar hot water panels preheat 100% of the hot water supply to the building, cutting energy use for hot water by two-thirds.

WATER

This building saves 687 000 litres of water a year compared with a standard building of similar size. The water efficient devices employed lead to a 43% reduction in water consumption. An additional 10% is saved by rainwater collection.

To achieve this saving, the building uses a number of systems:

- Water-free urinals: Water-free urinals utilise a biodegradable blocking fluid rather than the conventional flush of water to contain odours.
- Hands free taps: Infra-red taps reduce both water and energy consumption. Water is only released when hands are under the infra-red beam below the tap spout.
- 3/6L dual-flush toilets: on average use 4 litres per flush.
- 5A rated shower heads: Shower heads also achieve a 60% reduction in water usage.

In addition to the water consumption savings, the water efficient devices employed lead to a 36% reduction in emissions to the sewer.

IEQ

Extensive research was undertaken to ensure that all materials used have either no or extremely low VOC levels. In addition, a general exhaust riser is available for tenants to connect to so that emissions from photocopying and printing equipment can be collected at the source and exhausted.

James Andrews, Associate Architect, Daryl Jackson Alastair Swayn

"The beauty of 8 Brindabella is its understated greenness at a reasonable cost to the client, no gimmicks, no fuss, just application of sound green principles.”
8 Brindabella Circuit

The office space is continually supplied with 100% outside air, and exceeds the requirements of AS1668.2 (1991) by 185%. This ensures continuous fresh air and no accumulation of airborne contaminants or objectionable odours in the building.

The T5 high frequency ballasts used for artificial lighting minimise the ‘flicker’ typical of fluorescent lights. Flicker, whether it is consciously or unconsciously detected, can have severe effects on workers leading to eyestrain and headaches.

The building has been certified by an acoustics consultant to ensure it has a low noise level, with the building services contributing less than 5dB to the noise within the space. This is achieved through the use of double glazing and thick insulation, ensuring that noise from external sources is virtually eliminated.

The active chilled beam system allows conditions in the local area to be maintained by adjusting the supply temperature from each unit. These units service a much smaller area than is typical for office buildings with zone sizes reduced from 100m² in a standard building to 35m². This leads to improved occupant satisfaction within the space.

Shading on the outside of the building has been designed to minimise glare and heat. The shading devices have been modelled to ensure maximum passive design savings. Internal blinds are also included so that occupants can manually adjust the level of light entering the building.

MATERIALS
Over 30% of the cement used in most of the concrete has been replaced with an industrial waste product. This increases the strength of the concrete while also using a significant quantity of what would otherwise go to landfill.

Ninety percent of the steel used in the building is either recycled or reused. It reuses a significant amount of steel from demolished buildings, reducing waste to landfill and meaning that less energy is required during manufacture, because the steel does not have to be re-melted. For all the major steel uses such as steel beams, used beams were obtained and re-worked. The result has been less energy usage in the rejuvenation than in the recycling process.

The timber used is almost entirely sourced from recycled timber (Blackbutt-Eucalyptus Pilularis) obtained from demolished buildings.

WASTE
Over 80% of the waste created by the construction of 8 Brindabella Circuit is collected and sorted for re-use/recycling.

Office waste is sorted for recycling. There is a central recycling storage area in the Park to collect all recyclables. All workstations in the Park have separate recyclable and non-recyclable bins. Organic waste from landscaping is either recycled or used as fertiliser for local farmers.

EMISSIONS/TRANSPORT
All of the refrigerants used have an Ozone Depletion Potential of zero. Insulation products have also been carefully selected to ensure all substances used in its manufacture have an ODP of zero.

Canberra Airport provides and subsidises a regular bus service. Buses travel regularly to and from the airport connecting to the city and Russell within 15 minutes at just $3.10 for airport tenants.

Optimum levels of car parking are provided to encourage the use of alternative transport. In addition, a number of small car and motorbike parking spaces have been provided near the entrance to the building to encourage the use of more fuel efficient small cars and mopeds/motorbikes.

Secure enclosed bicycle storage is provided for staff, with showers, change rooms and lockers available adjacent to the bike store.

REFERENCES
Canberra International Airport

“We used waterless urinals and all the A grade fittings and they’re all hands free activation on all the taps in the bathrooms etc. so it’s a sort of measured dose, and also auto flush cycles on all the toilets so it takes the chance of someone leaving a tap on or something running out of the equation.”

Brindabella’s central plant
Martin Osolnik, Associate, Daryl Jackson
Alastair Swayn
30 The Bond

Thirty The Bond is an A Grade office building located in Millers Point, Sydney and is currently the headquarters for Lend Lease. The building is part of a complex on Hickson Road which also includes heritage buildings, a residential building and a public plaza. ‘The Bond’ committed to a 5 star energy rating (AGBR), resulting in 30% lower greenhouse emissions than a typical office building.

**BUILDING TYPE**
New

**CLIMATE**
Temperate

**LOCATION**
Millers Point, Sydney, New South Wales

**CLIENT**
Deutsche Office Trust

**ARCHITECTS**
Lend Lease Design, PTW Architects

**ENGINEERS**
Bovis Lend Lease, Arup, Lincolne Scott

**SIZE**
19,700m² net lettable area

**Energy**
1243mWh per year (63kWh/m²)

**Water**
Figure not yet available

**Greenhouse Gas Emissions**
1 162 300kg CO₂ per year (59kg CO₂/m²)

**Capital cost**
$112 million

**Savings**
$157,000 per year (compared to 3 star AGBR building)

**Payback**
No additional costs

**KEY AREAS OF ACHIEVEMENT**
- The building is the first in Australia to achieve a 5 Green Star As Built rating.
- The building has now delivered a 5 star AGBR rating for two years of operation.
- Features the first use of chilled beams.
- Plants used as a natural air filtration system.
- High amount of recycled timber used in the fitout.

**PROJECT BACKGROUND**
The site of the building is within the former Australian Gas Light (AGL) gasworks plant established in 1871 to provide lighting to the surrounding area. A four-storey sandstone wall, originally hewn by convicts, remains as a main feature of the atrium.

Lend Lease staff gave a large amount of input into the design and fitout of the building. Staff identified three key issues to address in the design of the building: greenhouse gas emissions, indoor environment quality and social aspects.

**ESD CONSIDERATIONS**

**MANAGEMENT**
Management has taken thorough steps to ensure the ESD initiatives incorporated into the design have been maintained during the crucial operation stage of the building’s life cycle.

Before moving into the premises, the staff were given presentations about the sustainability initiatives incorporated in the building, how the building works and ways to maintain the sustainability of the building. The post occupancy study has shown that 84% of occupants feel more comfortable, with 51% saying they are more productive.

**ENERGY**
A chilled beam air conditioning system is the major contributor to the reduction in energy consumption. Chilled beams operate by pumping chilled water through cooling elements in the ceiling. Hot air created by occupants and equipment (such as computers and lights) is cooled by the chilled beams and falls, creating a natural convection process of hot air rising and cold air falling. Additional radiant cooling from the chilled beams supports the convection process.

In addition to the chilled beams, fresh air is continually provided to the workplace and exhausted out of the building without being recirculated. This significantly increases the air quality within the office space and considerably reduces the risk of sick building syndrome.
30 The Bond

Naturally ventilated sunrooms on each floor can operate comfortably for up to 60% of the year.

The long front elevation of the building faces desirable views to the west, overlooking wharves. Overheating through the expansive glazing is avoided through use of individually operated external shades. As workers tilt the shades to block glare and heat, they also affect the appearance of a continuously changing, lively facade as seen from the street.

WATER
The roof top garden has been planted with native fauna and a drip soil system with moisture detection installed to reduce water consumption. Low flow water fittings and fixtures have been installed throughout.

IEQ
Narrow floor plates, access to view, high daylight levels, single pass double code outdoor air quantity, T5 lighting and low VOC materials such as carpets and paints, all combine to give a world leading indoor environment.

A roof garden, featuring mainly native flora, acts as a social hub for the tenants.

MATERIALS
Bamboo flooring and products are used extensively throughout the building. Other timbers used have either been recycled or harvested from sustainable plantations.

Low VOC products, including cork (a renewable resource), were used for interior walls. Sourcing also included goat’s hair carpets.

Ninety-six percent of the components of office chairs can be reused, and contain 42% recycled material.

WASTE
The site’s former life as home to AGL’s first gas manufacturing plant in Sydney meant residual contamination, including tarry waste, remained beneath the ground. Remediation works were carried out which included installing permanent groundwater barrier walls (secant piles), excavation of tar and applying odour suppressing techniques to the removed tarry waste. The project team also applied new on-site mixing techniques which proved successful in turning the semi-liquid tar into a more stable, manageable material for removal, transportation and treatment offsite.

EMISSIONS/TRANSPORT
Bike racks, lockers and showers have been provided for the staff. A tenant has purchased a car parking space to add a further 14 bike spaces and has installed showers and lockers on their floor.

Public transport is readily available, with the building located 500m from two railway stations, two ferry stations and a bus.

REFERENCES


Edwards, P. 2003, Developers viewpoint on a sustainable approach, Bovis Lend Lease.


‘In terms of artificial components on energy efficiency, we have T5 lighting…We’re achieving 6.7 W per square metre….’

Energy efficiency 30 the Bond
Paul Edwards, General Manager, Environment Sustainability Initiatives, Lend Lease Australia Pacific
The City of Melbourne’s Council House 2 (CH₂) has achieved a 6 Star Green Star - Office Design v1 certified rating. Set in the heart of Melbourne CBD, CH₂ houses 540 council employees as well as retail outlets on the lower floors. Sustainable principles have been incorporated in every detail of the design. Significant reductions in greenhouse gas emissions have been achieved – in this case, 87% less than the existing council house next door.

**BUILDING OUTPUTS**

<table>
<thead>
<tr>
<th>Energy</th>
<th>515.5mWh per year (55 kWh/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>100kL mined per day, 72% reduction in potable water use</td>
</tr>
<tr>
<td>Greenhouse Gas Emissions</td>
<td>562 tonnes CO₂ per year (60kgCO₂/m²)</td>
</tr>
<tr>
<td>Capital cost</td>
<td>$51 million for the building excluding fitout</td>
</tr>
<tr>
<td>Savings</td>
<td>$1.2 million per year</td>
</tr>
<tr>
<td>Payback</td>
<td>Around 10 years</td>
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</tbody>
</table>

**Note:** This building is still in monitoring phase. Figures given are estimates of final performance.

**KEY AREAS OF ACHIEVEMENT**

- 6 Star Green Star rating.
- Features shower towers, phase change materials and chilled ceiling panels as the radiant cooling system.
- Water mining plant that recycles black water from city’s sewers for non-potable reuse.
- Vertical garden on the north façade to minimise glare and increase ambience.
- Displacement air-conditioning provides 100% fresh air requirements.

**PROJECT BACKGROUND**

The Melbourne City Council is known for its role as a leading green organisation and wanted the design of its new council building to reflect its position. The council desired a lighthouse project that would demonstrate what a green building, integrated into an urban environment, could achieve. In addition to the projected energy and water savings, the key driver of the project was to create an environment that promoted staff well-being, retention and effectiveness.

**ESD CONSIDERATIONS**

**MANAGEMENT**

An Environmental Management Plan was required at tender stage. The contractor was also required to be certified to ISO 14001 Standard.

A Building User’s Guide will be developed and available to all building users, occupiers and tenants to promote effective and efficient use of the building.

**ENERGY**

Chilled panels on the ceilings aid air circulation and radiant cooling. This process allows significant energy savings. The heat from occupants and equipment is absorbed into the thermal mass, circulating fluid passing through chilled panels.

