



Australian Government  
Department of the Environment and Heritage

EDITION 2

# ESD DESIGN GUIDE

FOR AUSTRALIAN GOVERNMENT BUILDINGS



## The Department of the Environment and Heritage

Content written by Sustainable Built Environments and Centre for Design at RMIT University.

Prepared with reference to the Manningham City Council Doncaster Hill Sustainability Guidelines.

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Video clips have been included in the online guide to provide additional content, context and experience (see: <http://www.deh.gov.au/settlements/publications/government/esd-design/>). 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, Kerry Wilmott, Chris Barnett, Martin Osolnik, Tim Hurburgh, Paul Edwards, Paul Bannister and Sean McArdle for their participation.

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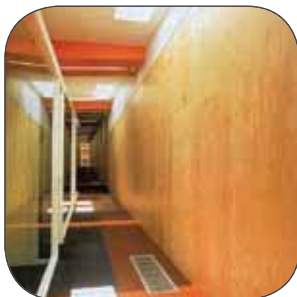
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743 Ann Street, Brisbane, used with permission from TVS partnership



SES Headquarters, used with permission of H2o architects Melbourne



CH<sub>2</sub> image used with permission of the City of Melbourne and DesignInc Melbourne

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## introduction

The State of the Environment report published in 2001 clearly puts into context that humans have had a large impact on the earth and that this is not sustainable. The study concludes:

*“Existing pressures from human settlements are not consistent with a sustainable environment. Uneven distribution of wealth in our human settlements means that some communities (e.g. Indigenous communities and small rural towns) do not always have the capacity to look after their environment. Most indicators of resource consumption continue to outpace population growth. An example is personal mobility, as measured by vehicle kilometres travelled, which is increasing in metropolitan areas. There is a high and increasing per capita energy usage in human settlements leading to increase in greenhouse gas emissions, particularly through electricity generation and transport usage.”<sup>1</sup>*

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 world’s energy. Buildings also produce 40% of waste going to landfill and 40% of air emissions.<sup>2</sup> 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.<sup>3</sup>



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

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 Government buildings, specifically ABGR, NABERS and Green Star. The bulk of this guide is an outline of 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:

*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’. (NSES, DEH 1992)*

- 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
- CH<sub>2</sub>, Melbourne, Australia’s first 6 Star Green Star - Office Design project
- 743 Ann Street – a refurbishment of an office building in Brisbane
- Waaliti Building: Murdoch University – Perth 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, integrating many Australian first technologies and has achieved a 6 Star Green Star - Office Design certified rating
- Galleries, Museums and Libraries various ESD opportunities in public buildings

1 DEH (2001) State of Environment Summary Brochure. The Department of the Environment & Heritage: Canberra. [www.deh.gov.au/soe/2001/key-findings/pubs/key-findings-2001.pdf](http://www.deh.gov.au/soe/2001/key-findings/pubs/key-findings-2001.pdf).

2 OECD (2003) *Environmentally Sustainable Buildings: Challenges and Policies*. A report by the OECD

3 DEH (2001) *Australia State of the Environment report*. The Department of the Environment & Heritage: Canberra.

## AUSTRALIA AND ecologically sustainable development

Ecologically Sustainable Development (ESD) represents one of the greatest challenges facing Australia's governments, industry, business and community in the coming years.<sup>4</sup> In 1990, Australian Governments 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'.<sup>5</sup>*

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 (NSESD) 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.<sup>6</sup>

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 report as outlined in the document *Generic ESD and Environmental Performance Indicators for Commonwealth Organisations (GPICO)*.<sup>7</sup>

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*, with an updated version currently under development. For Australian Government buildings, this policy requires reporting on the lighting energy use, general energy use, the number of kilometres travelled and the amount of energy used per fuel type.

As part of this policy, specific portfolio targets were adopted for government office buildings (not public buildings) as follows:

- Tenant light and power - 10,000 MJ/person/annum
- Central Services - 500 MJ/m<sup>2</sup>/annum

New portfolio targets will be announced in late 2005, these targets will not be for individual buildings.

To achieve best practice of 4.5 stars ABGR in new government office buildings and major refurbishments, a maximum of 10 Watts/m<sup>2</sup> for lighting and 9 Watts/m<sup>2</sup> for general power (tenancy) should be considered.

4 DEH (1992) NSESD Prepared by the Ecologically Sustainable Development Steering Committee Endorsed by the Council of Australian Governments December, 1992 ISBN 0 644 27253 8, Introduction.

5 *ibid* Introduction

6 For more information of ESD reporting see [www.deh.gov.au/epbc/publications/esd-guidelines/pubs/esd-reporting-guidelines-2003.pdf](http://www.deh.gov.au/epbc/publications/esd-guidelines/pubs/esd-reporting-guidelines-2003.pdf).

7 For more information of ESD indicators see [www.deh.gov.au/epbc/publications/esd-indicators/esd.html#legislation](http://www.deh.gov.au/epbc/publications/esd-indicators/esd.html#legislation).

## AUSTRALIA AND ecologically sustainable development



Figure 2. 743 Ann Street interior, TVS Partnership.

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

For related policies see the Policy Framework for Greening of Government:

[www.deh.gov.au/settlements/government/purchasing/policy.html](http://www.deh.gov.au/settlements/government/purchasing/policy.html)

### 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.



Figure 3. 743 Ann Street interior, TVS Partnership.

For assessing a range of environmental aspects of commercial buildings in Australia, **Green Star - Office Design v2** assesses a project's approach 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 uses 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 issues. For that reason it is discussed first:

### ABGR

ABGR is administered nationally by a group of sustainable energy agencies (SEDO, SEAV, 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 for the base building (central services), individual tenancies or a whole building.

### ABGR Homepage

[www.abgr.com.au](http://www.abgr.com.au)

## RATING TOOLS AND environmental performance

### 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 eg. design, procurement, construction and refurbishment. There are currently four Green Star rating tools relevant to office buildings.

#### What the Green Star tools rate:

- *Green Star - Office Design v2* evaluates the environmental potential of the design of commercial office buildings (base building construction or refurbishment). That is, it is a rating of the design potential of the building before it is built.
- *Green Star - Office As Built v2* evaluates the same design initiatives as Green Star - Office Design but the validation documentation differs in that it is retrospective and therefore evaluates those initiatives that are relevant to the construction of the building and are the responsibility of the contractor. That is, it is a rating of the contractor's performance once the building has been built.
- *Green Star - Office Interiors v1* evaluates the environmental initiatives and/or the potential environmental impact of class 5 office tenancy fitout. It was developed primarily to assess an office tenancy fitout once construction is complete, however it should also be used during the tenancy fitout design phase to ensure green initiatives are incorporated at the earliest possible stage.
- *Green Star - Office Asset (pilot)* rates the environmental attributes

of existing office buildings that have been constructed and handed over not less than 24 months prior to an application for a Green Star certified rating. The tool assigns a Green Star rating to the physical building and its services independent of the tenants' operation or behaviour. That is, it is a rating of the asset which is over 24 months old, and uses the *ABGR* tool to measure potential energy use and not actual consumption.

### Green Building Council Australia

For case studies on Green Star accredited buildings see Attachment 2 and [www.gbcaus.org/greenstar](http://www.gbcaus.org/greenstar)

### NABERS

NABERS was developed by the Australian Government and is currently being commercialised by the NSW Department of Energy, Utilities and Sustainability (DEUS), the administrators of ABGR.

NABERS measures environmental performance against a comprehensive set of key impact categories. The relevance of these impact categories in a NABERS assessment will depend on whether the rating is for a Commercial Office Building, Commercial Office Tenancy, or Residential Home.



Figure 4. Queenscliff Ecocentre, DPI Victoria.

NABERS is structured this way to allow recognition of the different realms of accountability and responsibility for commercial building owners, commercial tenants, or home owners.

### National Australian Built Environmental Rating System

[www.nabers.com.au](http://www.nabers.com.au)

*"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."*



*5 Star, Green Star - Office Design v1 implementation at Brindabella*  
Martin Osolnik, Associate, Daryl Jackson Alastair Swayn

## RATING TOOLS AND environmental performance

Information required for Green Star - Office Design v2 <sup>8</sup>	Green Star category	NABERS category	Information required for NABERS
Commissioning documentation Waste and environmental management plans	Management		
Predicted ventilation, light, views, user control, VOCs, noise and asbestos	IEQ	Indoor Air Quality	Levels of dust, CO, CO <sub>2</sub> , Ozone, VOCs, bacteria, fungi and mould
		Occupant Satisfaction	Actual satisfaction – noise, temp, light and health aspects such as headaches, nausea etc.
ABGR rating with a minimum of 4 stars, metering, peak offset, zoning	Energy	Energy use and Greenhouse Emissions	Enter ABGR score 0-5 stars,
Proximity to public transport and car parking minimisation	Transport	Transport	Transport type, engine size, km and number of trips
Planned appliances and fixtures, metering, cooling tower, irrigation, water collection and reuse	Water	Water Use	Actual m <sup>3</sup> of water used
	(see water)	Stormwater Runoff	Rainwater captured and used, permeable and non permeable surfaces, rainfall, evaporation
	(see emissions)	Sewage Outfall Volume	Actual m <sup>3</sup> of water sent to sewer and reused
Reuse, recycled content, PVC minimisation, timber	Materials	Toxic Materials	Presence, storage and disposal per type
Existing building system (façade/structure) reuse	(see materials)	Waste	Total waste and waste to landfill
Soil reuse, adding ecological value and quality through remediation to land	Land use	Landscape Diversity	Landscape types and m <sup>2</sup>
Refrigerant capture, water pollution minimisation, sewage minimisation, light pollution, cooling tower, insulation blowing agent	Emissions	Stormwater Pollution	Actual m <sup>2</sup> of different surfaces on which storm water falls e.g. garden with fertilizer
	(see emissions)	Refrigerant use (GWP and ODP)	Type, amount and actual leakage (by top up required)
New untried technologies, techniques and approaches	Innovation		

**Table 1.** Comparison of the information required by Green Star and NABERS

<sup>8</sup> Green Star - Office Design v2 [www.gbcaus.org](http://www.gbcaus.org)

<sup>9</sup> NABERS [www.deh.gov.au/industry/construction/nabers](http://www.deh.gov.au/industry/construction/nabers)



## PRINCIPLES OF environmentally sustainable building design

### 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.

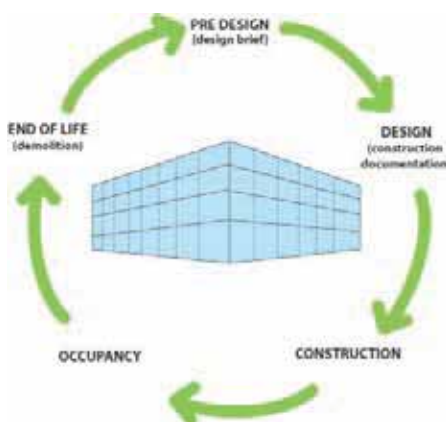


Figure 5. Life cycle of a building.



Figure 6. Trees, image sourced from *Doncaster Hill Sustainability Guidelines*, Manningham City Council.