The building is naturally cooled at night. This process is called night purging. Windows on the north and south facades open to allow the air to flow through the space. The heat absorbed by the high thermal mass building structure, during the day time operation, is released to the cool night air as it flows through the building.
CH₂, Council House 2

There are five shower towers on the outside of the building that condition the air on the ground floor and retail space. The water is evaporatively cooled and used to remove heat from the phase change material which, in turn, is used to cool the water that runs through the chilled beams and panels. Photovoltaic cells on the roof generate 3.5kW of energy, enough to power the wooden louvres on the western façade. Electrical heat and energy is also supplied by a micro-turbine co-generation system.

General light levels are kept low. Office lighting is zoned into areas no larger than 100m². They use high frequency T5 ballasts that achieve lighting power density of less than 2.5 W/m² per 100 lux. Task lighting is provided to employee work areas.

Highly energy efficient equipment such as LCD monitors are used.

IEQ
One hundred percent fresh air is funnelled down vertical supply ducts that supply air to the office space via vents in the floor. These vents can be adjusted by the users for comfort. Turbines exhaust air during night purging. CO₂ levels in the air are constantly monitored and fresh air supplied accordingly.

Natural light is provided where possible. The lower floors, which are exposed to less light than upper floors, have larger windows. To minimise glare and heat, louvres are positioned on the east and west façades, made up respectively of perforated steel and recycled timber. The northern façade also features a vertical garden, which provides shading as well as a micro climate for the balcony areas.

Light shelves inside and outside reflect light onto the ceiling, providing diffused lighting. General light levels are kept to 150 lux. Task lighting of 320 lux is provided for individuals.

Plants specifically selected for their ability to filter toxins from the air are placed around the office space.

The council expects between a one and five percent increase in staff effectiveness due to the increased ambience and air quality.

WASTE
During the construction period, CH₂’s contractors recycled 80% of the construction waste.

Recycling facilities to recycle all types of office waste are provided to staff.

EMISSIONS/TRANSPORT
CH₂ is located in the heart of Melbourne’s CBD, with convenient access to public transport. Keeping this in mind, there are 80 bicycle storage spaces (10% of staff) with shower facilities. There are visitor bike parking facilities near the front entrance. Twenty two car parking spaces have been provided in the basement area.

REFERENCES
City of Melbourne
www.ch2.com.au

‘We use natural ventilation for night flushing. This cools the concrete ceiling down, and we expose as much thermal mass to the space, which works on the principle that we feel more radiant cooling.’

Mick Pearce, Design Manager, City of Melbourne

WATER
A water mining plant in the basement draws 100 000 litres per day of black water from the city’s sewer system for recycling. This purified water is used for purposes such as plant watering and toilet flushing. Surplus amounts are used in fountains, street cleaning and plant irrigation around the city of Melbourne.

Rainwater is collected and used with the recycled water to irrigate the plants.

All fittings are AAAA rated including low-flow shower heads, dual-flush toilets and sensor-triggered flushing for the urinals.

Solar hot water panels on the roof provide 60% of the hot water normally supplied by the co-generation plant.

MATERIALS
Low VOC products are used, where possible, to replace high VOC products in paint finishes, and laminates.

Ninety percent of the timber used is recycled or sustainably harvested. PVC use in hydraulics and electrical components has been eliminated.
BUILDING TYPE
Existing - Refurbished

CLIMATE
Warm - Humid

LOCATION
Fortitude Valley, Brisbane, Queensland

CLIENT
PMM

ARCHITECTS
TVS Partnership Architects

ENGINEERS
Lincolne Scott

SIZE
1821.07m² net lettable area

This building is a complete transformation of an outdated 1980s office building into a commercially viable and sustainable development. It houses the headquarters of PMM, a town planning, urban design and surveying firm, and retail shops at street level.

BUILDING OUTPUTS

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<thead>
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<tr>
<td>Water</td>
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<tr>
<td>Greenhouse Gas Emissions</td>
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<td>Capital cost</td>
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<tr>
<td>Savings</td>
<td>Figure not yet available</td>
</tr>
<tr>
<td>Payback</td>
<td>Figure not yet available</td>
</tr>
</tbody>
</table>

KEY AREAS OF ACHIEVEMENT
- Solar hot water panels provide hot water to the tenants.
- A thermosiphon wall reduces heat load in the building.
- Bio filter plants filter pollutants from the air.
- Where possible, materials were recycled from the original building.

PROJECT BACKGROUND
The aim of the building’s urban renewal was to develop an external built form with striking street appeal, housing an attractive, healthy and functional workplace for staff, showcasing a multitude of sustainable, leading edge design measures.

ESD CONSIDERATIONS

MANAGEMENT
The ESD elements of the building have been promoted by management. By January 2005, over 1000 visitors (including international groups) have toured the building, hosted and guided by trained PMM management and staff.

A Building User Guide was developed so that building users understand and know how to maintain the ESD features in the building. There are also monitoring programmes and educational displays in the foyer of the building that provide ongoing information on the building’s performance in water and energy consumption.

Staff actively and enthusiastically participate in a committee known as ‘Team Green’, ensuring the monitoring and ongoing improvements of the building’s environmental performance, including energy and water saving measures, transport initiatives and recycling programmes.

ENERGY
Passive thermal and solar design principles used in the building reduce the amount of energy it consumes.

The general air conditioning system is turned off after hours to prevent unnecessary cooling. Localised units were installed for tenants to use as required. All switches and timers are clearly identified to avoid unnecessary use.

Skylights on the second (top) level of the office provide natural light to the occupants, reducing the need for artificial lighting.

Artificial lighting is provided by high frequency T5 ballasts.

Solar hot water panels provide the hot water demands and photovoltaic cells on the roof provide additional energy, supplementing the mains power. The cells produce between 4-4.5 MW a year, which is enough to power a residential house.

The building was fitted out with energy efficient appliances such as fridges, microwaves and dishwashers.

Heating and cooling is controlled through a digital system that is part of the security and timing switch system.
743 Ann Street

WATER
Stormwater is stored in a 11 000L storage tank and used to flush toilets and irrigate xeriscaped gardens.

A heat trace system on the hot water pipes makes hot water immediately available to users, saving on running cold water out of taps prior to use.

Water efficient fixtures such as AAA rated shower roses, sink aerators and dual flush toilets were installed, as well as waterless urinals.

IEQ
The north-west wall of the building features a thermosiphon wall that regulates the heat load inside the building by absorbing the sun’s heat on the wall, which causes hot air in the vent behind the wall to rise and exit from the top of the wall on hotter days.

The building’s atrium is naturally ventilated through the use of thermostatic controlled vents.

Natural lighting has been maximised through the use of skylights and sunshade structures over the front patio area that restrict heat from penetrating the building. Double-glazed windows help restrict heat and noise entering the building from Ann Street.

A biofilter planter system in the foyer uses potted plants and charcoal to filter internal air and remove pollutants.

Low VOC finishes and products were used throughout.

MATERIALS
One of the aims of the design was to reuse as much of the existing building materials as possible and to maximise recycling of demolished waste materials. Ceiling tiles, ceiling grid, glass and metal elements were reused.

Plantation pine rather than steel was used for stud frames to partition walls rather than steel.

The walls are painted in Rockcote EcoStyle paints which are odourless, without toxic fumes and low in hazardous chemicals and solvents. The Interface modular carpet is also recyclable.

The timber used for the patio is constructed using Modwood, which is made from sawdust and recycled domestic plastics.

Modular workstations can easily be refigured, and are made from E1 emission rated particleboard, recycled plastic edge strip, and recycled rubber/foam materials.

WASTE
A waste management system was implemented by builder Multiplex, achieving the recycling of 80% of demolished materials.

Ongoing waste management strategies include organic waste recycling, which is fed to a vermiiculture station (worm farm) adjacent to the staff cafeteria. The resulting compost is used in the gardens. The building also has an extensive paper recycling scheme.

EMISSIONS/TRANSPORT
PMM was conscious of site selection. The building is located close to a train station and has bus access at its door. Staff are actively encouraged to car pool and utilise public transport in travelling to work.

Bicycle facilities including lockers and showers have been provided and electric bikes, smart and hybrid cars have been investigated to replace company vehicles.

REFERENCES

‘In Ann St, the major energy efficiency initiative we introduced was a thermosiphon naturally ventilated system into the atrium of the building… other important features included energy efficient T5 lighting, carefully considered zoning related to occupant layouts and maximum daylight usage. We established a system where it is hard for people to turn on excess lights… and… simple things like clear identification on the switches…’
The new Victorian State Emergency Services headquarters is located in the Melbourne CBD. The building has won several awards for its approach to sustainable design and architecture and was a finalist in the ‘Leadership in Sustainable Buildings’ category in the 2004 Banksia Awards.

**PROJECT BACKGROUND**

The brief from the Department of Justice was to design and construct a benchmark environmentally responsive building as a model to the construction industry and other government departments. This outcome was achieved by incorporating:

- a design with a shape and form responding to sustainable requirements
- passive and active venting and lighting solutions
- sustainable material selection and
- promotion of sustainable construction approaches.

Artificial lighting is supplied by low-energy, high frequency T5 tubes. These uplights focus the light towards the curved ceilings, which are painted white, to evenly distribute the light over the workspace. They are also dimmable and are programmed via a central system that measures the amount of natural light present. A conscious effort made by the design team was to provide only 200 lux to the working area when operating at 100%. This level is below the recommended 320 lux. This was to encourage the use of task lighting when required. The task lights are also wired so that they are turned off by the central control system when out of hours.

Passive cooling/heating is provided by a large concrete slab located underneath the raised floor. Night purging using outdoor air cools the slab which stores coolth and then releases it over a period, thereby reducing the instantaneous cooling load and reducing energy consumption.

**WATER**

Eight solar hot water panels provide most of the water heating requirements. However, the water supply is linked to a central gas service which boosts the supply.
SES Headquarters

on cloudy days and when demand exceeds hot water supplied by the solar panels.

IEQ
The building uses a mixed mode ventilation system combining natural ventilation from louvres located on the south side (sea breezes) with an underfloor displacement air conditioning system. The intent of this design was to allow occupants in each bay to choose the mode of ventilation desired. Floor vents are also adjustable to suit individual users comfort levels.

Air quality has been increased by the installation of a central vacuum system which prevents the recycling of dust from cleaning. The main storage unit and pump is located in the car park area. Piping from the wall outlets to the main unit is located in the raised floor plenum.

Low VOC materials were used where possible, including paint selection, plywood for flooring and low-allergenic polyester insulation.

MATERIALS
Waste reduction methods were employed throughout construction. To reduce wastage, as much as possible of the ground-floor slab from the previous building was used as the car park base. Sorting for recycling was also employed.

Recycled materials were also chosen in preference to new. This included using recycled bricks and formwork components.

Plantation harvested timbers were used in structural flooring.

EVALUATION
Following occupation, the SES management decided to operate on full air conditioning mode rather than natural ventilation. The building functioned well in natural ventilation mode; however they found that odours arising from the building’s proximity to a highway tunnel were flowing towards the building during certain climatic conditions. Investigations are underway to link the Building Automation System to Citylink’s (the tunnel’s authority) monitoring stations to control the ventilation.

REFERENCES
Articles
• Architect (Melbourne/Australia), October 2002, pages 20–21.
• Steel Profile (Melbourne/Australia), December 2002, cover and pages 30–38.
• Indesign (Sydney/Australia), issue 13, May 2003, pages 112-119
• Herald Sun (Melbourne/Australia), 9 October 2003, page 38.

‘Developing a building profile ... has allowed us to heat and cool naturally for part of the year, to light the building naturally for as much of the year as possible and ventilate the building naturally. We did this by establishing a long narrow floor plate, by having openable vents in the south façade, extracting the air through a series of louvres on the north façade and minimising glazing from east to west. This set-up an opportunity to minimise running costs by not having to use artificial systems.’

Natural ventilation and lighting
SES Headquarters
Tim Hurburgh, Director + Principal, H2o architects
The Waalitj Environmental Technology Centre is a complex situated within the grounds of the Murdoch University Campus in Perth. The site features an office area, research laboratories and an exhibition space.

### BUILDING TYPE
New

### CLIMATE
Hot dry, cold winter

### LOCATION
Perth, Western Australia

### CLIENT
Murdoch University, Environmental Technology Centre

### ARCHITECTS
Earth House, Marco Vittino

### ENGINEERS
Consortium Builders and Healey Engineering

### SIZE
100m² of office space plus lecture, gallery and teaching areas

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**ESD CONSIDERATIONS**

**MANAGEMENT**

The site of the technology centre was chosen due to the fact that the land had been cleared some years previous and it minimised the need for roadwork.

The Building Management System was built with an internet server to provide information about the performance of the building on simple internet pages.

**ENERGY**

The south wall of the office building provides most of the light requirements. The designers wanted to use the diffuse uniform light provided from the south to prevent excess glare for those using computer monitors.

The building has 30cm thick thermal mass outer walls which helps keep the air temperature inside the buildings cool in summer and warm in winter.

A photovoltaic system on the roof generates 13 682kWh and is used to power lighting, fans and office equipment. Excess energy is pumped into the main grid.

Solar hot water panels are mounted on the roof and provide most of the hot water needs. During cloudy periods an electric booster is used to meet the shortfall.

A roof plenum solar heating and cooling system has been installed. In winter, warm air from the office interior is drawn into the plenum where it is warmed by heat generated from sunlight hitting the roof panels. The warmed air is then blown into the office space by fans. In summer, warm air from the office rises and is expelled from the plenum by fan to the outside. A ceiling dampener is closed to prevent the roof’s warm air from entering back into the office. At night, cool air from outside is drawn into the room and the warm air is purged. The building management system monitors the temperature within the plenum and the office area so that during the winter, for example, it will purge the warmer air from the plenum into the office space.

An in-slab floor heating system uses a phase change material (PCM) embedded within the concrete to control the amount of heat released, which is done slowly, gently warming the air near the floor area.

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**KEY AREAS OF ACHIEVEMENT**

- Use of thermal mass walls made of rammed earth and recycled materials to control heat.
- Solar heating and cooling system, and collection of solar energy.
- Sewage treated then used to irrigate landscaping.
- High use of recycled materials in construction, preventing waste going to landfill.

**PROJECT BACKGROUND**

The clients desired a “functional sustainable building” that incorporated sustainability principles into the building development process. Their target was a zero emission building.
Waallitj Building: Murdoch University

WATER
The Waallitj building utilises storm water and black water to minimise use of potable water. There are two 3000 L interconnected steel rainwater tanks that preferentially provide the building’s water supply and only use scheme water if rainwater tank levels are insufficient. Rain water from the roof of the building is used to water the native garden and the remainder flows into an ephemeral, infiltration basin next to the car park, encouraging biodiversity through wetland biomimicry. The waste water from the kitchen and toilets is treated by an aerobic treatment unit (ATU) before irrigating the courtyard lawn and gardens through drip irrigation. This provides a pleasant outdoor area for staff and visitors.

A south facing cooling pond, landscaped and fed by storm water (topped up by bore water) in front of a low gable window takes advantage of prevailing summer winds to deliver cool air to the building for summer heat relief.

Elsewhere on site there are rainwater tanks, waterless toilets, greywater diverters, a reverse osmosis desalination unit, a flow form, drip irrigation and several ponds serving various purposes.

The average water use from the two toilets and kitchen is 150 L/day.

IEQ
Operable walls form part of the wall along the western edge of the courtyard. These walls reflect and channel winds into areas to aid cross ventilation of the buildings. In the winter, the walls are kept closed to protect the buildings from cold wind.

Small north facing windows are used to prevent excessive heat in summer and prevent glare on computer equipment. The architects decided on large south facing windows to naturally light the space.

Evaporative cooling ponds were designed into the office space. These ponds cool the hot easterly breeze that enters the building in the summer. The pond sources its water from the excess rainwater from the roof.

Many of the walls are left untreated, however, where plasterboard is used, it is painted with organic finishes.

Planting has been used extensively around buildings to provide shade for the buildings and for landscaping around the complex. A mixture of low-water use plants, fruit trees and herbal gardens have been used.

MATERIALS
A great amount of thought and effort went into the choice of materials. Where possible, materials that were recycled, or which incorporated waste products, or had low embodied energy were used. The industrial by-products used were sourced locally.

Concrete for the floor slab is made of crushed concrete waste, window-glass waste and coal fly ash. This reduces the cost of cement as well as reduces the amount of raw materials used. It also diverts materials from going to landfill.

The thermal mass walls are made of 10% cement with stabilised building rubble composed mostly of recycled red brick. They are also are made of stabilised, rammed recycled earth.

The courtyard pavers are cement mixed with 10-15% coal fly ash. This reduced the embodied energy and cost of the pavers.

The operable walls form part of the wall along the western edge of the courtyard. These are made from recycled plastic panels.

EMISSIONS/TRANSPORT
The site is located within the Murdoch University Campus, approximately 15 minutes walk from the main areas off the campus. The centre has provided approximately 100 bikes for free use as a means of commuting from the main campus to the technology centre.

There are also public transport facilities approximately 150m from the site. The university also encourages car pooling amongst staff.

REFERENCES
Murdoch University Environmental Technology Centre
wwwies.murdoch.edu.au/etc/pages/waallitj/wpages/backg.htm

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National Museum of Australia

Australia’s new National Museum was opened in 2001. It is a stunning building and architecturally bold. It is very much a modern building with obvious post modern influences.

As with any museum, there are certain limitations inherent in protecting and displaying archival material. In terms of the elements of environmentally preferable building construction and maintenance, there are always actions and choices that can be made. Within these constraints, the National Museum is continuing to find ways of improving its environmental performance.

**ESD CONSIDERATIONS**

**NATURAL LIGHT**

The National Museum uses filtered natural lighting in the exhibition galleries in order to meet specific lux and UV levels set by conservation standards. Generally lighting in exhibition cases is limited to 50 lux and around 200 lux for walkways and external case lighting.

In other public areas, particularly the spectacular main hall, large feature windows and skylights maximise the use of natural light.

**ENERGY EFFICIENT LIGHTING**

The lighting control system installed by the National Museum of Australia is a Dynalite Direct Digital Lighting System. It controls all lighting throughout the gallery and administration areas.

Over the past three years the National Museum has worked with its specialist lighting contractors, Sound Advice, to systematically reduce the lux levels in exhibition cases to the levels required by conservation standards. This had to be balanced with ensuring that signage is legible and object details are still captured for the public to see.

Also in the past three years the National Museum has been progressively changing the lamping configurations of the exhibition spaces. To date, the National Museum has replaced around 95% of the 50 W, 10 degree angle dichroic lamps with 35 W 24-38-60 degree lamps. This has dropped the light levels to an average of 50 lux but has increased the readability of exhibition text and signage within the gallery spaces. Aside from the immediate 15 W reduction in energy usage per lamp the change has reduced condensed heat off the lamps and extended lamp life.

In addition to the re-lamping of the exhibition cases the National Museum has undertaken to retrofit the single channel systems to multi-channel dimming controllers. This gives the capacity to programme individual lights or sets of lights to specific lux levels or set lights to highlight objects or signage more clearly. A further benefit is more flexibility with design options within the exhibition cases when not constrained to having one lighting level.

In open exhibition and public areas where 500 W lamps were utilised, the museum re-lamped with 300 W lamps, gaining a reduction in energy usage while maintaining lighting levels in the concourse areas.

The Dynalite system allows the museum to utilise ‘soft starting’ procedures and specific dimming settings of lights for cleaning, security patrols and general operations and exhibition timeframes. This has prolonged lamp life significantly and reduced maintenance requirements.
National Museum of Australia

to the areas. The newly constructed extension to the annexe includes occupancy sensors to active lighting only in areas that are occupied.

THERMAL MASS AND PASSIVE DESIGN
The actual National Museum building has a modern design encompassing the whole site so it has a large building ‘footprint.’ The building’s thermal shell or envelope consists of an anodised aluminium aesthetic covering, with an external rain shield of galvanised iron sheeting. There are R4 rated insulation batts and also concrete panels which increase the thermal mass in one gallery area and associated ‘back of house’ work areas.

There have been some issues in maintaining positive air pressure within the gallery spaces particularly in scenarios with a failed air-conditioning plant.

Even with the use of double glazed windows, the high and wide expanse of the glazed areas requires significant energy usage to maintain environmental conditions. The majority of the National Museum plant operates 24 hours a day, 365 days per year.

Within the design of the heating and ventilation and air conditioning (HVAC) system, use of enthalpy or heat recovery wheels provides some pre-heating or pre-cooling of the air brought into the building. This helps to maintain environmental conditions, fresh air requirements and to maintain pressurisation within zoned areas. Additionally the HVAC system utilises carbon dioxide (CO₂) sensors to allow for greater fresh air flow when CO₂ levels increase within specific zones.

MATERIALS
The architects have used modern materials to meet the modern layout and aesthetics required for the design.

The structure is a combination of poured concrete, steel frame or prestressed prefabricated concrete panels. Anodised feature aluminium panels are a predominate aspect of the external building structure. Some areas have poured concrete panelling in some areas (fast erection times, with reasonably good thermal efficiency). The internal fixings are mainly of plasterboard or similar materials.

WATER EFFICIENCY
The National Museum uses dual flush toilets and auto flush urinal systems to reduce water consumption.

SAVINGS
The National Museum has added power factor correction to better manage load sharing across major plant. The museum has been supplemented by an energy monitoring system in the last six months. It is envisaged that energy saving trends will begin to emerge as a full annual operating cycle is completed.

PROJECT MANAGEMENT
A special project management style was developed for the design and construction of the museum. In a world first for a major public building construction project of this size, it was decided to join members of the design and construction team in an innovative ‘Project Alliance’ which would deliver the new facilities. The Alliance partners agreed at the commencement of the project to be jointly responsible for the total project results, pledging themselves to work cooperatively in an integrated team to achieve agreed cost, time and quality targets. The agreement provided financial incentives to encourage and reward outstanding performance, as well as financial penalties if cost, time or quality targets were not achieved. The Alliance agreement promoted a ‘no dispute’ culture, prohibited litigation except for wilful default, and avoided the adversarial approach associated with many traditional contracts. The result was the project came in on budget and on time and with the private sector partners’ profits intact.

PEOPLE
Both responsibility and opportunities rest in the fact that these are public buildings. The responsibility is to involve key stakeholders like Indigenous landholders and the community in the process of creating the building. There are great opportunities to educate the public about art, history and the environment as well as sustainable design.

For the National Museum of Australia, the traditional owners of the Acton Peninsula were consulted about the development of the site. Before building began a smoking ceremony was performed by the Ngunnawal people to purify the site.

‘The National Museum has an ongoing responsibility to protect culturally significant sites on the Acton Peninsula on which the National Museum buildings are located.’
The National Museum has an ongoing responsibility to protect culturally significant sites on the Acton Peninsula on which its buildings are located.

During the development of the design and building, collaboration and cooperation was encouraged through membership on committees and memoranda of understanding with neighbours, such as the Australian Institute of Aboriginal and Torres Strait Islander Studies and the Australian National University.

The museum also integrates environmentally sustainable development information into exhibitions when appropriate, such as in the Tangled Destinies gallery.

REFERENCES


Figure 53. National Museum of Australia, Interior of Main Hall, John Gollings.
60 Leicester Street is located in Carlton, an inner suburb of Melbourne. Built in the late 1800s the former factory building has had a new third floor built and has been fully refurbished. The old section has been integrated with a new building. Currently the building has 15 tenants including the Australian Conservation Foundation.