### 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 to use an integrated design process 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

## PRINCIPLES OF 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 on going 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.

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 (CSIRO), but these are yet to be tested in the market place.

#### Online Resources

##### LCA

Department of the Environment and Heritage

[www.den.gov.au/industry/corporate/lca](http://www.den.gov.au/industry/corporate/lca)

Greening the Building Life Cycle

[buildlca.rmit.edu.au](http://buildlca.rmit.edu.au)

provides case studies, links to LCA tools and a guide to LCA use for building design

Canadian Architect

[www.canadianarchitect.com/asf/perspectives\\_sustainability/measures\\_of\\_sustainability](http://www.canadianarchitect.com/asf/perspectives_sustainability/measures_of_sustainability)

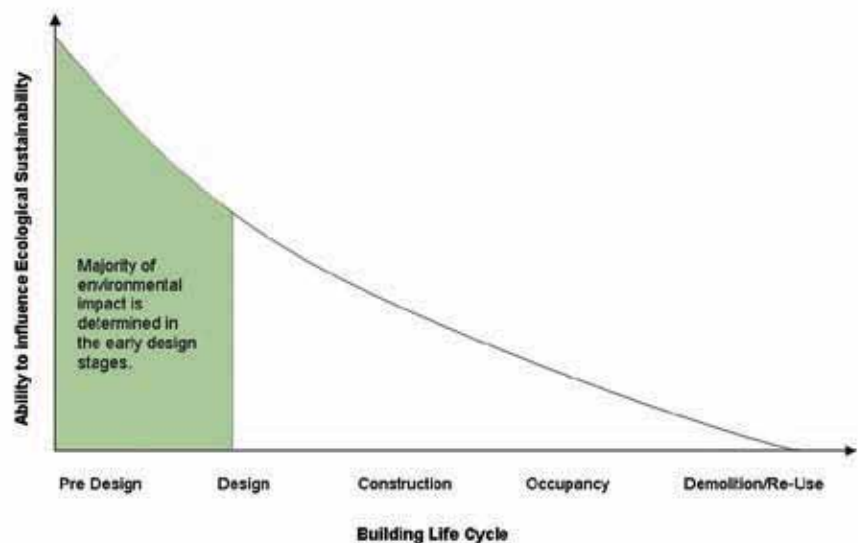
LCAid

[www.projectweb.gov.com.au/dataweb/lcaid/](http://www.projectweb.gov.com.au/dataweb/lcaid/)

*“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.

## SUMMARY OF esd opportunities in building

OPPORTUNITIES	PRE DESIGN	DESIGN	CONSTRUCTION DOCUMENTATION	CONSTRUCTION	OCCUPANCY
1. INTEGRATED DESIGN & PROCESS MANAGEMENT	Establish design values of project. Set environmental performance targets. Consider collaborative design workshops.	Consider thermal modelling. Assess design against benchmarks and targets. Consider environmental cost-benefit analysis.	Peer reviews to confirm innovative technology.		Use environmental performance ratings, on-site monitoring and user feedback.
2. SOCIAL SUSTAINABILITY AND OCCUPANT SATISFACTION	Consider the broader urban environment.	Design for access and mobility. Maintain site biodiversity.		Minimise disturbance to offsite areas.	
3. INDOOR ENVIRONMENT QUALITY	Set criteria for Indoor Air and Environment Quality (IAQ and IEQ).	Consider total indoor environment – light, fresh air, views, materials, radiant and convective temperature, landscape and user control.		Provide safeguards and performance indicators in specifications to promote appropriate material selection and substitution. Protect from respiratory impacts.	Monitor air quality.
4. ENERGY MANAGEMENT	Consider renewable energy options. Consider engaging specialist environmental engineer.	Integrate into the Building Management System (BMS) a process for review and improvement of energy performance. Explore multiple benefit solutions that solve more than one problem. Use passive design T5 lighting. Flat screen monitors.	Specify energy efficient appliances. Specify adequate insulation. Provide sufficient detail of draught proofing. Specify provision of separate energy meters.	Encourage builders to use green power during construction. Ensure builders have an energy component to their Environmental Management Plan.	Carry out regular metering, reporting and adjustment for improved performance. Look for energy efficiency opportunities at refurbishment.
COMMISSIONING & OPERATIONS		Consider an independent commissioning agent.	Require the provision of operating and maintenance instructions and manuals.	Commission building systems. Carry out building manager and user training. Provide building use manuals.	Make environmental performance indicators visible. Undertake post-occupancy evaluation. Periodic re-commissioning.
5. TRANSPORT	Consider location in relation to use. Are there alternative transport options to the site?	Include shower and locker facilities and adequate bicycle parking.	Consider car parking spaces that are adaptable for other uses.	Make parking provisions for contractors.	Occupant education to promote use of public transport, cycling and walking.
6. OZONE LAYER DEPLETION			Specify use of refrigerants with a zero ODP and a maximum of 10 GWP.		Audit regularly for leaks, minimise where possible.
7. CHOOSING MATERIALS (incl. minimising toxicity)		Use material selection rules of thumb. Choose materials which minimise toxicity.	Further research information on material maintenance, reuse and recycling. Environmental criteria included in final specifications.	Review material certification and installation. Provide method for contractors to use in material substitution.	Building use material selection guideline, particularly for cleaning.
8. WASTE MINIMISATION		Design building for flexibility and future disassembly. Contact local waste contractors for site access advice. Design-in waste collection areas.	Specification to call for waste management plan from builder. Detail for easy modification of services.	On-site waste separation and recycling. Allow for material salvage in demolition. Regular reporting and auditing.	Occupant education on waste recycling.
9. WATER USE REDUCTION	Contact local water authority (re approvals).	Investigate site water collection and re-use options. Investigate waste water treatment options.	Specify minimum AAA rated fittings. Specify use of water wise landscaping.	Ensure stormwater runoff is contained and sediment removed prior to leaving site.	Occupant education on water saving.

**Table 2.** Whole of life opportunities in Government buildings. Adapted from Doncaster Hill Sustainability Guidelines, City of Manningham, Victoria 2004

## OPPORTUNITY 1 integrated design

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.

*“try to make each element of the design work more than once ...such as external blinds for glare and solar control and our atrium for exhaust relief air path as well as a buffer zone and an amenity for people.”*



*Use of integrated design*  
30 the Bond  
**Paul Edwards, General Manager,**  
**Environment Sustainability Initiatives, Lend**  
**Lease Australia Pacific**

### 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, within the integrated design process described above, 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. Completing the design and documentation process requires that the ESD opportunities identified in the charrette be carried through and documented.



**Figure 8.** CH<sub>2</sub> construction image, vaulted ceilings from inside looking out, City of Melbourne. (6 Star, Green Star - Office Design v1)

The Council House 2 project (CH<sub>2</sub>) used a charrette process. This was run over 2 weeks, with the consultants and project team sitting together every morning and going away in the afternoons to carry out specific research on elements discussed in the morning, in order to return the next day to report. This process ensured that in a short period, around 80% of all the building design and systems were resolved in an integrated holistic fashion. All the consultants understood the systems and why they were in place. Further, there was a sense of trust that had been built up, resulting in a shorter design period to the point that a guaranteed bill of quantities was produced in 9 months, (even accounting for a change of site in the 3rd month).



**Figure 9.** CH<sub>2</sub> charette, City of Melbourne

OPPORTUNITY 1  
integrated design



**Figure 10.** Clouds, image sourced from *Doncaster Hill Sustainability Guidelines*, Manningham City Council

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.

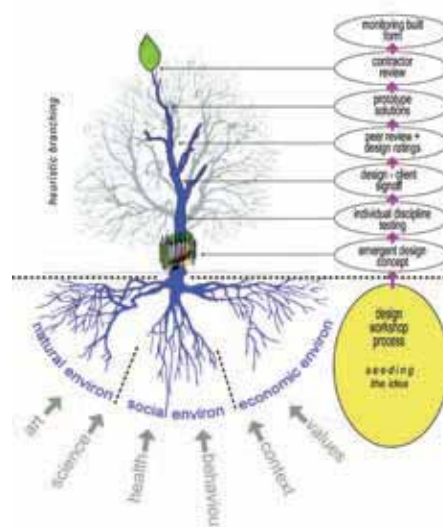
After construction, and during the handover period, there should be a thorough commissioning stage to prove that the building has been built as designed and is functioning as intended. Depending on the size of the building the following steps need to be taken during this process:

- Step 1 – ensure that the construction documentation 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.

In addition, reduction of the environmental impacts of the building in operation can be further achieved by a thorough building management system (including an EMS) that has regular audits and a policy of continual improvement for areas such as water use, energy use and waste production. To a certain extent, purchasing and transport policies also have an impact, and it is beneficial if these are also addressed.

Another tool that can be used in the holistic building management strategy is to have tenant initiatives such as green leases and tenant building user manuals. These can be supported by regular meetings between key parties, such as through a building management committee.



**Figure 11.** Integrated design process, DesignInc Melbourne.

Online Resources

**Integrated Design**  
City of Fort Collins  
[www.fcgov.com/utilities/power/save/indesign.php](http://www.fcgov.com/utilities/power/save/indesign.php)

**Environmental Management System (EMS)**  
DEH EMS  
[www.deh.gov.au/settlements/government/ems](http://www.deh.gov.au/settlements/government/ems)

**Property Council of Australia**  
[www.propertyoz.com.au/vic/EMS/home.htm](http://www.propertyoz.com.au/vic/EMS/home.htm)

**Vic EPA**  
Victorian Government EMS  
[www.epa.vic.gov.au/Government/EMS](http://www.epa.vic.gov.au/Government/EMS)

**SEAV**  
Module 4 Developing an Energy Management System  
[www.sea.vic.gov.au/advice/business/EGMToolkit.asp](http://www.sea.vic.gov.au/advice/business/EGMToolkit.asp)

**Green Leasing**  
Freehills Commercial Lawyers  
[www.freehills.com.au/publications/publications\\_2243.asp](http://www.freehills.com.au/publications/publications_2243.asp)

## OPPORTUNITY 2 social sustainability and occupant satisfaction



Figure 12. Queenscliff Ecocentre - courtyard, DPI Victoria.

*“Most of the comments on the NAB and the Bond is what a good space it is, not about how much energy saving it is. In terms of getting that culture shift in organisations, I think that the healthy aspect is what is driving it. In CH<sub>2</sub>, the idea of 100% fresh air, the access to landscape, has been far more upfront than the energy side of things.” Stephen Webb.*

A building can make a contribution to social sustainability in 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

Disability Discrimination Act  
[www.austlii.edu.au/au/legis/cth/consol\\_act/dda1992264/](http://www.austlii.edu.au/au/legis/cth/consol_act/dda1992264/)

Royal Australian Institute of Architects  
 ESD award checklist  
[www.architecture.com.au/i-cms/file?page=2993/esd\\_checklist.pdf](http://www.architecture.com.au/i-cms/file?page=2993/esd_checklist.pdf)

Occupant satisfaction measure  
 NABERS  
[www.deh.gov.au/industry/construction/nabers](http://www.deh.gov.au/industry/construction/nabers)

Occupant satisfaction probe studies  
[www.usablebuildings.co.uk/](http://www.usablebuildings.co.uk/)



Figure 13. AGO southside of courtyard, DEH.