**BUILDING OUTPUTS**

<table>
<thead>
<tr>
<th>Energy</th>
<th>71 kWh/m² (3 year average data up to June 2006)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>15.7l/p/day for assumed occupancy of 200 people, 250 days/year (2 year average data up to June 2006)</td>
</tr>
<tr>
<td>Greenhouse Gas Emissions</td>
<td>Zero - purchases 100% new green power and is therefore considered ‘greenhouse neutral’</td>
</tr>
<tr>
<td>Capital Cost</td>
<td>$8 million</td>
</tr>
<tr>
<td>Savings</td>
<td>Figure not available</td>
</tr>
<tr>
<td>Payback</td>
<td>Figure not available</td>
</tr>
</tbody>
</table>

**KEY AREAS OF ACHIEVEMENT**

- Green Leasing ensures tenants are supplied with information and guidance on the building’s operations, helping maximise the building’s sustainability.
- Natural ventilation and lighting help to reduce energy consumption to 1/3 of a standard building of similar size.
- Solar panels used to supplement mains energy supply. Green power is sourced as mains supply.
- Three-step water recycling system supplies potable and non-potable water to tenants.

**PROJECT BACKGROUND**

60L was designed to be a model of superior environmental performance that demonstrated the Green Building Partnership and ACF’s commitment to ecologically sustainable development. They wanted to create a building that was commercially viable and incorporated, as far as was practical in the commercial context, sustainable design principles into every facet of the building.

**ESD CONSIDERATIONS**

**MANAGEMENT**

Green Leasing - the performance of the building as a ‘green building’ is dependent on the behaviour and the participation of the tenants. Tenants are required to sign a ‘green lease’ which informs tenants of green building principles and rules, includes an Environmental Management Plan (EMP) and places additional obligations on tenants over and above normal commercial requirements.

The lease and EMP provide advice in sourcing office equipment and materials for fit out; practices for tenancy operation, tenancy fit out and the relocation of the tenant. The building manager provides additional information and advice to tenants on sourcing the most environmentally appropriate materials and advises on issues such as office waste management.

**ENERGY**

By optimising natural ventilation and natural lighting in the design of the building, 60L is able to use only about one-third of the energy of a similar sized conventional office building. This equates to approximately 238 mWh per year. The building has achieved an 80% reduction in energy used for lighting a typical commercial building of similar size.

A large central atrium and six light wells allow daylight to penetrate the building with natural light. These features have been placed so they perform dual lighting and ventilation roles. The light wells allow air to flow across all the tenancies and into the central atrium which vents the air using four thermal chimneys. Tenants can also adjust the windows and some of the louvres in their spaces to control the flow of air, and have
access to domestic reverse cycle air conditioners should the natural conditions be outside comfort levels.

The open plan design and the use of light shelves help the light penetrate further into the office spaces. Light coloured paint on ceilings help maximise the reflection of light.

High efficiency light fixtures were designed to reduce the installed lighting load to 7W/m² compared to 20W/m² for office buildings. The light fittings used are 36W single tube with (in most tenancies) non-dimmable electronic ballast on nominal 2.4m spacing. The tubes are triphosphor, low mercury type in fixtures with semi-specular reflectors and 10 cell low glare, louvres.

The common area lighting control system is AUTO ‘OFF’ and MANUAL ‘ON’. Building occupants turn the lights on when required. The system incorporates a timer so that common area lights are turned off after 10 minutes.

The building also uses solar panels located on the roof to help supplement the power required for operation of building systems. Green power, energy which is derived from non-fossil fuel and renewable sources is purchased as the building’s main energy supply.

Energy efficient appliances are used in the public area of the building and tenants are also encouraged to purchase energy efficient office equipment. Building management can advise in the selection of equipment, particularly in the fit-out stage of tenancy.

**WATER**

The water use at 60L is dealt with in three ways as follows:

Water efficient fixtures such as low-flow shower heads which discharge 5L per minute and dual flush toilet systems that can cope with grey water systems are installed as well as waterless urinals which contain an oil seal that prevents odours. These fixtures reduce water usage by half compared with conventional items.

Rainwater is the principal source of water for use throughout the building. This is collected from the roof and stored in two 10 000 litre storage tanks on the ground floor. The water is filtered and then sterilised to provide a potable water supply for use by tenants in taps, showers and for drinking.

The wastewater generated (greywater) and sewage is treated in the building’s own sewage treatment system. This purifies the water using biological treatment that is free from chemicals.

The treated water is designed to be used for the reclaimed water treatment plant which further purifies the water for use in flushing toilet pans and for irrigation of the landscape features such as the rooftop garden. Surplus reclaimed water from this stage is designed to flow out through a water feature in the atrium. This features a succession of cascading tanks containing aquatic plants and organisms feeding on residual nutrients in the treated water.

![Figure 55. Low VOC materials selection.](image)
60L: 60 Leicester Street

IEQ
The indoor environment quality in 60L is focussed on the individual comfort levels of the tenants rather than the building as a whole. Tenants are able to adjust (within limits) the levels of light and air flow to meet their individual needs by opening a window or adjusting louvres. The building operates within a 19-26ºC comfort band in passive mode. When the external ambient temperature is outside this range, tenants are able to use the reverse cycle air conditioners available in their space.

Low-emissive products were chosen where possible for paint and carpets, and to minimise the use of glues, sealants, adhesives and paints with high VOC (volatile organic compounds) levels. Smoking is not allowed in any area of the building.

MATERIALS
The original building was partially dismantled and existing materials re-used whenever practical including timber floor joists and planking, bricks and glazed partitions.

New concrete used in construction contained, on average, 60% recycled content, including crushed concrete reclaimed from other buildings, and fly ash extenders. All bricks used were either reused from the old building or recycled bricks from dismantling of other buildings. All reinforcing steel was made from recycled steel.

Recycled materials were used in other fixtures and structural components whenever possible. Recycled hardwood timber was used for the ground floor, and all window and door frames. The carpet contained approx. 30% recycled content. Purchased recycled products such as bricks, timber steel and copper were given preference over virgin materials.

The use of PVC products was eliminated from all water and wastewater pipes as well as electrical conduits and most light fittings.

EMISSIONS/TRANSPORT
Parking facilities are not available on site. Tenants are encouraged to utilise public transport services, which are conveniently located to the building, or ride a bike. Facilities such as a secure bike parking and showers are available on site.

REFERENCES
60L Green Building Website, The Green Building Partnership
www.60lgreenbuilding.com/index.htm

Hes, D. Greening the Building Life Cycle: Life Cycle Assessment Tools in Building and Construction 60L Green Building, Environment Australia
buildica.rmit.edu.au/casestud/60l/60L.html

60 Leicester Street Carlton: Australia’s Leading Example of Commercial Building for a Sustainable Future, The Green Building Partnership
www.60lgreenbuilding.com/genbrochure.pdf
During 2004 and 2005, Szencorp transformed an average 20-year-old office block in South Melbourne into an environmentally cutting-edge space that sets a new benchmark for sustainable buildings in Australia. This 1,215m² office building is the new headquarters of the Szencorp group of companies, which provides expertise in sustainable business. The vision for 40 Albert Road was one of ‘walking the walk’, with several cutting edge sustainable technologies and ‘firsts’ incorporated into the refurbishment.

BUILDING OUTPUTS

<table>
<thead>
<tr>
<th>Energy (Gas and electricity)</th>
<th>214 MWh per year (176kWh/m² electricity)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>121 kL per year</td>
</tr>
<tr>
<td>Greenhouse Gas Emissions</td>
<td>183 tonnes CO₂ per year</td>
</tr>
<tr>
<td>Capital cost</td>
<td>No applicable business decision</td>
</tr>
<tr>
<td>Savings</td>
<td>No applicable business decision</td>
</tr>
<tr>
<td>Payback</td>
<td>No applicable business decision</td>
</tr>
</tbody>
</table>

KEY AREAS OF ACHIEVEMENT

• First occupied Australian building and retrofit to have a 6 Star Green Star - Office Design certified rating.
• Thought to have a world first integrated sensor and management system for occupancy lighting, HVAC and security control.

PROJECT BACKGROUND

The initial approach to the refurbishment project was driven by Peter Szental, who owns the Szencorp group of companies. The design combines original building features and fabric with an innovative programme of alterations and additions to improve environmental performance and occupant amenity.

The original building had a long concrete tube with a stairwell at the front, which restricted natural light and ventilation. To address this, a new glazed stairwell was created in the centre of the building with a glass atrium to provide a natural light core. 40 Albert Road has new floor-to-ceiling windows with opening sections on the eastern and western façades to provide views, fresh air and abundant natural light. From street level, the building presents a visually stunning mix of full length glass, stone, polished metal pillars and full height ultra-modern metal net screens.

ESD CONSIDERATIONS

MANAGEMENT

In order to maintain its 5 star ABGR rating, auditing and building tuning will be performed over 10 years. Extensive commissioning of the building has been undertaken, with a range of alterations and adjustments made to the building management system after opening to fine-tune performance and improve operating characteristics.

The Building Management System provides a single interface for the passive and active thermal control system, lighting control system, security and other automated systems. Via a high level interface the BMS also integrates the information from a weather station to ensure passive opportunities are utilised to the maximum, and prevent cross winds from unbalancing internal air flows (drawing internal air to the outside, wasting energy).
40 Albert Road

A Building Users’ Guide will provide tenants with all necessary instructions on how to properly use the building’s facilities. Monitoring, verification and public reporting is a strong emphasis with 40 Albert Road having one of the most advanced and transparent building performance monitoring systems in Australia, which is publicly available at [www.ourgreenoffice.com](http://www.ourgreenoffice.com) and enables any interested party to monitor real-time building performance. Performance over its first year of operation has been compiled into a comprehensive report also available to the public.

The building consumed 214MWh of energy in its first year, made up of 92 MWh of electric energy and 122MWh gas. These results, especially for gas usage, are expected to improve significantly with further fine-tuning and adjustments to building systems.

- Electricity use is lower than predicted at 91.7 MWh compared to predictions of 95 MWh. A large portion of this extra energy saving is due to the lower than designed occupancy. This is a 61% reduction on the 238 MWh previously used in the building, on a per square metre basis, from 196 kWh/m²/annum to 76 kWh/m²/annum.
- There has been unexpected consumption, particularly in the form of electricity consumption of the fuel cell and the heat pump controls for the gas air-conditioning units. Both of these technologies were the first installations of their type in Australia and were forecast to consume little electricity, but together accounted for 12.1 MWh or 13% of total consumption.
- The building’s ceramic fuel cell is the first in commercial operation in Australia. Fuel cells use chemical reactions rather than combustion reactions to provide electrical power, while the waste heat generated is used to provide the building with hot water. However, as a result of timing changes in the commissioning of the ceramic fuel cell, which did not produce electricity in the first twelve months against a predicted 9 MWh.
- A 1 MWh per annum amorphous PV array plus a 4.8 MWh per annum crystalline Origin PV array, both grid connected, supply additional electricity for the building. Allowing for seasonal factors, generation from these arrays is in line with expectations.
- The roof-mounted gas engine driven air conditioning units are a first for an Australian office building. Using internal combustion engine technology, rather than electric motor conditioning units, avoids grid electricity use, thereby avoiding peak demand, emissions and network infrastructure upgrades. These units account for 83% of total gas use, so gas consumption varies considerably with weather conditions and is dependent on the performance of other systems within the building such as natural ventilation and Building Management Systems controls. Overall gas consumption

The aim of 40 Albert Rd is to demonstrate how to recycle a typical existing suburban office building into a leading edge building offering best practice performance in energy, greenhouse and sustainability.”
of 440GJ is higher than initially expected at 245GJ. Further sub metering of gas-consuming components during the different seasons is required in order to fully determine individual system performances.