## OPPORTUNITY 3

# optimising indoor environment quality

PROJECT	PRODUCTIVITY INCREASES	REASON
ING bank (Netherlands) <sup>14</sup>	15%	IEQ
San Fran Sustainable Development Committee studies (US) <sup>15</sup>	3% to 15%	IEQ
Nevada Post office (US) <sup>16</sup>	6%	Better lighting and use of natural light.
Verifone Corporation (US) <sup>17</sup>	45% decrease in absenteeism	Daylighting, air filtration and low toxicity material specification.
Twelve Public Offices (US) <sup>18</sup>		Mechanically ventilated buildings had significantly more people with symptoms of sick building syndrome than occupants of naturally ventilated buildings, after adjustment for confounding factors.

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

Indoor Environment Quality (IEQ) is mainly assessed on by how the environment in the building is perceived by it 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.<sup>10</sup> Minimising the toxicity of their indoor environment is therefore a priority, particularly when indoor air is shown to be more toxic than outdoor air.<sup>11</sup> The US EPA estimates that 20 to 35 percent of all workers in modern mechanically ventilated buildings may experience negative air-quality related signs and symptoms.<sup>12</sup> 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 percent of new and remodelled buildings worldwide may be the subject of complaints related to indoor air quality.<sup>13</sup>

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

10 Wargocki, P., Wyon, D.P., Baik, Y.K., Clausen, G. and Fanger, P.O. (1999) Perceived air quality, Sick Building Syndrome (SBS) symptoms and productivity in an office with two different pollution loads. *Indoor Air*, p 9, 165–179 and Fisk, W.J. and Rosenfeld, A.H. (1997), 'Estimates of Improved Productivity and Health from Better Indoor Environments', *Indoor Air*, vol. 7 (3), pp. 158-172

11 Patrick K (2004) 'IEQ : Coming To A Building Near You', *Property Australia*, Property Council of Australia: Sydney, p. 8

12 *ibid* p. 8

13 *ibid* p. 8

14 *ibid* p. 9

15 *ibid* p. 10

16 Edwards L. and P. Torcellini (2002) A Literature Review of the Effects of Natural Light on Building Occupants, *National Renewable Energy Laboratory* p. 11 [www.ornl.gov/sci/hybridlighting/pdfs/NREL\\_TP\\_550\\_30769.pdf](http://www.ornl.gov/sci/hybridlighting/pdfs/NREL_TP_550_30769.pdf)

17 *ibid* p. 10

18 Fisk, W.J. and Rosenfeld, A.H. (1997) 'Estimates of Improved Productivity and Health from Better Indoor Environments', *Indoor Air*, vol. 7 (3), pp. 158-172.

*"...Indoor Environment Quality... in the past few years it has probably been the single biggest thing that has come up and has got these buildings over the line..."*



**Importance of IEQ**  
CH2 (6 Star Green Star - Office Design v1)  
**Stephen Webb, Director, DesignInc Melbourne**

## OPPORTUNITY 3 optimising indoor environment quality

### 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 CH<sub>2</sub> is aiming for 22.5l/s/person. Another useful tool is CO<sub>2</sub> sensors that control ventilation systems to only turn on 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. International standard for thermal comfort is ISO 7730.

#### Noise

Ensure noise levels are kept at appropriate levels. For example in 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”<sup>19</sup>

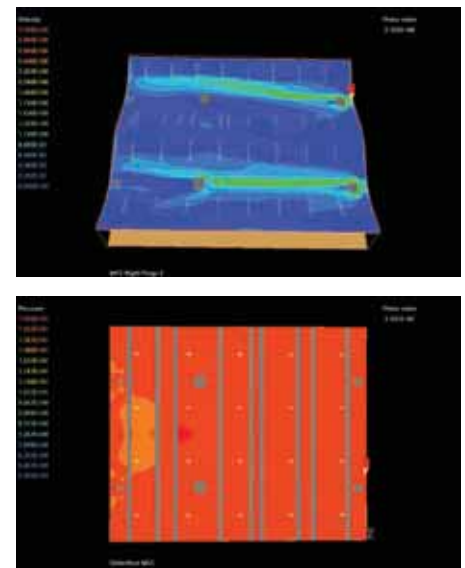
#### Pollutants

##### Material selection

Ensure asbestos and other mineral fibres are eliminated from the occupied space. Minimise materials that emit volatile organic compounds (VOCs) and have formaldehyde emissions. Ensure that spaces containing equipment such as printers and photocopiers are isolated and well ventilated. Ensure combustion plant is 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.<sup>20</sup>

##### 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.



**Figure 14.** CH<sub>2</sub> Modelling velocity (blue) and pressure (red) of air distribution through room (AEC, City of Melbourne report).

- 19 Green Star – Office Design v2 Indoor Environment Quality credit IEQ-12 'Internal Noise Levels' [www.gbcaus.org](http://www.gbcaus.org)
- 20 Green Star – Office Design v2 Emissions credits Em-1 'Refrigerant ODP' [www.gbcaus.org](http://www.gbcaus.org)

#### Online Resources

**IEQ**  
Department of the Environment and Heritage  
[www.deh.gov.au/soe/2001/settlements](http://www.deh.gov.au/soe/2001/settlements)

**Building Green**  
[www.buildinggreen.com/menus/subtopics.cfm?TopicID=5](http://www.buildinggreen.com/menus/subtopics.cfm?TopicID=5)

**US EPA**  
IAQ for large buildings  
[www.epa.gov/iaq/largebdgs/index.html](http://www.epa.gov/iaq/largebdgs/index.html)



## OPPORTUNITY 4 minimising energy use

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 created 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<sup>21</sup>, 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.<sup>22</sup>

Greenhouse gasses are measured by greenhouse gas equivalents relating to Global Warming Potential (GWP). CO<sub>2</sub> is set as a GWP of 1. All other gasses are given a relative score – eg if a gas has twice the global warming potential when compared to CO<sub>2</sub>, it gets a GWP of 2.<sup>23</sup>

### 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.<sup>24</sup>

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

### PASSIVE DESIGN

Passive design is the name given to any design technique that requires no active (energy using) intervention. For example, the use of thermal mass (e.g. a large slab of concrete) to absorb heat generated in a building during the day and then using night purging to cool the thermal mass is an example of passive design (see



**Figure 15.** CH<sub>2</sub> during construction photo of high thermal mass wavy ceilings, City of Melbourne.  
(6 Star Green Star - Office Design v1)

image of concrete ceilings used at CH<sub>2</sub> above).

The following are a few other examples of passive design techniques that can be used:

#### 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.

- 21 AGO. (2003) *Global Warming – Cool it!*, - fact sheet, Australian Greenhouse Office: Canberra.
- 22 DEH (2001) *Australian State of the Environment report*. The Department of the Environment & Heritage: Canberra.
- 23 Emissions credits Emi-1 Emissions 'Refrigerant ODP' and Emi-2 'Refrigerant GWP' [www.gbcaus.org](http://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.

## OPPORTUNITY 4 minimising energy use

### 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. 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.

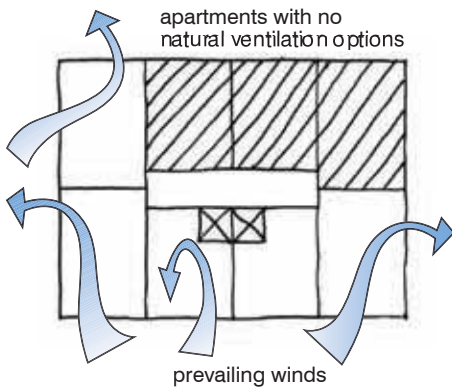


Figure 16. Floorplate with enclosed circulation.

### 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 the space.

### 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. Both those 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 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.

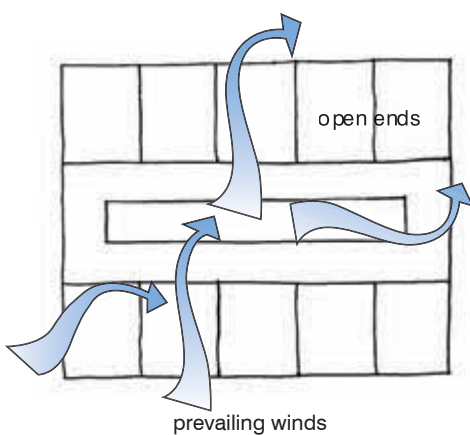


Figure 17. Floorplate with open circulation.

## OPPORTUNITY 4 minimising energy use

### 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 facades 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 that ensures that there is 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.

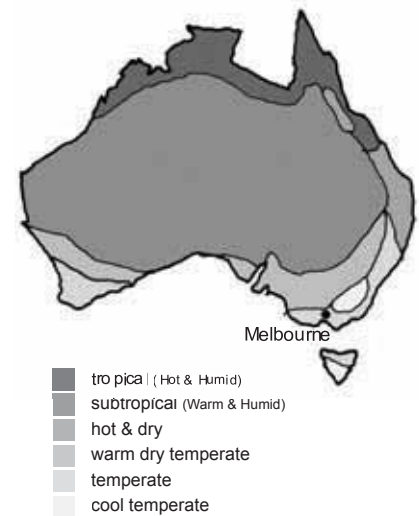


Figure 18. Australian climate zones, image sourced from *Doncaster Hill Sustainability Guidelines*, Manningham City Council

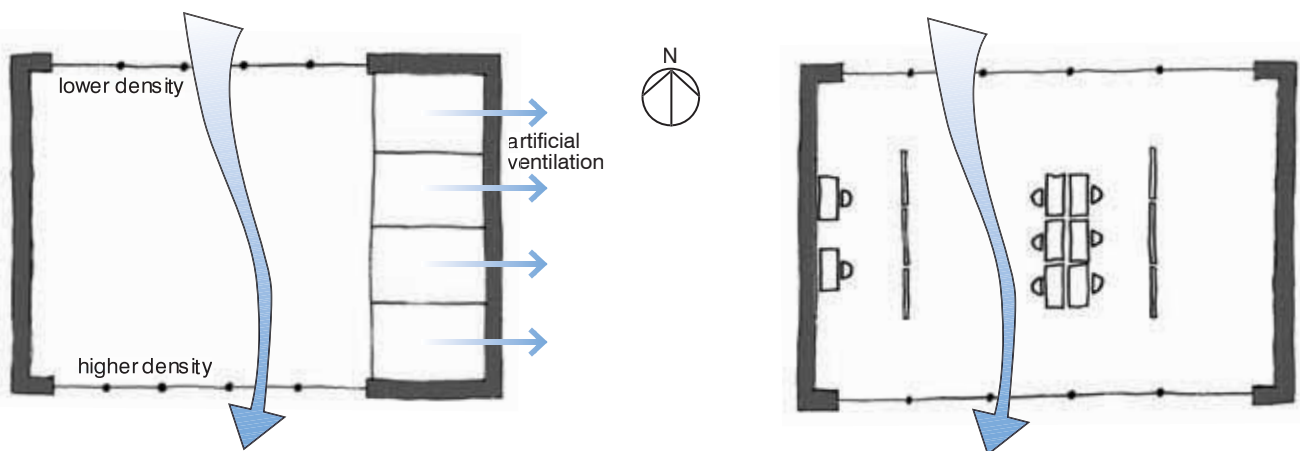


Figure 19 + 20. Plan partitions so as to not block flow of air through the building.