WATER
The building features a comprehensive water management system designed and built by the water conservation group from within Energy Conservation Systems. Water consumption is minimised at each end use point by using the latest in controlled flow showerheads and taps, some of them sensor activated only. Toilets are an award winning dual flush design using only 4.5/3 litres per flush. Urinals are waterless.

Lightly polluted water gathered from hand basins and showers (greywater) is collected, treated and reused for toilet flushing. This is complemented with a rainwater harvesting system providing 4400 litres of rainwater storage, estimated to be enough for 3 weeks of normal flushing.

The Szencorp Building was designed to achieve an 82% reduction in water use over the industry average (measured as a 2.5-star NABERS level of 1210 litres/m²/annum). Total normalised water use over its first year was 121 000 litres or 116 litres/m²/annum, which is 90% below the industry average.

IEQ
Thermal comfort is achieved by combining natural ventilation with mechanical cooling and heating. Mechanically operated opening windows and dampers allow fresh air in and expel used air. Natural ventilation is automated and is optimised according to inside and outside environmental conditions. Mechanical cooling or heating is supplied by ceiling-mounted fan coil units.

The DryKor dry conditioning unit dries and cools the office space simultaneously, using a process of natural desiccant absorption of water vapour from the air. This technology is non-toxic and non-hazardous, and the humidity is ducted outdoors, eliminating the need for condensate pumps, pipes and drainage system. This aims to address ‘Sick Building Syndrome’ problems associated with poor indoor air quality as the process removes up to 94% of micro-organisms, as well 77% of particles greater than 5 microns.

Natural light is maximised by floor-to-ceiling high-performance double-glazing and is supplemented by the atrium and glass in the central stairwell and skylights above the boardroom. Daylight modelling shows that there will be significant natural light at desk level across one third of the office space. This will also reduce energy use on artificial lighting, since the automated lighting system will dim whenever and wherever daylight levels permit, to optimise overall light levels.

A central vacuum cleaning system is less noisy and more effective in reducing allergenic mould, dust and moisture problems than portable vacuums. These reductions increase occupant health and wellbeing, and prolong the life of carpets.

All new materials introduced into the building have been chosen with office air quality in mind.

‘The project will achieve leading sustainable performance without compromising any conventional features - from the users perspective it will provide standard high end office accommodation.’

Figure 59. 40 Albert Road, interior, Szencorp.

Figure 60. Szencorp offices, Szencorp.
40 Albert Road

Volatile organic compounds (VOCs) emission levels are minimised in the carpets, adhesives and sealants used, and 95% of painted surfaces use low VOC paints. All composite wood used in the furniture is low in formaldehyde emissions, and a dedicated exhaust riser is provided to remove emissions from printers and photocopiers.

Air handling systems in the building have reduced air pollutants and dust by over 90% compared to the outside air. Independent studies performed by the Mobile Architecture Built Environment Laboratory (MABEL) showed no detectable formaldehyde levels and very low VOCs, concluding that air quality within the Szencorp Building is equivalent to rural air quality despite its inner city location.

MATERIALS
Most of the reinforced concrete structure and 88% of the original façade was retained. The additional concrete required uses recycled aggregate as well as incorporating industrial waste. The material specification for the refurbishment timber (using the good wood guide) and structural concrete incorporates strict sustainability criteria.

WASTE
An environmental management plan ensured that at least 80% of the waste used in the construction of the building is collected and sorted for recycling.

During operation, onsite recycling facilities are provided to recycle paper, co-mingled plastic and glass. According to waste audits undertaken at the Szencorp Building by Great Forest Australia Pty Ltd, a daily total of 7.9 kg of waste (114 litres) is being produced, comprising:
- 5.3 kg (93 litres) collected for recycling (82% by volume of all waste)
- 2.6 kg (21 litres) sent to landfill (18% by volume of all waste)

Research carried out by Resource NSW (2002) found that the average office worker generates 173 kg of waste and recycling per year. The Szencorp Building is generating 94 kg of waste and recycling per staff member each year, placing it 54% below the established benchmark.

EMISSIONS/TRANSPORT
The Drykor and air conditioning units use no ozone depleting refrigerants, and the building, ductwork and pipe work insulation is similarly free of all ozone depleting substances. Verified greenhouse credits have been purchased to offset the residual impact the building and its occupants have on climate change using standard recognised greenhouse calculation and offset products currently available.

Car parking is provided at ground and basement levels. Analysis of projected building user numbers allowed the overall number of car parking spaces to be reduced, and small spaces to be introduced into the mix. Bicycle storage, lockers and shower facilities are provided to enable tenants and visitors to cycle to the building with convenience and security. However, the majority of occupants still use private vehicles, an example of where building design cannot guarantee behaviour changes and environmental outcomes sought by developers.

REFERENCES
The Greening of 40 Albert Road
www.ourgreenoffice.com/
Galleries, museums and libraries are special spaces with particular requirements, such as high levels of lighting and strict temperature and humidity control. This constrains the possibilities for use of some sustainable building practices and requires greater innovation to incorporate sustainable measures. This case study looks at both the simple and innovative measures that venues around Australia and overseas have taken to be more ecologically sustainable.

ESD CONSIDERATIONS

NATURAL LIGHT

The use of natural light or daylighting can have an aesthetic benefit as well as achieve energy use reductions. The changes in natural light conditions and intensity can create a less clinical ambience but it also creates challenges for conservators. For conservators the ideal situation involves no ultra violet light.

As the main purpose of galleries, museums and libraries is the protection and public access to documents, the conservation department needs to be consulted from the earliest stages of development or refurbishment planning. Consideration of international standards for the protection of archive material has to be incorporated.

State Library of Victoria

Glass panels were reinstated in the dome over the La Trobe Reading Room. They had previously been covered in 1959 to prevent water seeping in. The glass panelling reduces the need for artificial lighting and includes UV filters. The natural light reaches to the areas for the public to read from the library’s works.

The reading room is 35m high and circled by four levels. Daylight conditions were found to be unpredictable, so a study of the light in the space was commissioned. The aim was to make best use of the spaces without compromising the material.

Two of the four levels were converted to exhibition spaces. There are eight sides to these galleries in the round, four of which have arches which allow daylight into the whole area and the other four sides are sealed with no arches. Conservators and exhibition curators arrange material so that only graphic reproductions are displayed in the areas with daylight and the other areas display the material that needs fully controlled lighting. In order to meet the lux level standards for different material (i.e. max 50 lux for natural fibres and max 200 lux for paintings), the lighting strategy has not changed but the exhibition strategy is designed around the limitations of the space.

Future developments of the site will include the creation of courtyards that view the dome and which will have glazed coverings.

National Gallery of Victoria International

The National Gallery of Victoria (International) was refurbished in 2004. It has since won national and international awards for its design. In the refurbishment, two towers were added to the gallery’s basic rectangular structure and three square courtyards.

At the top of the courtyard, glass panels arch to the skylights and bring light into the bottom of the courtyards. There are also skylights in the upper level galleries and glazing on the high side of the skylights. The skylights all have UV diffusers. This lighting condition in the upper galleries creates a difficult situation for conservators and required a change in exhibition strategy. The modern pieces tend to be displayed on these floors51. Often the skylights are closed off for an exhibition, so the predominant area of daylighting impact is in the lighting of the courtyards.

Peckham Library (UK)

The architects used daylight analysis to design the building in such a way as to operate the building without use of artificial lighting for large amounts of the year. This saves energy and provides visual comfort for users. Bright glass on the north side of the building lets in a large amount of daylight.

Galleries, Museums and Libraries

Frederick R Weisman Art Museum, University of Minnesota
Designed by Frank Gehry, the Weisman Art Museum is a teaching museum for the University of Minnesota and the community. Large picture windows at the front of the building enable views from the outside of the Museum’s lobby and the galleries beyond. The main daylighting feature is the group of four sculptural skylights which light the east, west, north and south walls.

John Allen, the Director of Visitor Services explains the current and future policy about the skylights:

'It also creates some challenges with regard to protecting the artwork - especially photographs, prints, and other works on paper - from damage caused by light. We try to design our exhibitions with daylight in mind and, with the assistance of Frank O. Gehry Architects, we are exploring methods to diffuse the natural light from the skylights through the use of scrim, UV filters, and other materials.'

'Regardless of the level of daylight in the galleries, most of the art on display is lit with artificial light sources so the savings on lighting costs there is negligible. There is likely some savings on the lighting costs in the administrative offices, meeting spaces, museum store and other non-gallery areas due to the presence of natural light from windows and skylights."'52

ENERGY EFFICIENCY
East Melbourne Library
Energy will be saved through the use of passive heating and cooling as well as artificial light levels being regulated by sensor readings.

The National Museum of Australia
Various actions were taken on the site to reduce energy use. Some of these included:

- changing the wattage of lighting in the Hall from 500 W to 300 W – this policy will be extended into all galleries and operational areas
- exhibition lighting from 50 W to 35 W dichroic lighting to create a higher light output but reduced colour fade53 and
- installing an energy monitoring system which will track usage and effects of any policy changes

Mark Twain House Museum (USA)
The overall energy efficiency of the HVAC system is nearly 30% greater than a system designed to building code. This is mainly from the use of geothermal wells which will meet the predominant heating and cooling needs of the building. The building is underground, which contributes to significant reductions in the heat gain and heat loss from the building envelope. The monumental stair case between the first to second floors allows the elimination of a passenger elevator. The building is designed to allow future additions such as photo-voltaic solar panels on the south wall and, potentially, fuel cells.

THERMAL MASS AND PASSIVE DESIGN
Queensland Gallery of Modern Art
The key passive design elements of the Queensland Gallery of Modern Art include the incorporation of an extensive overhanging roof, as well as other fixed shading elements to all elevations. The building has adopted a lightweight shell with a thermally massive core to deliver the level of thermal stability required to ensure international gallery conditions are met. Polished concrete slabs also contribute to the thermal stability of the space.

Peckham Library (Battle McCarthy architects, UK)
Passive design elements used in the Peckham Library in London include natural ventilation using openings high in the roof and natural cross ventilation. The building is cooled at night. The windows are double glazed and lots of thermal insulation has reduced the need for heating in winter. The building itself is built in a concrete L-shaped frame with a façade shaded by a cantilevered overhang. No air conditioning has been installed.

East Melbourne Library
East Melbourne Library is being demolished and will be replaced with a library that will incorporate passive heating and cooling mechanisms using natural ventilation and thermal mass.

Art Gallery of South Australia
Humidity control is a critical factor while designing the HVAC system of any museum. In the Art Gallery of South Australia an innovative displacement ventilation air conditioning system was installed for the new extension. The Shaw method of air conditioning (SMAC) improved the internal conditions for temperature as well humidity. The SMAC employs twin coil technology where dehumidification of the outside air occurs in one coil while the dry bulb temperature is controlled.

by the other coil. As a result the dehumidified outdoor air is only a small component of the total air and when it is mixed with the returned air, this means that the need to reheat air is diminished substantially. The result of this is a significant reduction in both electrical and gas energy consumption. Comparing current and past consumption showed savings of up to 47%.

Further features of the project are that they employ the nearby Brisbane River to reject heat from the air conditioning system rather than into the atmosphere. This system eliminates cooling towers from the design and provides a significant reduction in water demands.

Lastly optimum levels of natural day lighting are introduced to the interiors to reduce lighting requirements and energy demands. Energy efficient T5 lighting, electronic dimming and automatic switch-off further reduce demands.


MATERIALS

There are two ways in which materials are important considerations in designing and running a library, museum or gallery. One is the selection of materials to reduce the environmental impact of the building generally and the other is the way in which materials can impact the conservation of archived objects.