## OPPORTUNITY 4 minimising energy use

### APPROPRIATE SIZING OF LIGHTING, HEATING AND COOLING SYSTEMS

Several concepts need to be understood, and considered, when choosing heating and cooling plant:

#### Natural ventilation

Uses external air and air movement to ventilate a building.

#### Mechanical ventilation

Uses machines to move the air – fans, air conditioners etc.

#### Mixed mode ventilation

Uses a mixture of natural and mechanical systems.

#### Refrigerant cooling

Uses 'refrigerants' in heat pump systems (such as a fridge) to move heat from one place (such as inside the fridge) to another place (such as the back or bottom of the fridge).

#### Evaporative cooling

Uses the latent energy of water evaporation to remove heat.

#### Comfort

A measure of the perception of people in a space. The Predicted Mean Vote (PMV ISO 7730-1984) and Adaptive Comfort (ASHRAE-55<sup>25</sup>) 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.

#### 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 heat.

#### 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.

<sup>25</sup> ANSI / ASHRAE Standard 55-2004, *Thermal Environmental Conditions for Human Occupancy*.

*“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

## OPPORTUNITY 4 minimising energy use

The assessment above 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 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 comfort in the air.

*"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**

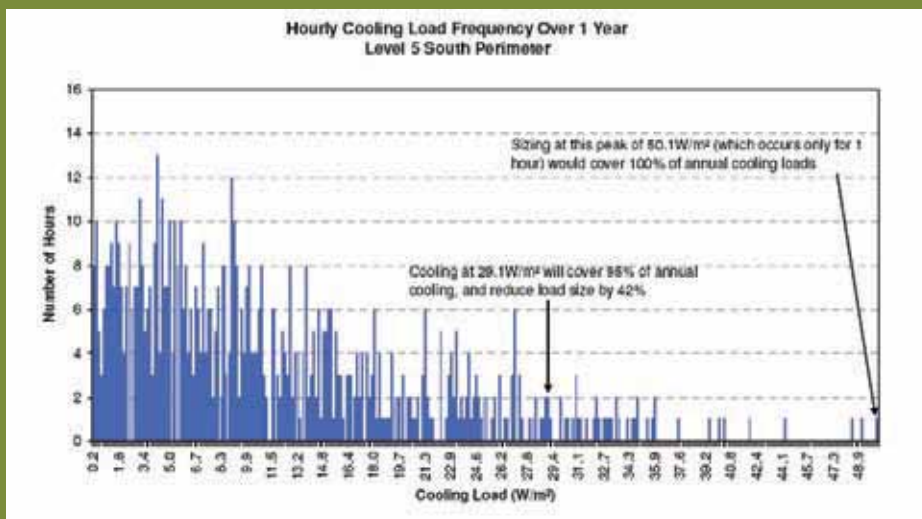


Figure 21. Risk assessment CH<sub>2</sub> for cooling load (AEC, City of Melbourne report).

The Council House 2 project (CH<sub>2</sub>) 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. Below is an example of the analysis and its implications on cooling load for one section of CH<sub>2</sub>. 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.

## OPPORTUNITY 4 minimising energy use

*“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.”*



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

### 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 needs 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 a task light.

### 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 room, allows for the early

detection of problems and the optimisation of performance.

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.

Efficient office equipment specification



**Figure 22.** Comparable energy savings between monitor types and client, CH<sub>2</sub> (AEC, City of Melbourne report).

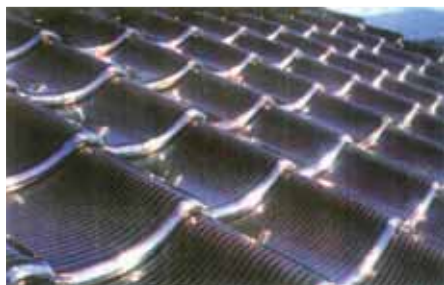
Liquid Crystalline Display (LCD) computer monitors are expected to consume 77% less energy than older cathode ray tube (CRT) computer monitors. The adoption of the LCD monitors and the thin client technology for the computing requirements will reduce the internal heat load and therefore, the amount of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

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

## OPPORTUNITY 4 minimising energy use



**Figure 23.** Photovoltaic curtain wall, image sourced from *Doncaster Hill Sustainability Guidelines*, Manningham City Council.



**Figure 24.** Integrated amorphous photovoltaic tiles, image sourced from *Doncaster Hill Sustainability Guidelines*, Manningham City Council.

(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 policy, energy saving settings and periodic review of equipment settings (people often turn efficiency settings off when they don't understand their function) are initiatives to consider. For more information see the DEH Green Office Guide and DEH's voluntary environmental purchasing tools (refer to online resources).

### 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.

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 and the meter turned backwards.

### EMBODIED ENERGY MINIMISATION

Embodied energy is discussed in opportunity 7 choosing materials.

- 26 SEAV (2005) Personal Conversation Sustainable Energy Authority Victoria 9/3/2005.  
27 Crawford R.H. and Treloar G.J. (2004) Net energy analysis of solar and conventional domestic hot water systems in Melbourne, *Australia Solar Energy*, vol. 76 (1-3), January-March 2004, pp. 159-163.  
28 Going Solar 2005, Conversation 9/03/05.  
29 E. A. Alsema and E. Nieuwlaar Energy viability of photovoltaic systems *Energy Policy*, Volume 28, Issue 14, November 2000, Pages 999-1010.

#### Effectiveness of hot water and PV systems

**Domestic hot water**  
cost payback: 6-7 years<sup>26</sup>  
embodied energy  
payback: 0.5-2 yrs<sup>27</sup>

**Domestic and commercial  
photovoltaic systems**  
cost payback: Greater than 10  
years<sup>28</sup>  
embodied energy  
payback: 2.5-3 yrs<sup>29</sup>

#### Online Resources

**Passive Design Techniques**  
Square One  
[www.squ1.com](http://www.squ1.com)

**Sustainable Building Sourcebook**  
[www.greenbuilder.com/sourcebook/PassiveSol](http://www.greenbuilder.com/sourcebook/PassiveSol)

**Renewable Energy**  
Greenpower  
[www.greenpower.com.au/](http://www.greenpower.com.au/)

**Solar Power**  
ATA (Alternative Technology Association)  
[www.ata.org.au/](http://www.ata.org.au/)

**National Renewable Energy Laboratory**  
[www.nrel.gov/solar/](http://www.nrel.gov/solar/)

**Energy Efficient Fittings & Equipment**  
Australian Greenhouse Office  
Toolkit for local Government  
[www.greenhouse.gov.au/lgmodules](http://www.greenhouse.gov.au/lgmodules)

**Department of the Environment and Heritage**  
Environmental Purchasing Guide  
[www.deh.gov.au/settlements/government/purchasing](http://www.deh.gov.au/settlements/government/purchasing)

**Green Office Guide**  
[www.deh.gov.au/settlements/government/purchasing/pubs/](http://www.deh.gov.au/settlements/government/purchasing/pubs/)

## OPPORTUNITY 5 minimising transport impact

Buildings have a role to play in the minimisation of environmental impact caused by transport. If there is a choice of locations, choose the site with the best access to public transport (refer Figure 19) 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 (refer Figure 20), clothes storage, changing facilities and showers (a provision for 5% of the staff is common practice).<sup>30</sup>

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.



Figure 25. Public transport, image DesignInc.



Figure 26. Bicycles, images freefoto.



Figure 27. Runners, image sourced from *Doncaster Hill Sustainability Guidelines*, Manningham City Council.

30 Green Star - Office Design transport credit Tra-3 'Cyclist Facilities' [www.gbcaus.org](http://www.gbcaus.org)

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 (CH<sub>2</sub>) has planned to include bicycle parking and changing facilities, but on asking 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.

### Online Resources

#### Minimising Transport Impacts

Travel Smart Australia  
[www.travelsmart.gov.au](http://www.travelsmart.gov.au)

GreenFleet  
[www.greenfleet.com.au](http://www.greenfleet.com.au)



## minimising ozone layer depletion

OPPORTUNITY 6

*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 (O<sup>3</sup>) situated far above the build up of greenhouse gases that 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, disruption of normal functions of micro-organisms, and melting of the ice caps.

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 gasses 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, CO<sub>2</sub>, ammonium and hydrocarbons) and ensuring there are systems in place to minimise or eliminate refrigerant leaks.<sup>31</sup>

Refrigerant leaks can be up to 15% of the volume of refrigerants 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.

<sup>31</sup> Green Star - Office Design v2 Emissions credits Em-1 'Refrigerant ODP' and Emi-2 'Refrigerant GWP' [www.gbcaus.org](http://www.gbcaus.org)

*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

Montreal Protocol  
[www.unep.org/ozone/Montreal-Protocol/Montreal-Protocol2000.shtml](http://www.unep.org/ozone/Montreal-Protocol/Montreal-Protocol2000.shtml)

Department of the Environment and Heritage  
[www.den.gov.au/atmosphere/ozone/](http://www.den.gov.au/atmosphere/ozone/)

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

CSIRO  
[www.dar.csiro.au/publications/holper\\_2001a.html](http://www.dar.csiro.au/publications/holper_2001a.html)

Bureau of Meteorology  
[www.bom.gov.au/lam/Students\\_Teachers/ozanim/ozoanim.shtml](http://www.bom.gov.au/lam/Students_Teachers/ozanim/ozoanim.shtml)  
provides an animation on the chemistry behind ozone layer depletion

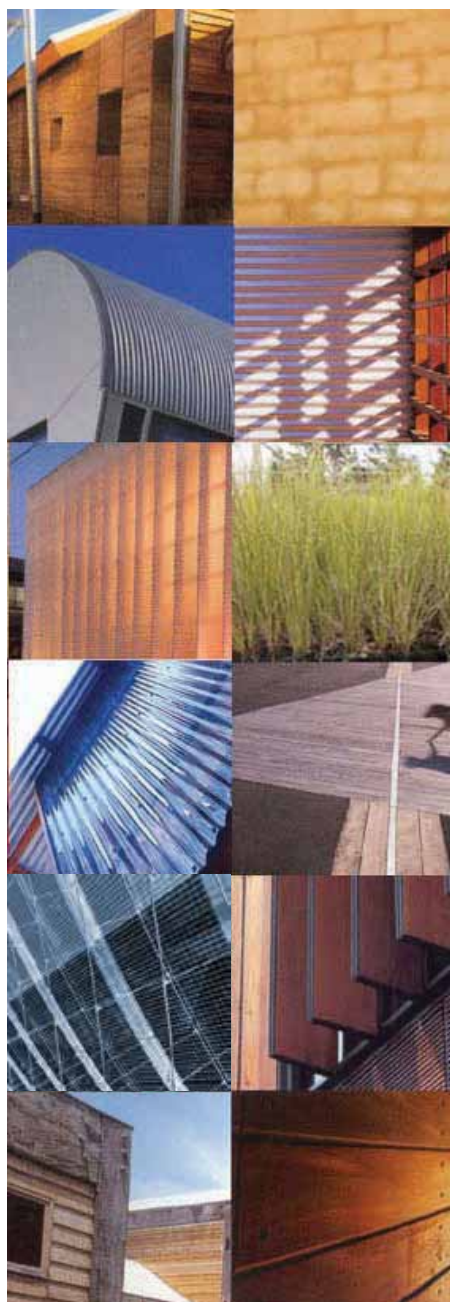
Standards Australia - (HB 40.1-2001): Appendix 3 & 4 summarise OPD potential for most common types of refrigerants  
[www.standards.com.au](http://www.standards.com.au)

AIRAH  
Refrigerant Selection Guide 2003  
[www.airah.org.au/downloads/AIRAH\\_RSG2003.pdf](http://www.airah.org.au/downloads/AIRAH_RSG2003.pdf)

Australian Government building responsibilities are invoked because Australia is a signatory to the Montreal protocol. 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.

## OPPORTUNITY 7 choosing materials



**Figure 28.** Materials, image sourced from *Doncaster Hill Sustainability Guidelines*, Manningham City Council.

### 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)
- 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 – the Australian Environmental Labelling Association etc.

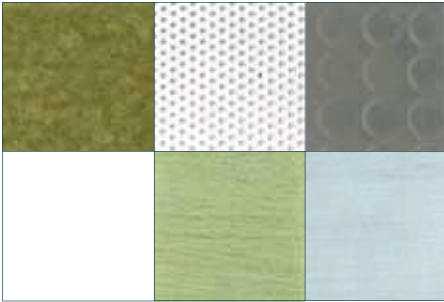
### Embodied Energy

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 products that have 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 early 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

## OPPORTUNITY 7 choosing materials



**Figure 29.** Materials and finishes selection, DesignInc.

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.<sup>32</sup> VOC emissions are a problem because some (such as formaldehyde) have been shown to be carcinogenic.<sup>33</sup> VOC's 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 effect 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; secondly, choose materials that have third party certification indicating that sustainable management strategies are in place.

- 32 Green Star - Office Design v2 Indoor Environment Quality credits IEQ-13 'Volatile Organic Compounds' [www.gbcaus.org](http://www.gbcaus.org)
- 33 Formaldehyde classified as human carcinogen International Agency for Research on Cancer, part of the World Health Organization, released information 06/15/04 [www.iarc.fr/ENG/Press\\_Releases/pr153a.html](http://www.iarc.fr/ENG/Press_Releases/pr153a.html)

#### Online Resources

##### Materials

Ecospecifier  
[www.ecospecifier.org](http://www.ecospecifier.org)

##### LCAid

[www.projectweb.gov.au/dataweb/lcaid/](http://www.projectweb.gov.au/dataweb/lcaid/)

Australian Environmental Labelling Association  
[www.aela.org.au](http://www.aela.org.au)

##### Embodied Energy

Canadian Architect  
[www.canadianarchitect.com/asf/perspectives\\_sustainability/measure\\_of\\_sustainability/measure\\_of\\_sustainability\\_embodied.htm](http://www.canadianarchitect.com/asf/perspectives_sustainability/measure_of_sustainability/measure_of_sustainability_embodied.htm)

##### CSIRO

[www.cmit.csiro.au/brochures/tech/embodied/](http://www.cmit.csiro.au/brochures/tech/embodied/)

National Pollutant Inventory  
[www.npi.gov.au/](http://www.npi.gov.au/)



**Figure 30.** Timber, image sourced from *Doncaster Hill Sustainability Guidelines*, Manningham City Council.



**Figure 31.** EcoCore doors, plantation veneers, New Age veneers.



**Figure 32.** Roof garden with use of recycled glass mulch, Reservoir Civic Centre, Darebin City Council.

## OPPORTUNITY 8 minimising waste



Figure 33: waste management in construction, DEH.

### 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. That is, do not order it if you do not need it; plan use so as to optimise material efficiency (design height for plasterboard size); put aside cut offs for later reuse; etc. (see figure 33).

### 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 being 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 noted above.

### Design Stage

The design stage produces very little waste comparatively. Yet this is the stage where many of the waste opportunities can be optimised. Some strategies are outlined below:

<b>Design for materials and design for standard sizes</b>	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.
<b>Design for flexibility</b>	Design spaces and systems that can easily adapted to changes in management and company structures.
<b>Design of assembly and disassembly</b>	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.
<b>Design using prefabricated components</b>	Linked to the above, use systems that can be prefabricated off site and then assembled on site saving waste and time.
<b>Design for ease of recycling</b>	Design waste areas with easy access and spaces on each floor that encourage staff to recycle.

### Documentation Stage

In preparing the specification 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. You can 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 impact, 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 accreditation 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

## OPPORTUNITY 8 minimising waste



**Figure 34:** Old building demolition for reuse, Reservoir Civic Centre, Darebin City Council.



**Figure 35:** Old building demolition for reuse, Reservoir Civic Centre, Darebin City Council.



**Figure 36:** Waste, image sourced from *Doncaster Hill Sustainability Guidelines*, Manningham City Council.

savings by implementing a waste and recycling reporting, auditing and management program 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, etc. as it 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 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.

*One government agency recently carried out an audit of the waste being taken away by a contractor over the period of two weeks. They were paying on the basis of a service (not mass charging) arrangement. They found that the contractor's guess about the amount going to landfill was 16 times more than their direct audit. The audit also found that they could reduce their waste to landfill by 75% by simply getting all staff to use the recycling facilities already available.*

### Online Resources

#### Waste

EcoRecycle Victoria  
Designing in Waste Minimisation design guide  
[www.ecorecycle.vic.gov.au/asset/1/upload/Designing\\_in\\_Waste\\_Minimisation\\_\(1998\).pdf](http://www.ecorecycle.vic.gov.au/asset/1/upload/Designing_in_Waste_Minimisation_(1998).pdf)

Cluses which can be used in waste management contracts  
[www.ecorecycle.vic.gov.au/asset/1/upload/Model\\_Contract\\_Clauses.pdf](http://www.ecorecycle.vic.gov.au/asset/1/upload/Model_Contract_Clauses.pdf)

Clean Up Australia  
[www.cleanup.com.au](http://www.cleanup.com.au)

#### Construction & Demolition

EcoRecycle Victoria  
Building Construction & Demolition Waste resources  
[www.ecorecycle.vic.gov.au/www/default.asp?casid=2636](http://www.ecorecycle.vic.gov.au/www/default.asp?casid=2636)

Resource NSW  
Construction & Demolition Section  
[www.resource.nsw.gov.au/cd2.html](http://www.resource.nsw.gov.au/cd2.html)

Department of the Environment and Heritage  
[www.deh.gov.au/industry/construction/wastewise/pubs](http://www.deh.gov.au/industry/construction/wastewise/pubs)

## OPPORTUNITY 9 water conservation

...studies show that reductions of up to approximately 80% of scheme 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.<sup>40</sup>

There are two topics 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 to 10% of water in Australia (the major users being agriculture at 70% and manufacturing at 20%)<sup>34</sup>, 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<sup>37</sup> (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 per cent of this.”<sup>38</sup>*

### 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<sup>39</sup> 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).

### 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.

Star Rating	Water Consumption (kl/m <sup>2</sup> /year)
1	1.50
2	1.25
2.5	1.125
3	1.0
4	0.75
5	0.5

Source: [www.deh.gov.au/settlements/government/water](http://www.deh.gov.au/settlements/government/water)

### OPTIMISING WATER CONSERVATION Potable Water Reduction Opportunities

There are many opportunities that can be implemented quickly and cheaply to reduce water consumption.

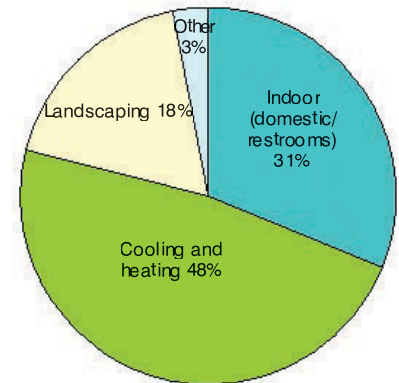


Figure 37: Breakdown of end use in a typical commercial building (US data<sup>35</sup>).

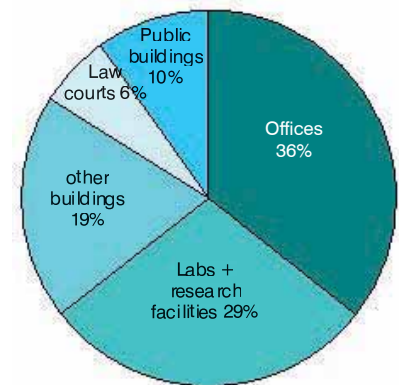


Figure 38: Breakdown of Australian Government Water use by Building Type excluding defence.<sup>36</sup>

34 ABS (May 2000), *Water Account for Australia* released by the ABS, for the year 1996-97.

35 California Urban Water Conservation Council (2001), *BMP 9 Handbook: A guide to implementing commercial, industrial, institutional conservation programs*, California Urban Water Conservation Council, California.

36 Chanan, V., White, S., Jha, M., & Howe, C. 2003, 'Sustainable Water Management in Commercial Office Buildings' *Innovations in Water: Ozwater Convention & Exhibition*, Perth, 6-10 April 2003.

37 Research done for the CH<sub>2</sub> 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.

38 Hennessy, S. (2004) *Where Every Drop Counts. Engage the Technical Bulletin of AHA Management*, vol. 5 (1). [www.aha.com.au/engage\\_v5\\_no1.htm](http://www.aha.com.au/engage_v5_no1.htm)

39 [www.isf.uts.edu.au/publications/VC\\_SW\\_CH\\_MJ\\_2003.pdf](http://www.isf.uts.edu.au/publications/VC_SW_CH_MJ_2003.pdf)

40 Chanan, V., White, S., Jha, M., & Howe, C. 2003, 'Sustainable Water Management in Commercial Office Buildings' *Innovations in Water: Ozwater Convention & Exhibition*, Perth, 6-10 April 2003.

## OPPORTUNITY 9 water conservation

### Government Buildings – Possible Water Savings

'The potential savings available from Australian Government buildings and operations are between 4,296 and 7,405 ML/year. This is based on savings assumptions by building type developed through the desktop study and site assessments. Achieving these savings would cost between \$8.2 and \$14.6 million based on cost assumptions derived from empirical case studies in the literature.'<sup>43</sup>

A recent study by the Institute for Sustainable Futures showed that an 80% reduction of potable water and 90% of sewage was possible in a commercial building

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. This 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 for positive feedback.
- Regular inspections of toilets, urinals, taps and showers.



Figure 40: Water image, stock.XCHNG.