Mark Twain House (USA)
This was the first American museum to receive LEED (Leadership in Energy and Environmental Design) certification. Some examples of the principles used to select materials for the new Museum at Mark Twain House are:

- Local materials were sourced from within a 500–mile radius.
- Recycled material content exceeds 25 % throughout the project. Building materials have been selected to minimise, if not eliminate, the negative consequences of VOCs.
- Wood products used in this project were from Forest Stewardship Council (FSC) certified sources that confirm renewable and responsible forestry practices.

Conservation

Issues for storage of material includes sealing of spaces to stop vermin and infestation, air conditioning that can deal with extreme temperatures as needed and maintain a stable environment for fragile artefacts, access to objects for monitoring and maintenance, appropriate environmental controls and monitoring.

Some useful ideas include:

- Cabinets made from wood with formaldehyde content cannot be used. The formaldehyde can affect paintings and objects stored in them. Formaldehyde can also be an irritant to employees so it is best specify low or ‘zero’ formaldehyde content board or use a wood which has not been glued.
- Minimise dust by having shelving going to the ceiling rather than having surfaces that collect dust.
- Good use of thermal mass can assist in maintaining a stable environment and reduce the need for air conditioning.


WATER EFFICIENCY

East Melbourne Library
The East Melbourne Library will collect rainwater from the roof and recycle it for use in the facility and in the garden will also use recycled water.

Mark Twain House (USA)
A closed-loop system eliminates water lost to evaporation through the cooling tower in a conventional system. Parking has been minimised, thereby reducing storm water runoff and pollution impact. Native vegetation has been selected to eliminate the need for an irrigation system and increased water use.

Galleries, Museums and Libraries

PEOPLE
There is both responsibility and opportunities in the fact that these are public buildings. The responsibility is to involve key stakeholders like indigenous landholders and the community in the process of creating the building. There are great opportunities to educate the public about art, history and the environment as well as sustainable design.

National Museum of Australia
The Traditional Owners of the Acton Peninsula were consulted about the development of the site. Before building began a smoking ceremony was performed by the Ngunnawal people to purify the site.

The museum has an ongoing responsibility to protect culturally significant sites on the Acton Peninsula on which the museum buildings are located.

During the development of the design and building, collaboration and cooperation was emphasised through membership on committees and memoranda of understanding with neighbours, such as the Australian Institute of Aboriginal and Torres Strait Islander Studies and the Australian National University.

The museum also integrates ecologically sustainable development information into exhibitions if appropriate, such as in the Tangled Destinies gallery.

PROJECT MANAGEMENT
National Museum of Australia
A special project management style was developed for this building. It became known as the Alliance Project, in which all parties shared the profits and the risks of construction. This was a first for a building development in Australia. There was one overall contract and the result was that the project came in on budget and on time.

REFERENCES

The National Museum of Australia
www.nma.gov.au

National Gallery of Victoria, International

State Library of Victoria
www.slv.vic.gov.au
For information on the redevelopment see Department of Infrastructure, Major Projects section, www.doi.vic.gov.au/web3/majorproj.nsf

East Melbourne Library
For information see the City of Melbourne’s web site: www.melbourne.vic.gov.au/info.cfm?hop=-146&dispq=1139

Peckham Library
Architects
www.alsoparchitects.com
Consulting Engineers
www.battlemccarthy.com

Mark Twain House Museum
www.marktwainhouse.org/themuseum/index.shtml

Frederick R Weisman Art Museum,
University of Minnesota
For information on the architecture of the building see: www.weisman.umn.edu/architecture/arch.html

LEED (Leadership in Energy and Environmental Design – programme and rating system administered by the US Green Building Council)
www.usgbc.org/

Figure 65. National Gallery of Victoria, John Gollings.
Richmond 36 and 37 Squadron Headquarters, a part of the RAAF Richmond Reinvestment Project, is the first project to achieve the Green Star - Office Design (September 2005), Green Star - Office as Built (November 2005) and Green Star - Office Interiors (June 2006) Certified ratings. It is the first Green Star development by the Department of Defence and will inform Defence’s approach to Environmentally Sustainable Design (ESD) on new and refurbishment projects.

**DESIGN BUILDING PERFORMANCE**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy (Gas and electricity)</td>
<td>20% better than 5 star ABGR benchmark (base building)</td>
</tr>
<tr>
<td>Water</td>
<td>1.5 ML per annum lower than a standard building</td>
</tr>
<tr>
<td>Greenhouse Gas Emissions</td>
<td>Figure not available</td>
</tr>
<tr>
<td>Capital cost</td>
<td>$14 million</td>
</tr>
<tr>
<td>Savings</td>
<td>Figure not available</td>
</tr>
<tr>
<td>Payback</td>
<td>Figure not available</td>
</tr>
</tbody>
</table>

**KEY AREAS OF ACHIEVEMENT**

Under both the Office Design and Office as Built Green Star tools, a 100% score was achieved for both the management and water categories.

**PROJECT BACKGROUND**

The new RAAF headquarters building was designed to accommodate Australian Defence Force personnel. The challenge was to ensure that the operating costs, energy and water consumption, and ongoing support costs were kept low.

**ESD CONSIDERATIONS**

**MANAGEMENT**

The concept of ‘hot desking’ was introduced in the design of this building. This means that the desks for people like pilots, who were not in the office for long periods of time, could be occupied by others. Additional storage space was provided, so that people ‘hot desking’ have dedicated storage space for their work. To facilitate this change from normal Defence practice, a change manager was engaged.

**ENERGY**

Energy used for the heating, ventilation and air conditioning (HVAC) system has dropped significantly, through the integration of a mixed mode (both natural and mechanical ventilation) function.

**WATER**

Fixtures and AAAA fittings used throughout the RAAF building were as efficient as practicable. For example, waterless urinals were used and rainwater collected in a 52,000 litre storage tank and used for toilet flushing. The landscaping has also been designed to be drought resistant.

All sewage is treated by the RAAF Richmond’s wastewater treatment plant and then reused for irrigation on the RAAF Base.

**IEQ**

The design team provided innovative solutions to increase the quality of the indoor environment with high levels of fresh air and natural light. Some 74% of the net lettable area (NLA) has been designed as mixed mode space, able to be naturally or mechanically ventilated. The remaining 26% is mechanically ventilated for operational purposes.
RAAF Richmond

External air is provided at a rate 150% above the Australian Standard requirement and is 100% outside air economy cycle with no recirculation. Furthermore, natural ventilation is improved by under slab natural ventilation culverts, hollow core slabs and automated louvres allowing the effective use of thermal mass and passive cooling.

Indoor air quality has been improved through the use of low off-gassing paint, carpet and composite wood products. External views and natural light are provided for a significant proportion of work areas. Electric lighting levels at 320 lux and high frequency ballasts further improve occupant’s comfort by minimising the chances of flickering.

External views and natural light are provided for a significant proportion of work areas. Average lighting intensity for the NLA is approximately 2.44 W/m² per 100 lux. High frequency ballasts further improve occupant’s comfort by minimising the chances of flickering. Lighting was controlled by combinations of daylight sensors and occupant sensors.

MATERIALS

Materials were selected to decrease any adverse impact on the environment, for example the structural concrete was specified to incorporate a minimum of 30% fly-ash. More than 65% of timber used was sourced from recycled stock including timber used for external cladding and internal flooring. Of the remaining timber all but 5% of the total timber used had certification for sustainable timber, ensuring third party impartial verification of the sustainability of the timber source.

Of the refrigerants used, all had zero ozone depletion potential, with refrigerant leak detection and recovery systems integrated to ensure minimal impact on ozone depletion and climate change. Finally, as mentioned above, to minimise emissions from fitout, low VOC emission materials were used, (specifically minimising formaldehyde).

WASTE

Extensive waste storage areas have been provided in the building to facilitate waste separation and recycling of office waste. In excess of 80% of construction waste diverted from landfill.

EMISSIONS/TRANSPORT

Extensive facilities such as showers, lockers and changing areas have been provided for cyclists including 20 secure bike spaces. In addition, visitor bike spaces have also been provided. In accordance to the Green Star requirements, 25% of parking spaces were designed for small cars, in order to encourage the use of more efficient smaller cars.

The aforementioned innovative solutions and processes developed for the project will inform Defence’s green building procedures for future projects.

REFERENCES


Adhesive

Air quality

Alliance partnerships
A long-term commercial partnering arrangement that enhances project team innovation and avoids the cost of tendering for team formation on every new project. This can assist integrated delivery of sustainable design objectives. (Property Council of Australia, Sustainable Development Guide, 2001).

Aquifer
A geological formation that will yield water to a well in sufficient quantities to make the production of water from this formation feasible for beneficial use; permeable layers of underground rock or sand that hold or transmit groundwater below the water table. (Property Council of Australia, Sustainable Development Guide, 2001).

B
Base Building Brief
Working document which specifies at any point in time the relevant needs and aims, resources of the client and user, the context of the project and any appropriate design requirements within which all subsequent briefing (when needed) and designing can take place. (Adapted from definition of brief in ISO 9699).

BDP

BCA
Building Code of Australia.

Biodegradable
A material capable of being decomposed by bacteria or other living organisms as a result of the action of micro-organisms. (Property Council of Australia, Sustainable Development Guide, 2001).

Biodiversity
The variety of all life forms; the different plants, animals and micro-organisms, the genes they contain and the ecosystems they form. (Property Council of Australia, Sustainable Development Guide, 2001).

Brownfield Site
Land within an urban area on which development has previously taken place. (Corus Construction Centre glossary, http://www.corusconstruction.com/page_9041.htm).

Building monitoring systems or Building Management System (BMS)
A Building Management System includes more of the systems and plans for review and improvement while the building monitoring system is a computerised system that monitors the engineering services, security and other building systems for the purpose of recording, reporting and operational control of the systems to maximise safety, security, operational performance and for overall cost minimisation and efficiency. (Property Council of Australia, Sustainable Development Guide, 2001).

C
Carbon credit
A term that refers to three types of units of greenhouse gas reductions defined under the Kyoto Protocol:
• emissions reduction units are generated via joint implementation under Article 6 of the Kyoto Protocol,
• certified emission reduction units are generated and certified under the provisions of Article 12 of the Kyoto Protocol, the Clean Development Mechanism, and
• verified emission reductions are verified reductions in greenhouse gas emissions below a pre-determined baseline. (Property Council of Australia, Sustainable Development Guide, 2001).

Chlorofluorocarbons (CFCs)
Synthetic products which do not occur naturally and contain chlorine and fluorine; commonly used in various industrial processes and as refrigerants and, prior to 1990, as a propellant gas for sprays. CFCs are a powerful greenhouse gas. (Property Council of Australia, Sustainable Development Guide, 2001).

CFCs are used as a refrigerant. They are the worst ozone depleting product and the most significant cause of ozone layer depletion. CFCs are being phased out as part of the Montreal Protocol. (Melbourne Docklands ESD Guide, Oct 2002).

Client brief
A project vision statement and sustainable development criteria provided to the design team. (Property Council of Australia, Sustainable Development Guide, 2001).

Climate Change Levy
A tax on corporate energy use introduced by the government in 1999 aimed at reducing energy consumption. (Corus Construction Centre glossary, http://www.corusconstruction.com/page_9041.htm).

Cogeneration

ABGR
The Australian Building Greenhouse Rating Scheme is the universally accepted benchmarking tool for energy consumption of commercial buildings in Australia. It has been incorporated in other rating systems to ensure a consistent approach from industry to this important issue. (DEUS, 2005).
glossary

Commercial buildings
Typically refers to any non-residential building such as a shopping centre, office tower, business park, industrial property or tourism and leisure asset. (Property Council of Australia, Sustainable Development Guide, 2001).