### 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 floater to use minimal water
- 3/ 4.5L dual flush toilets
- Urinal flush controls – sensors
- Waterless Urinals

### Showers

- Flow regulators – 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 have a good shower

### Taps

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

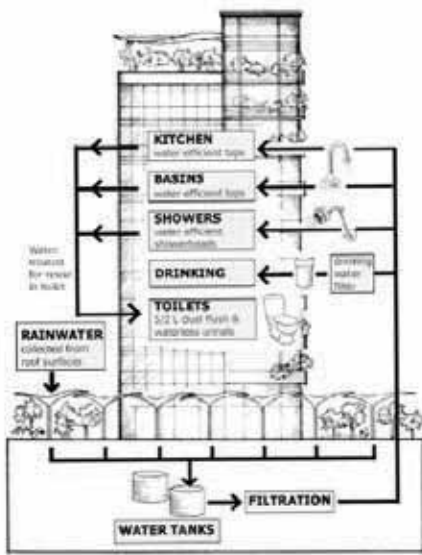


Figure 39: Water reduction methods<sup>42</sup>, ISF.

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 40kL/year. For the Edmund Barton building, with approximately 2,800 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.'<sup>41</sup>

41 Berry T., Edgerton N., Milne G., Jha M. and White S. (2004) *Feasibility Study for a Policy on Water in Government Operations*, ISF, Sydney, July 2004.) p. 41-42.

42 Chanan, V., White, S., Jha, M., & Howe, C. 2003, 'Sustainable Water Management in Commercial Office Buildings' *Innovations in Water: Ozwater Convention & Exhibition*, Perth, 6-10 April 2003.

43 Berry T., Edgerton N., Milne G., Jha, M. and White S. 2004, *Feasibility Study for a Policy on Water in Government Operations*, ISF, Sydney, July 2004.)

## OPPORTUNITY 9 water conservation

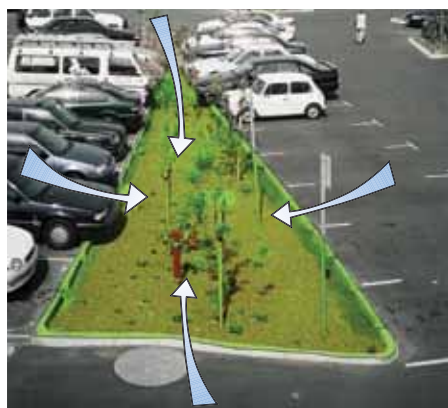
### Cooling towers

- Making sure float valves are correctly set.
- 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.
- Improving the overall efficiency of chillers through plant upgrades or waste heat recovery.

Further options for improving efficiency in cooling towers can be found in Sydney Water's "Best Practice Guidelines for Cooling Towers in Commercial Buildings" ([www.sydneywater.com.au/html/wcr/pdf/business/Sydney\\_Water\\_Best\\_Practice\\_Guidelines\\_Cooling\\_Towers\\_v6.pdf](http://www.sydneywater.com.au/html/wcr/pdf/business/Sydney_Water_Best_Practice_Guidelines_Cooling_Towers_v6.pdf)).

### Sprinkler water testing

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



**Figure 41.** Reservoir Civic Centre car park designed to collect rainwater into treed areas, Darebin City Council.

### Water Sensitive Landscaping (Xeriscape)

- Using native and indigenous plants for the garden as they require less water compared to exotic varieties.
- Using mulch in the landscape to minimise the loss of water from the soil by evaporation.
- Scheduling the irrigation time using timer controls so that irrigation is done after sunset, to minimise loss of water to evaporation.
- Installing 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. It is dependent on collection area, rainfall and amount of space available for water storage tanks.

### Grey water

Water 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 Gordon building has been recycling grey water since the late 1990s.

### Waste or Black water

Water from kitchens and toilets. Recycling this water is possible with

*'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'.<sup>44</sup>*

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 CH<sub>2</sub> that is planning to use a mechanical system.

### 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 DEH 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

<sup>44</sup> EA (2002) *Introduction to Urban Stormwater Management in Australia*, Environment Australia, Canberra. p. 50. [www.deh.gov.au/coasts/publications/stormwater](http://www.deh.gov.au/coasts/publications/stormwater)



## OPPORTUNITY 9 water conservation

### On-site stormwater detention (OSD)<sup>45</sup>

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



Figure 42. Queenscliff Ecocentre, DPI Victoria.

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.<sup>46</sup>

Green roofs are an example of one initiative that minimises several impacts – stormwater run off, 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 & Recovery (ASR)

These involve 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 and pumping it underground.<sup>47</sup>

- 45 Ribbons, S., Warwick, M. & Knight, G. (1995). Section 94 contributions or on-site detention: Council's dilemma. In Preprints of papers: the second international symposium on urban stormwater management 1995: *Integrated management of urban environments*, p. 27.
- 46 Urriola, Humberto (1999). Roof gardens: an environmental asset. In Wood, J.A. (ed.) (1999). *Water sensitive design & stormwater re-use: seminar proceedings*, 31 March 1999. Stormwater Industry Association: Sydney, p. 1.
- 47 Gerges, N.Z. *Aquifer storage and recovery: type and selection of aquifer*. Primary Industry and Resources, Canberra.

### Online Resources

#### Water

#### Stormwater

<http://www.deh.gov.au/coasts/publications/stormwater/pubs/stormwater.pdf>

#### Savewater.com.au

<http://www.savewater.com.au>

#### City of Calgary – water conservation ideas

<http://content.calgary.ca/CCA/City+Hall/Business+Units/Waterworks/Commercial>

#### Clearwater

<http://www.clearwater.asn.au/>

#### Water Efficiency Labelling

[www.deh.gov.au/water/urban/scheme.html](http://www.deh.gov.au/water/urban/scheme.html)

#### Water Saving Gardens

#### Yarra Valley Water

<http://www.yvw.com.au/environment/water-saving-plants.html>

## OPPORTUNITY 10 land use and ecology



Figure 43. Queenscliff Ecocentre, DPI Victoria.

The DPI Queenscliff research facility in Victoria minimised its impact by providing for regeneration, provision of habitat and minimal site disturbance. This involved the remediation of the site and the construction of wetlands.



Figure 44. Native grasses use in the Reservoir Civic Centre, Darebin City Council.

### IMPORTANCE OF LAND USE AND PROTECTION OF ECOLOGY

The main issues with the choice of land to be used for a building are to consider if it is an efficient use of the land and if it protects biodiversity. 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<sup>48</sup>, and more than 50% of threatened species, occur in urban fringe areas.<sup>49</sup> 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 NSESD.

### 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.<sup>50</sup>

#### Online Resources

#### Land use and Ecology

Department of the Environment and Heritage

[www.deh.gov.au/biodiversity/toolbox](http://www.deh.gov.au/biodiversity/toolbox)

Australian Museum

[www.austmus.gov.au/biodiversity/](http://www.austmus.gov.au/biodiversity/)

48 Newman et al. (2001) *Human Settlements Theme, Australia State of the Environment Report 2001*. An independent report to the Commonwealth Minister for Environment, Department of Environment, Sport and Territories. CSIRO Publishing, Melbourne.

49 Yencken D. and Wilkinson D. (2000) *Resetting the Compass: Australia's Journey Towards Sustainability*. CSIRO Publishing, Melbourne.

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

## 8 Brindabella Circuit



**Figure 45.** Image used with permission of Daryl Jackson Alastair Swain Pty Ltd. 5 Star, Green Star - Office Design v1

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

<b>Energy</b>	610MWh per year (141 kWh/m <sup>2</sup> )
<b>Water</b>	775 kL per year
<b>Greenhouse Gas Emissions</b>	552 Tonnes CO <sub>2</sub> (128kgCO <sub>2</sub> /m <sup>2</sup> )
<b>Capital cost</b>	12% above conventional office building
<b>Savings</b>	\$30,103 per year on energy costs
<b>Payback</b>	Figure not yet available

### 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

<b>BUILDING TYPE</b>	<b>New</b>
<b>CLIMATE</b>	<b>Temperate</b>
<b>LOCATION</b>	<b>Canberra, ACT</b>
<b>CLIENT</b>	<b>Canberra International Airport</b>
<b>PROJECT MANAGER</b>	<b>Construction Control</b>
<b>ARCHITECTS</b>	<b>Daryl Jackson Alastair Swain Pty Ltd</b>
<b>ENGINEERS</b>	<b>Rudds Consulting Engineers, Cardno Youngs</b>
<b>SIZE</b>	<b>4313m<sup>2</sup> net lettable area</b>

- 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

8 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 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.

## 8 Brindabella Circuit

### 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, provide 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 watt T5 fittings for all tenant lighting, reducing the lighting load to approximately 9 watts/m<sup>2</sup> (ordinarily 15 watts/m<sup>2</sup> 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 m<sup>2</sup> 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. Water sub meters featuring leak

*"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."*



**James Andrews, Associate Architect, Daryl Jackson Alastair Swayn**

detection systems are installed on all water uses in the building, including cooling towers. In non-monitored buildings, water leakages typically account for 25% of water consumption.

All water used for irrigation at Brindabella Business Park and the entire airport precinct is recycled, rainwater or is non-potable groundwater. Since switching to this system, Canberra International Airport has not had to draw on the ACT's potable water supply for irrigation. In addition, a low water use/high efficient system has been designed. This consists of local drippers and in-soil wetting blankets.

### 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.

## 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 is of 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 100m<sup>2</sup> in a standard building to 35m<sup>2</sup>. This leads to improved occupant satisfaction within the space.

External 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 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  
[www.canberraairport.com.au/5greenstar.htm](http://www.canberraairport.com.au/5greenstar.htm)

*"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

<b>BUILDING TYPE</b>	<b>New</b>
<b>CLIMATE</b>	<b>Temperate</b>
<b>LOCATION</b>	<b>Millers Point, Sydney</b>
<b>CLIENT</b>	<b>Deutsche Office Trust</b>
<b>ARCHITECTS</b>	<b>Lend Lease Design, PTW Architects, AEC</b>
<b>ENGINEERS</b>	<b>Bovis Lend Lease, Arup, Lincolne Scott</b>
<b>SIZE</b>	<b>19,700 m<sup>2</sup> net lettable area</b>



Figure 46. 30 The Bond, Bovis Lend Lease.

30 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 OUTPUTS

<b>Energy</b>	1243 mWh per year (63kWh/m <sup>2</sup> )
<b>Water</b>	Figure not yet available
<b>Greenhouse Gas Emissions</b>	1,162,300kg CO <sub>2</sub> per year (59kg CO <sub>2</sub> /m <sup>2</sup> )
<b>Capital cost</b>	\$112 million
<b>Savings</b>	\$157,000 per year (compared to 3 star AGBR building)
<b>Payback</b>	No additional costs

### KEY AREAS OF ACHIEVEMENT

- The building features a 5 star *ABGR* energy rating, the first office building in Australia to sign a commitment agreement.
- 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

The management have taken thorough steps to ensure the ESD initiatives incorporated into the design have been maintained during the crucial stage of the building’s life cycle: operation.

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. They have also conducted half-yearly presentations to staff regarding

the results of their pre and post-occupancy evaluations of the building.

An internal website is updated each month with waste, water and energy results so staff can track their progress. Another website available is an A-Z users’ guide, so staff have detailed information on a variety of topics from the chilled beams to wintergardens, at their fingertips.

### 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 percent 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

Staff identified indoor environment quality as one of the important issues they wished to address.

Fresh air is constantly supplied throughout the building. Broad leaf plants placed around offices help oxygenate the air.

Low VOC materials were chosen where possible.

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 5% of 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

Eco friendly building 2004, radio broadcast, Earthbeat - ABC Radio National, Sydney, 24/02/05. Transcript available: [www.abc.net.au/rn/science/earth/stories/s1124840.htm](http://www.abc.net.au/rn/science/earth/stories/s1124840.htm)

Architecture Week. 2003, Sustaining Sydney Spaces, Architecture Week, [www.architectureweek.com/2004/0714/design\\_1-1.html](http://www.architectureweek.com/2004/0714/design_1-1.html)

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

Lend Lease. 2003, Lend Lease Unveils Australia's First Five Star Greenhouse Office Building, Lend Lease, [www.lendlease.com.au/llweb/llc/main.nsf/all/news\\_20030430](http://www.lendlease.com.au/llweb/llc/main.nsf/all/news_20030430)

*"In terms of artificial components on energy efficiency, we have T5 lighting... We're achieving 6.7 watts per square metre...."*



*Energy efficiency*

30 the Bond  
Paul Edwards, General Manager,  
Environment Sustainability Initiatives, Lend  
Lease Australia Pacific

# CH<sub>2</sub>, Council House 2

<b>BUILDING TYPE</b>	<b>New</b>
<b>CLIMATE</b>	<b>Temperate</b>
<b>LOCATION</b>	<b>Melbourne, Victoria</b>
<b>CLIENT</b>	<b>City of Melbourne</b>
<b>PROJECT MANAGER</b>	<b>City of Melbourne</b>
<b>ARCHITECTS</b>	<b>Mick Pearce (CoM) and DesignInc</b>
<b>ENGINEERS</b>	<b>Lincolne Scott, AEC, Bonacci Group</b>
<b>SIZE</b>	<b>9,373m<sup>2</sup> net lettable area</b>

The City of Melbourne’s Council House 2 (CH<sub>2</sub>) has achieved a 6 Star Green Star - Office Design v1 certified rating. Set in the heart of Melbourne CBD, CH<sub>2</sub> will house 540 council employees as well as incorporate retail outlets on the lower floors. Sustainable principles have been incorporated 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. This project is expected to be

### BUILDING OUTPUTS

<b>Energy</b>	515.5 mWh per year (55 kWh/m <sup>2</sup> )
<b>Water</b>	100kL mined per day, 72% reduction in potable water use
<b>Greenhouse Gas Emissions</b>	562 Tonnes CO <sub>2</sub> per year (60kgCO <sub>2</sub> /m <sup>2</sup> )
<b>Capital cost</b>	\$51 million for the building excluding fitout
<b>Savings</b>	\$1.2 million per year
<b>Payback</b>	Around 10 years

**Note:** This building is still in construction stage. 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 beams as the air conditioning 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.

### PROJECT BACKGROUND

The Melbourne City Council is known for its role as a leading green organisation and wanted the design of their new council building to reflect their position. They 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



**Figure 47.** CH<sub>2</sub> Swanston Street view, City of Melbourne. 6 Star, Green Star - Office Design v1

developed and available to all building users, occupiers and tenants to promote effective and efficient use of the building.

### ENERGY

Chilled beams 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 beams.

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 at night.

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.



## CH<sub>2</sub>, Council House 2

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 100m<sup>2</sup>. They use high frequency T5 ballasts that achieve lighting power density of less than 2.5 Watts/m<sup>2</sup> per 100 lux. Task lighting is provided to employee work areas.

Highly energy efficient equipment such as LCD monitors are used.

### 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. This comprises 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 supply normally supplied by the co-generation plant.

### IEQ

One hundred percent fresh air is funnelled down vertical turbine shafts that supply air to the office space via vents in the floor. These vents can be adjusted by the users for comfort.

CO<sub>2</sub> levels in the air are constantly monitored and fresh air supplied accordingly.

Natural light is provided where possible. The lower levels, which are exposed to less light than upper levels, 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. Light levels are kept to 320 lux. Task lighting will be provided for individuals.

Plants are specifically selected for their ability to filter toxins for 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.

### MATERIALS

Sixty percent recycled steel was used for structural components. This had to be sourced from outside Australia to guarantee the recycled content.

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

Ninety percent of the timber used is recycled or sustainably harvested.

PVC use in hydraulics and electrical components has been eliminated.

### WASTE

During the construction period, CH<sub>2</sub>'s contractors will recycle 80% of the construction waste.

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

### EMISSIONS / TRANSPORT

CH<sub>2</sub> 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](http://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."*



*Night flushing*

CH<sub>2</sub>  
Mick Pearce, Design Manager, City of Melbourne

# 743 Ann Street

<b>BUILDING TYPE</b>	<b>Existing - Refurbished</b>
<b>CLIMATE</b>	<b>Warm - Humid</b>
<b>LOCATION</b>	<b>Fortitude Valley, Brisbane</b>
<b>CLIENT</b>	<b>PMM Group</b>
<b>ARCHITECTS</b>	<b>TVS Partnership Architects</b>
<b>ENGINEERS</b>	<b>Lincolne Scott</b>
<b>SIZE</b>	<b>1821.07m<sup>2</sup> net lettable area</b>



Figure 48. 743 Ann Street, TVS Partnership.

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

### BUILDING OUTPUTS

<b>Energy</b>	Figure not yet available
<b>Water</b>	1,138kL per year
<b>Greenhouse Gas Emissions</b>	Figure not yet available
<b>Capital cost</b>	\$4.4 million (including acquisition)
<b>Savings</b>	Figure not yet available
<b>Payback</b>	Figure not yet available

### 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 1,000 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 programs 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 programs.

### 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 vermiculture 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

The PMM Group were 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

CD Rom: 743 Ann St Brisbane Redevelopment for the future, EPA Qld & PMM Group 2003.

*"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..."*



*Energy efficiency initiatives*  
743 Ann Street  
Mark Thomson, Director, TVS Partnership

# SES Headquarters

<b>BUILDING TYPE</b>	<b>New</b>
<b>CLIMATE</b>	<b>Temperate</b>
<b>LOCATION</b>	<b>Melbourne, Victoria</b>
<b>CLIENT</b>	<b>Victorian State Emergency Services</b>
<b>ARCHITECTS</b>	<b>H2o Architects</b>
<b>ENGINEERS</b>	<b>AHW</b>
<b>SIZE</b>	<b>1700 m<sup>2</sup> net lettable area</b>



Figure 49. SES Headquarters, H2o architects.

The new Victorian State Emergency Services headquarters are 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.

### BUILDING OUTPUTS

<b>Energy</b>	510 mWh per year (300 kWh/m <sup>2</sup> )
<b>Water</b>	Figure not yet available
<b>Greenhouse Gas Emissions</b>	Figure not yet available
<b>Capital cost</b>	\$3.5 million construction costs, \$6.5 million total end costs
<b>Savings</b>	Figure not yet available
<b>Payback</b>	Figure not yet available

### KEY AREAS OF ACHIEVEMENT

- Maximising use of natural lighting to reduce need for artificial lighting.
- Solar hot water panels provide most water heating requirements.
- Central ducted vacuum system takes dust and other pollutants outside into a collector located in the car park, rather than allowing portions to escape into the air from conventional vacuums.

### 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.

### ESD CONSIDERATIONS

#### ENERGY

Natural lighting is an important energy saving feature in the design of the building. The main façade is orientated towards a southerly direction with minimal exposure to the west and south. North facing clearstory windows provide most of the natural light needed for most of the year. Internal light shelves direct and diffuse the light into the office spaces through the clerestory louvre windows. External shading has been designed so that it limits the amount of sunlight and solar radiation in the summer, whilst allowing both to enter in the winter period.

Artificial lighting is supplied by low-energy, high frequency T5 tubes. These uprights 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.

## SES Headquarters

### 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 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

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- *Steel Profile* (Melbourne / Australia), December 2002, cover and pages 30 – 38.
- *The Architectural Review* (London / United Kingdom), issue 1274, April 2003, pages 52 – 55.
- *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**

# Waalitj Building: Murdoch University

<b>BUILDING TYPE</b>	<b>New</b>
<b>CLIMATE</b>	<b>Hot dry, cold winter</b>
<b>LOCATION</b>	<b>Perth, Western Australia</b>
<b>CLIENT</b>	<b>Murdoch University, Environmental Technology Centre</b>
<b>ARCHITECTS</b>	<b>Earth House, Marco Vittino</b>
<b>ENGINEERS</b>	<b>Consortium Builders and Healey Engineering</b>
<b>SIZE</b>	<b>100m<sup>2</sup> of office space plus lecture, gallery and teaching areas</b>



**Figure 50.** Waalitj building, Murdoch University.

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 OUTPUTS

<b>Energy</b>	Figure not yet available
<b>Water</b>	252 l/day
<b>Greenhouse Gas Emissions</b>	Figure not yet available
<b>Capital cost</b>	\$320,000
<b>Savings</b>	Figure not yet available
<b>Payback</b>	Figure not yet available

### 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.
- Sewerage 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.

### 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 so that it can 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.

A Photovoltaic System on the roof generates 3kW 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.

## Waalitj Building: Murdoch University

### WATER

The Waalitj building utilises storm water and black water to minimise use of potable water. 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 bio-mimicry. 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 colling 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 252L/day or 92kL/year.

### 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 buildings to provide shade for the buildings and for landscaping around the complex. A mixture of low-water use plants as well as 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 have 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 made up mostly of recycled red brick. They are also 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  
[www.wies.murdoch.edu.au/etc/pages/waalitj/wpages/backg.htm](http://www.wies.murdoch.edu.au/etc/pages/waalitj/wpages/backg.htm)

# National Museum of Australia

<b>BUILDING TYPE</b>	<b>New Museum</b>
<b>CLIMATE</b>	<b>Temperate</b>
<b>LOCATION</b>	<b>Canberra, ACT</b>
<b>CLIENT</b>	<b>Commonwealth and ACT Governments</b>
<b>ARCHITECTS</b>	<b>An association of Ashton Raggatt McDougall and Robert Peck von Hartel Trethowan</b>
<b>BUILDING CONTRACTORS</b>	<b>Lend Lease Projects</b>
<b>SERVICES CONTRACTORS</b>	<b>Tyco International and Honeywell</b>
<b>EXHIBITION DESIGN</b>	<b>Anway and Company Inc, Boston USA</b>
<b>SIZE</b>	<b>6600m<sup>2</sup> of exhibition space</b>



**Figure 51.** National Museum of Australia. Photo George Serras.

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 their 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 watt, 10 degree angle dichroic lamps with 35 watt 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 watt 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 program 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 watt lamps were utilised, we have re-lamped with 300 watt lamps, gaining a reduction in energy usage while maintaining lighting levels in the concourse areas.

The Dynalite system allows us 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 to the areas.



## National Museum of Australia

### THERMAL MASS & PASSIVE DESIGN

The actual National Museum building is of 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. There are 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 (CO<sub>2</sub>) sensors to allow for greater fresh air flow when CO<sub>2</sub> levels increase within specific zones.