Commingles
Materials all mixed together, such as plastic bottles with glass and metal containers. Commingled recyclable materials require sorting after collection before they can be recycled. Current collections in the CBD are usually plastics marked 1, 2 and 3; glass beverage containers and aluminium and steel cans. Fully commingled collections also include paper. (Department of Treasury and Finance, Reporting of Office-Based Environmental Impacts by Government Departments: Guidance to Financial Reporting Direction FRD24, July 2003).

Commissioning
The start-up phase of a new or renovated building which includes testing and fine-tuning of the HVAC, electrical, plumbing and other systems to assure proper functioning and adherence to design criteria. Commissioning also includes preparation of the systems operations manual and instruction of the building maintenance personnel. (Property Council of Australia, Sustainable Development Guide, 2001).

Copper chrome arsenate (CCA)
A powerful preservative most commonly used to treat softwoods for external use to provide protection against fungi, termites and wood boring insects. Spills of CCA can leave short-term residues of arsenic and long-term residues of chromium in affected soils, which have serious health and environmental implications. (Property Council of Australia, Sustainable Development Guide, 2001).

Cost benefit analysis
A method of evaluating projects or investments by comparing the present value or annual value of expected benefits to costs. (Property Council of Australia, Sustainable Development Guide, 2001).

Demountable
Components or whole buildings which can be dismantled and re-erected elsewhere. (Corus Construction Centre glossary, http://www.corusconstruction.com/page_9041.htm).

Downcycling
The mechanical recycling of end-of-life products which produces materials of inferior quality. The secondary material cannot substitute the virgin state, an example being crushed concrete used as fill. (Corus Construction Centre glossary, http://www.corusconstruction.com/page_9041.htm).

Dual pipe system
A system where one pipe feeds potable or drinking water, the second feeds treated water, typically for toilet flushing or irrigation – also called the purple or lilac pipe. (Property Council of Australia, Sustainable Development Guide, 2001).

Embodied energy
The non-renewable energy consumed in the acquisition of raw materials, their processing, manufacture, transportation to site and the construction process. Also the non-renewable energy consumed to maintain, repair, restore, refurbish or replace materials, components or systems during the lifetime of a building. (Corus Construction Centre glossary, http://www.corusconstruction.com/page_9041.htm).

EMP
Environmental Management Plan – this document outlines the environmental requirements and responsibilities for an individual development as per the Docklands Authority requirements for the development of Melbourne Docklands. (Melbourne Docklands ESD Guide, Oct 2002).

EMS
Environmental Management System – this document outlines specific requirements for planning implementation, operation, checking and correct actions regarding environmental issues.

Environmental Management System
A management system to identify, manage and reduce an organisation’s impact on the environment. (Department of Treasury and Finance, Reporting of Office-Based Environmental Impacts by Government Departments: Guidance to Financial Reporting Direction FRD24, July 2003).

Environmental preferable products/materials
Products that embody one or several positive environmental attributes as a result of deliberately eliminating or reducing potential environmental impacts across its life cycle. These products don’t have negative impacts on human health and the environment when compared with competing products. This comparison may consider raw materials acquisition, production, manufacturing, packaging, distribution, reuse, operation, maintenance, or disposal of the product. (EcoRecycle, 2003).

EPBC Act
Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) is the Australian Government’s major piece of environmental legislation. It protects the environment, particularly matters of National Environmental Significance.

ESD
Ecologically Sustainable Development – development that does not compromise the ability of future generations to enjoy similar levels of development. This is done by minimising the effect of development on the environment. (Melbourne Docklands ESD Guide, Oct 2002) Also defined by the Australian Government as ‘using, conserving and enhancing the community’s resources so that ecological processes, on which life depends, are maintained, and the total quality of life, now and in the future, can be increased’. (NSES, DEH 1992).

F
Formaldehydes
A resin used as an adhesive, surface coating, foam or in the manufacture of laminates and sandwich panels. Formaldehyde adhesives can present a health hazard due to their off-gassing tendencies. (Property Council of Australia, Sustainable Development Guide, 2001).

Forest Stewardship Council (FSC)
An international organisation promoting responsible forest management. FSC has developed principles for forest management which may be used for verifying the management of forest holdings and a system of tracing, verifying and labelling timber and wood products that originate from FSC certified forests. (Australian Paper www.australianpaper.com.au/environs/glossary.asp).
Fuel Cell
Used to convert chemicals into electrical energy. This is an apparatus used for combining fuel and oxides to generate electricity. (Energy Australia www.energy.com.au).

G
Global warming potential (GWP)
GWP is a measure of how much a given mass of greenhouse gas is estimated to contribute to global warming. It is a relative scale which compares the gas in question to that of the same mass of carbon dioxide whose GWP is one. An exact definition can be found at the IPCC web site. Examples of the GWP of gases are as follows:
- carbon dioxide has a GWP of exactly 1 (since it is the baseline unit to which all other greenhouse gases are compared.)
- methane has a GWP of 21
- nitrogen dioxide has a GWP of 31
- some hydrofluorocarbon (HFC) compounds have GWPs of several thousands (HFC-23 is 11,700).

Greenfield site
Land on which no development has previously taken place. Usually on the periphery of an existing built-up area. (Corus Construction Centre glossary, http://www.corusconstruction.com/page_9041.html).

Groundwater
Water within the earth that supplies wells and springs; water in the zone of saturation where all openings in rocks and soil are filled, the upper surface of which forms the water table. (Property Council of Australia, Sustainable Development Guide, 2001).

H
Hydrochlorofluorocarbons (HCFCs)
HCFCs were used as the original replacement for CFCs and are still commonly used. HCFCs, like CFCs, cause ozone depletion, but to a lesser extent. HCFCs are being phased out under the Montreal Protocol. (Melbourne Docklands ESD Guide, Oct 2002).

Hydrofluorocarbons (HFCs)
Replacement replacements for CFCs, they are also greenhouse gases. (Property Council of Australia, Sustainable Development Guide, 2001).

HVAC systems
The equipment, distribution network and terminals that provide either collectively or individually the processes of heating, ventilation or air-conditioning to a building. (Property Council of Australia, Sustainable Development Guide, 2001).

I
Intergovernmental Panel on Climate Change (IPCC)
The IPCC was established in 1988 by two United Nations organisations, the World Meteorological Organisation (WMO) and the United Nations Environment Programme (UNEP) to assess the ”risk of human-induced climate change”. The panel is open to all members of the WMO and UNEP.

Green Star
Green Star was developed and funded by industry and government. Green Star’s framework brings existing tools and standards together under one unified system. Green Star rating tools are relevant to building type, phase of development cycle and geographical location. Green Star awards points for best practice initiatives and, as such, projects that receive a Green Star Certified Rating have demonstrated leadership and are considered to be in the top quartile of the market. Green Star rating tools are being released for all building types (office, retail, education, health, residential etc.).

Indoor environment quality (IEQ)
This factor describes the cumulative effects of indoor air quality, lighting and thermal conditions. Poor IEQ is responsible for health problems in the work place. (Melbourne Docklands ESD Guide, Oct 2002).

Integrated design
A design process that mobilises multidisciplinary design input and cooperation, ideally to maximise and integrate environmental and economic life cycle benefits. (Property Council of Australia, Sustainable Development Guide, 2001).

ISO 14000

ISO 7730
International standard for thermal comfort – this standard is based on a determination of the PMV (Predicted Mean Vote) and PPD (Predicted Percentage Dissatisfied) indices, and specification of the conditions for thermal comfort. (Melbourne Docklands ESD Guide, Oct 2002).

K
Kyoto Protocol
An international agreement reached in 1997 in Kyoto, Japan, which extends the commitment of the United Nations Framework Convention on Climate Change. In particular, it sets targets for future emissions by each developed country over the first commitment period and foreshadows further action over future commitment periods. (Property Council of Australia, Sustainable Development Guide, 2001).

An international agreement to limit greenhouse gas emissions. The protocol
was adopted in 1997 and has been ratified by 54 countries, including most developed countries. (Melbourne Docklands ESD Guide, Oct 2002).

LAeq
This scale measures the average energy of the noise level. It is the equivalent steady state level of a fluctuating noise level. When considered over a period of time T, this is represented by the scale dB LAeqT. ASINZS 1269.1:1998 sets out the method for calculating this level. (Green Star-Office Design v2).

Life cycle assessment (LCA)
A technique for assessing the environmental aspects and potential impacts associated with a product or process, by compiling an inventory of relevant inputs and outputs, evaluating the potential environmental impacts associated with those inputs and outputs, and interpreting the results of the inventory analysis and impact assessment phases in relation to the objectives. (Property Council of Australia, Sustainable Development Guide, 2001).

Life cycle costing (LCC)
A technique that enables a comparative cost assessment to be made for various investment alternatives, over a specified period of time, taking into account all relevant factors, both in terms of initial capital costs and future estimated cost. The objective is to identify the most economic overall choice. (Property Council of Australia, Sustainable Development Guide, 2001).

Lux
Measure of the amount of light at a certain point.

Montreal Protocol
This international treaty was first signed in 1987 (now signed by 181 countries). It sets a time schedule for the reduction and eventual elimination of ozone depleting substances. (Melbourne Docklands ESD Guide, Oct 2002).

NABERS

NatHERS
National House Energy Rating Scheme – this is a national scheme used to rate the energy consumption of residential buildings. (Melbourne Docklands ESD Guide, Oct 2002).

NSESDD
The National Strategy for Ecologically Sustainable Development sets out the broad strategic and policy framework under which governments will cooperatively make decisions and take actions to pursue ESD in Australia. It will be used by governments to guide policy and decision making, particularly in those key industry sectors which rely on the utilisation of natural resources.

Off-gassing
The release of gases or vapours from solid materials in a form of evaporation of a slow chemical change which produces indoor air pollution for prolonged periods after installation of a material. (Property Council of Australia, Sustainable Development Guide, 2001).

Operational energy

Ozone Depletion Potential (ODP)
A number that refers to the amount of ozone depletion caused by a substance. The ODP is the ratio of the impact on ozone of a chemical compared to the impact of a similar mass of CFC-11. Thus, the ODP of CFC-11 is defined to be 1.0. Other CFCs and HCFCs have ODPs that range from 0.01 to 1.0. The halons have ODPs ranging up to 10. Carbon tetrachloride has an ODP of 1.2, and methyl chloroform’s ODP is 0.11. HFCs have zero ODP because they do not contain chlorine. (US EPA web site www.epa.gov/ozone/defns.html).

Ozone layer depletion
The ozone layer protects earth from ultra violet rays, which are known to cause cancer. Refrigerants such as CFCs and HCFCs contribute greatly to ozone layer depletion. (Melbourne Docklands ESD Guide, Oct 2002).

Photovoltaic

Polychlorinated biphenyls (PCBs)
A group of synthetic chlorinated organic compounds, toxic to humans and identified as carcinogenic. They were used mainly in older electrical capacitors or transformers. (Property Council of Australia, Sustainable Development Guide, 2001).

Polyvinyl Chloride (PVC)
This common building material is mostly used for pipes and electrical cables. Production of PVC requires toxic chemicals and heavy metals. These additives risk polluting soil and waterways during PVC disposal. (Melbourne Docklands ESD Guide, Oct 2002).

Potable water

Predicted Percentage Dissatisfied
Predicted Percentage Dissatisfied. This measure is linked with PMV. A PMV of 0 indicates a PPD of 5% and a PMV of +1 indicates a PPD of 25%. This means that 25% of occupants perceive the space to be either warm or cool. (Melbourne Docklands ESD Guide, Oct 2002).

Project brief
Typically a response to a client brief and is prepared by the integrated design team. (Property Council of Australia, Sustainable Development Guide, 2001).

Phase Change Materials (PCM)
These are materials which turn from one phase to another (for example liquid to gas, or solid to liquid) at a certain temperature – such as water at zero degrees Celsius.
Recycled material
Material that would otherwise be destined for disposal but is diverted or separated from the waste stream, reintroduced as material feedstock and processed into marketed end products. (Property Council of Australia, Sustainable Development Guide, 2001).

Materials that have been reprocessed from recovered material by means of a manufacturing process and made into a final product or into a component for incorporation into a product. (EcoRecycle, 2003).

Recycled products
Materials that have been recovered, processed and used as a raw material for the manufacture of a useful new product through a commercial process. These products will contain a specified percentage of material that would otherwise have been disposed of as wastes. (EcoRecycle, 2003).

Recycling
Includes paper, commingles and compostables accepted and recycled by contractors or internally (i.e. through on-site worm farms). These figures can be extrapolated from waste assessments. (Department of Treasury and Finance, Reporting of Office-Based Environmental Impacts by Government Departments: Guidance to Financial Reporting Direction FRD24, July 2003).

Re-manufactured
Means to renew or restore a used product into its original form or into a useful new product through a commercial process. (EcoRecycle, 2003).

Renewable
A renewable product can be grown or naturally replenished or cleansed at a rate that exceeds human depletion of the resource. (Property Council of Australia, Sustainable Development Guide, 2001).

Renewable Energy
Renewable energy is obtained from sources that can be sustained indefinitely. Examples of renewable energy systems include photovoltaic solar collection, solar thermal turbine generation and wind power. (Melbourne Docklands ESD Guide, Oct 2002).

Reuse
The recovery of a material to be used again for a similar application without reprocessing. (Property Council of Australia, Sustainable Development Guide, 2001).

S
SEMP

Sustainable development
Development that meets the needs of the present without compromising the ability of future generations to meet their own needs. (Property Council of Australia, Sustainable Development Guide, 2001).

T
Toxic
Any substance which causes harm to living organisms, from very low to extreme toxicity. (Property Council of Australia, Sustainable Development Guide, 2001) Toxic substances are identified in the Australian National Pollutant Inventory.

Triple Bottom Line
Measures the economic, social and environmental sustainability of a project. A sustainable development aims for synergy rather than compromise between these factors.

U

V
VDU
Visual Display Units – computer monitors and other office equipment which include artificially illuminated surfaces.

Volatile organic compounds (VOCs)
Chemical compounds based on carbon and hydrogen structure that are vaporised at room temperatures. VOCs are one type of indoor air contaminant. Although thousands have been identified in indoor air, only a few are well understood and regulated. (Property Council of Australia, Sustainable Development Guide, 2001) These chemicals are found in paints and other building products. They are known to cause health problems, including asthma and other respiratory ailments. (Melbourne Docklands ESD Guide, Oct 2002).

W
Waste
All waste placed in landfill waste and recycling streams (paper, green waste, composts, commingles), including ‘one off’ clean outs, office relocations etc. (Department of Treasury and Finance, Reporting of Office-Based Environmental Impacts by Government Departments: Guidance to Financial Reporting Direction FRD24, July 2003).

X
Xeriscape
Xeriscaping is derived from the Greek word ‘xeros’, meaning ‘dry’ and combined with ‘landscape’, xeriscape means gardening with less than average water. A trademarked term referring to water-efficient choices in planting and irrigation design. It refers to seven basic principles for conserving water and protecting the environment. These include: (1) planning and design (2) use of well-adapted plants (3) soil analysis (4) practical turf areas (5) use of mulches (6) appropriate maintenance and (7) efficient irrigation. (Ecolodgical http://ecolodgical.yourhomeplanet.com/glossary.php).

Y

Z
ABGR and NABERS

PERFORMANCE BENCHMARKING
Incorporating sustainability in a building is no easy task. It takes dedication and coordination throughout the design, construction, commissioning, operation and maintenance of the building to achieve sustainable goals.

Throughout this process it is important to keep the end goal in mind. Performance benchmarks provide a measurement of this end goal. They transform the technical measurement of a sustainability impact into an intuitive and easily understood metric that shows the performance of the building on this issue relative to the rest of the market.

The NSW Department of Energy, Utilities and Sustainability manages the two key performance benchmarks for commercial property:

Australian Building Greenhouse Rating scheme (ABGR)
www.abgr.com.au
Greenhouse gas emissions from Australia’s commercial building sector are growing by 3 to 4% each year. Commercial buildings produce 8.8% of the national greenhouse emissions.

The ABGR scheme is a ‘world first initiative’ to help building owners and tenants across Australia rate their greenhouse performance. ABGR benchmarks a building’s greenhouse impact on a scale of one to five, representing the building’s performance relative to the market.

ABGR can also be used to improve the greenhouse efficiency of buildings from the outset. New buildings can target a high star rating, and bear that target in mind while designing the building. Once the building is operational an ABGR rating will be obtained to confirm that the design intent was met. Over time this feedback loop will improve the standard of building design and encourage innovative solutions for high efficiency buildings.

ABGR is the universally accepted benchmarking tool for energy consumption of commercial buildings in Australia, and it has been incorporated in other rating systems to ensure a consistent approach from industry to this important issue.

National Australian Built Environment Rating System (NABERS)
www.nabers.com.au
All buildings have an impact on the environment. Energy is used to provide light, heating, cooling and ventilation. Water is used for washing, drinking and air conditioning. Water from storms needs to be managed. Waste is generated. Occupants are affected by the quality of the air in the building. Local biodiversity is affected. Toxic materials are present.

NABERS is a performance-based sustainability rating system for existing buildings, based upon the ABGR methodology. NABERS will rate a residential or commercial office building on the basis of its measured operational impacts on the environment.

As householders, building owners, managers or occupants we can reduce these impacts. NABERS is designed to help you by giving a simple indication of how well you are managing these environmental impacts compared with your peers in other homes or office buildings.

NABERS was developed by the Australian Government Department of the Environment and Water Resources (DEW) in consultation with industry and stakeholders. It is a national initiative managed by the NSW Government Department of Energy, Utilities and Sustainability (DEUS). NABERS is able to provide ratings for office buildings, office tenancies and homes.

NABERS OFFICE is a performance based tool to assess the measured operational impacts of existing buildings. Environmental performance is assessed against a comprehensive set of key impact categories. ABGR is used to assess energy efficiency while a new tool to assess water use efficiency, NABERS OFFICE WATER, was released in June 2006. This tool measures water consumption on a scale of 1 to 5 stars, reflecting the performance of the building relative to the market, from least efficient (one star) to best practice (five stars). The current market average is two and a half stars.

Further tools are being developed to measure comprehensively the full range of environmental impacts including: refrigerants (greenhouse and ozone depletion potential), stormwater runoff and pollution, sewage, landscape diversity, transport, indoor environment, occupant satisfaction, waste and presence of toxic materials.

55 Text for this page supplied by the Department of Energy, Utilities and Sustainability (DEUS).
The Green Building Council of Australia is a national, not-for-profit organisation that is supported by both industry and governments across the country. Launched in 2002, the Green Building Council’s mission is to promote sustainable development and drive the adoption of green building practices through market-based solutions.

The council aims to drive the transition of the Australian property industry towards sustainability by promoting green building programmes, technologies, design practices and operations. Central to achieving these aims the council launched the Green Star environmental rating system for buildings in 2003.

GREEN STAR
The Green Star environmental rating system recognises and rewards environmental leadership in the building industry. Green Star rating tools are being released for different phases of development (i.e. design, construction, procurement and operation) and various building types (office, retail, education, health, residential etc.). Green Star builds on existing environmental rating systems for buildings, including the UK’s ‘BREAAM’ (Building Research Establishment Environmental Assessment Methodology) and North America’s ‘LEED’ (Leadership in Energy and Environmental Design) by establishing individual environmental measurement criteria relevant to the Australian marketplace and unique environmental context.

Green Star rating tools use stars to measure performance. Green Star is Australia’s only comprehensive, industry-owned, national, voluntary environmental rating system for buildings.

Green Star is the only rating system in Australia that evaluates the environmental impact of Australian buildings at all phases of development and across all environmental categories, including:
- management
- indoor environmental quality
- energy
- transport
- water
- materials
- land use and ecology
- emissions.

INTERACTION WITH OTHER TOOLS
Green Star was developed and funded by industry and government. Green Star’s framework brings existing tools and standards together under one unified system. Green Star rating tools are relevant to building type, phase of development cycle and geographical location. Green Star awards points for best practice initiatives and, as such, projects that receive a Green Star Certified Rating have demonstrated leadership and are considered to be in the top quartile of the market.

Recognising the existence of other regulatory tools and to ensure project teams are not doubling up on their efforts, Green Star rating tools incorporate the Australian Building Greenhouse Rating (ABGR) scheme under the energy category. Green Star also addresses other energy efficiency initiatives such as on-site demand management, energy metering for base building and tenancies and more.

GREEN STAR CERTIFICATION
All Green Star rating tools recognise and reward initiatives that reduce the environmental impact of development. Points are awarded under eight environmental categories where a project demonstrates that initiatives have been met. A total score for each environmental category is calculated and a weighting is applied to this score that reflects the geographical location of the project and the environmental impact.

Green Star rating tools use stars to measure performance:
- 4 Star Green Star Certified Rating recognises and rewards ‘best practice’
- 5 Star Green Star Certified Rating recognises and rewards ‘Australian excellence’ and
- 6 Star Green Star Certified Rating recognises and rewards ‘world leadership’.

GREEN STAR CERTIFIED BUILDINGS
5 Star Green Star - Office As Built v1:
- 30 The Bond in Sydney NSW
- RAAF Richmond Squadron 36 and 37 Headquarters in Richmond, NSW.

4 Star Green Star – Office As Built v1
- The Advertiser, Adelaide.

6 Star Green Star - Office Design v1
- CH₂, Melbourne, Victoria
- 40 Albert Road, Melbourne, Victoria.

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56 Text for these pages supplied by the Green Building Council.
GBCA and Green Star accredited buildings

5 Star Green Star - Office Design v1
- 8 Brindabella Circuit, Canberra, ACT
- RAAF Richmond Squadron 36 and 37 Headquarters in Richmond, NSW
- Flinders LinkStage 5 Office Development, Adelaide, SA
- Bendigo Bank Headquarters, Bendigo VIC
- 500 Collins Street, Melbourne VIC.

5 Star Green Star - Office Design v1 COBEII
- Bordo International Pty Ltd Headquarters in Scoresby, VIC
- Kangan Batman TAFE Automotive Centre of Excellence in VIC.

4 Star Green – Office Design v1
- 151 Pirie, Adelaide, SA
- 60 Light Square in Adelaide, SA.

5 Star Green Star - Office Design v2
- City Central Tower 1, Adelaide, SA
- Hume City Council Office Building in Broadmeadows, VIC
- Green Square South Tower, Brisbane QLD
- Metropolitan Fire Brigade, 450 Burnley, VIC
- Bendigo Bank Headquarters, Bendigo VIC
- Digital Harbour - Port 1010, Docklands VIC
- Forestry SA, Mount Gambier, SA
- Quad 4, Sydney Olympic Park, NSW.

5 Star Green Star - Office Interiors v1
- Morgan Stanley Tenancy at 30 The Bond, Sydney, NSW
- RAAF Richmond Squadron 36 and 37 Headquarters in Richmond, NSW
- Investa Office, Lv 6 and 7/126 Phillip St, Sydney NSW.

4 Star Green – Office Interiors v1
- Australian Research Council tenancy at 8 Brindabella Park, Canberra
- International Airport, Canberra, ACT.

100 other projects are registered
- 48 applying for Green Star - Office Design ratings
- 18 applying for Green Star - Office As Built ratings (some also targeting Green Star - Office Design)
- 33 applying for Green Star - Office Interiors ratings
- 1 for Green Star - Office Existing Building rating.

For updated information see: www.gbcaus.org
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