### MATERIALS

The architects have utilised 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 National 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 National 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

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

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

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.

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 Ngannawal 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.

## National Museum of Australia

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 National Museum also integrates environmentally sustainable development information into exhibitions when appropriate i.e. Tangled Destinies gallery.

### REFERENCES

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Figure 52. National Museum of Australia, Interior of Main Hall. Photo John Gollings.

## 60L: 60 Leicester Street

<b>BUILDING TYPE</b>	<b>Part new and part existing – Refurbished</b>
<b>CLIMATE</b>	<b>Temperate</b>
<b>LOCATION</b>	<b>Carlton, Victoria</b>
<b>CLIENT</b>	<b>The Green Building Partnership</b>
<b>ARCHITECTS</b>	<b>Spowers</b>
<b>ENGINEERS</b>	<b>AEC, John Mullen &amp; Partners. Lincolne Scott</b>
<b>SIZE</b>	<b>3375m<sup>2</sup> lettable floor space</b>



Figure 53. 60 Leicester Street, Carlton.

60 Leicester Street is located in Carlton, an inner suburb of Melbourne. Built in the late 1800's 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

<b>Energy</b>	Uses 30% of the average energy consumption of commercial office buildings in Melbourne.
<b>Water</b>	Reduced mains water consumption by over 80% compared to a conventional building.
<b>Greenhouse Gas Emissions</b>	Zero - purchases 100% new green power and is therefore considered "greenhouse neutral".
<b>Project cost</b>	\$8 million.
<b>Savings</b>	Figure not available.
<b>Payback</b>	Figure not available.

### 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 250mWh 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

## 60L: 60 Leicester Street

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/m<sup>2</sup> compared to 20W/m<sup>2</sup> 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:

Water efficient fixtures such as low-flow shower heads which discharge 5L per minute and dual flush 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.

## 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 19-26°C comfort band in passive mode. When the external ambient temperature is outside this margin, 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 replace 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.

Products with low levels of VOC emissions (including paints and carpets) were chosen where possible, and the use of glues, sealants and paints with high VOC (Volatile Organic Compounds) levels minimised.

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

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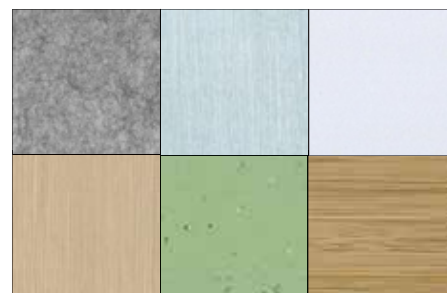


Figure 54. Low VOC materials selection.



Figure 55. Cyclist, image sourced from *Doncaster Hill Sustainability Guidelines*, Manningham City Council.

# 40 Albert Road

<b>BUILDING TYPE</b>	<b>Retrofit of existing office block</b>
<b>CLIMATE</b>	<b>Temperate</b>
<b>LOCATION</b>	<b>South Melbourne, Victoria</b>
<b>CLIENT</b>	<b>Szencorp</b>
<b>PROJECT MANAGER</b>	<b>Lascorp</b>
<b>ARCHITECTS</b>	<b>SJB Architects</b>
<b>ENGINEERS</b>	<b>Connell Mott Macdonald, Energy Conservation Systems</b>
<b>SIZE</b>	<b>1,215m<sup>2</sup> net lettable area</b>



Figure 56. 40 Albert Road, Szencorp.

40 Albert Road sets a new benchmark in office refurbishment achieving a 6 Star Green Star - Office Design certified rating, combining cutting edge sustainable design with a high-end look and feel. This 1,200m<sup>2</sup> office building in South Melbourne is the new headquarters of the Szencorp group of companies, who provide 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

<b>Energy</b> (Gas and electricity)	163 MWh per year (134kWh/m <sup>2</sup> electricity)
<b>Water</b>	61 kL per year
<b>Greenhouse Gas Emissions</b>	142 tonnes CO <sub>2</sub> per year
<b>Capital cost</b>	No applicable business decision
<b>Savings</b>	No applicable business decision
<b>Payback</b>	No applicable business decision

### 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.

- Aiming to be the first building in Australia to produce zero net emissions.
- Australian first use of ceramic fuel cells to reduce electricity used from the grid.
- Australian first use of the DryKor dry conditioning unit, which dries and cools the office space simultaneously, using a desiccant to absorb the water vapour from the air.
- Australian first use of natural gas engine AC units.

### 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 program 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 façade 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 the 5 star ABGR rating aimed for, auditing and building tuning will be performed over 10 years. Extensive commissioning of the building will also be undertaken.

A Building Users’ Guide will be available online and will provide tenants with all necessary instructions on how to properly use the building’s facilities. Performance will also be displayed online, linking the actual performance with information on how to improve it.

The innovations at 40 Albert Road are being demonstrated to the building development and management community, and the wider public. Controlled free access to the building and its systems are provided for educational and commercial purposes. The roof layout provides access to the PV arrays, the gas engine AC units, the DryKor

## 40 Albert Road

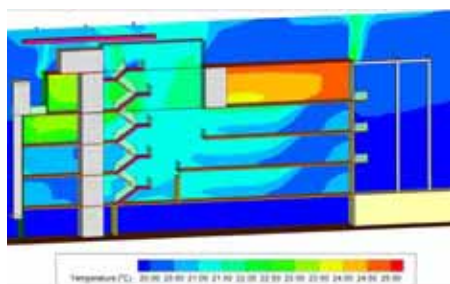


Figure 57. 40 Albert Road, temperature distribution by CMM, Szencorp.

de-humidifier and the ceramic fuel cell. As well, there is a comprehensive weather station and 59 individual meters monitoring the various building systems, including the PV arrays, DryKor unit, gas engine VRV, the fuel cell, rainwater/ grey water harvesting and re-use, natural ventilation, lighting, and occupancy. Energy Conservation Systems have provided many of the energy conservation measures under an Energy Performance Contract which guarantees outcomes and eliminates technical and financial risks.

### ENERGY

The building is expected to consume 163MWh of energy per year, made up of 95 MWh of electric energy and 68MWh gas. 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, for the control of the mixed mode ventilation, 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).

Each floor is split into several zones, where temperature, humidity,

daylight, lighting levels, air quality and occupancy are monitored. The system supplements passive thermal, ventilation and lighting systems with active systems as necessary. When a zone is unoccupied, active lighting and thermal systems are shut down to save energy. Electricity, gas and water usage is remotely monitored and SMS messaging is used to alert maintenance personnel of abnormal situations.

The Managed Lighting System (MLS) control system is a network of motion sensors that control lighting in offices in response to occupancy and dims lighting to compensate for natural lighting levels or lamp degradation. Energy efficiency is achieved by maintaining lighting only in zones that are occupied. Lighting will switch on automatically upon entering a zone and switch off when the zone is vacated after a delay. This functionality is designed to be adjustable to support flexibility. Similarly, the zoning can be adjusted to suit the office environment.

The ventilation system is mixed mode, with natural ventilation supplied by open windows and mechanical ventilation supplied by ceiling mounted fan coil units that have a damper to close off outside air. The roof-mounted gas engine driven air conditioning units are a first for Victoria. Using internal combustion engine technology, rather than electric motor conditioning units, provides several benefits. First, avoiding grid electricity use results in a lower overall contribution to global climate change emissions. Secondly, it reduces demand on the electricity grid, which cuts down on the need to upgrade the infrastructure. Thirdly, it cuts electricity demand at peak periods, thus reducing peak tariff usage.

*“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.”*

Ceramic fuel cells will reduce the building's demand for grid electricity. This will be the first ceramic fuel cell in commercial operation in Australia. Fuel cells use chemical reactions rather than combustion reactions to provide electrical power. Reactants are continually fed into the process to provide ongoing power output. The waste heat generated during power production will be used to provide the building with hot water. This hot water system is supplemented by a solar hot water panel with gas boost. This will result in the building saving approximately 12 MWh per annum by utilising solar energy to produce the majority of the domestic hot water.

A 1 MWh per annum amorphous PV array plus a 4.8 MWh per annum crystalline Origin PV array, both grid connected, will provide additional electricity to the building.

The central vacuum system saves energy as it can be used during office hours, so there is no need to run lighting and air conditioning out of hours for cleaning purposes. Also, cleaning with a central system is 40% faster than portable machines.

Significant energy savings are also achieved by linking the car park exhaust fans to the Building

## 40 Albert Road

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

Management System. These fans will only operate when the carbon monoxide sensors in the car park indicate that vehicles are being operated.

### 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 throughout, 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 4,400 litres of rainwater storage, estimated to be enough for 3 weeks of normal flushing.

The combination of these measures is expected to reduce freshwater consumption from the building by 82% compared to the original design while discharge to sewer will be reduced by 72%.

### 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 out. 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 addresses “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. Further, there are 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. For the majority of the time, artificial lighting will be dimmed up to eight metres away from the windows.



Figure 58. 40 Albert Road, Szencorp.



## 40 Albert Road

Sunlight glare is controlled through the full length shading screens to the east façade and the use of high performance low glare glazing. In addition, manually operated internal blinds are provided to all windows, as are automated blinds to the skylights and atrium.

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. 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.

### MATERIALS

Most of the reinforced concrete structure and 88% of the original façade has been 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. There are plans for recycling of organic waste and toner cartridges.

### EMISSIONS/TRANSPORT

The Drykor and AC units use no ozone depleting refrigerants, and the building, ductwork and pipe work insulation is similarly free of all ozone depleting substances. Kyoto compliant greenhouse credits will be 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.

*“40 Albert Rd will demonstrate innovative strategies and outcomes for the built environment that are anticipated to become standard practice over the next decade. It has been designed as a live case study with ongoing real time monitoring and verification and an ongoing test bed for new products and services.”*

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.

### REFERENCES

The Greening of 40 Albert Road  
[www.ourgreenoffice.com/](http://www.ourgreenoffice.com/)



Figure 59. 40 Albert Road, initial plans, Szencorp.



Figure 60. 40 Albert Road, initial plans, Szencorp.



Figure 61. 40 Albert Road, initial plans, Szencorp.

## Galleries, Museums and Libraries

Galleries, libraries and museums 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



Figure 62. National Gallery of Victoria, John Gollings.

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 floors<sup>43</sup>. 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. There is bright glass on the north side of the building which lets in a large amount of daylight.

<sup>43</sup> Paul Walker, 2004, 'New Interiors by Mario Bellini and Metier 3', *Architecture Australia*, March/April 2004.

## 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 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."<sup>44</sup>*

### 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 watts to 300 watts – this policy will be extended into all galleries and operational areas.
- Exhibition lighting has been changed from 50 watt to 35 watt dichroic lighting which creates a higher light output but reduced colour fade<sup>45</sup>.
- Installation of 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 percent 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 & PASSIVE DESIGN

#### Queensland Art Gallery

In the planning and design of the new Queensland Art Gallery, modelling was performed to plan the solar shading and thermal load on radiant

insulation. One of the main issues was dealing with the humidity and weather conditions in such a way that steady internal temperatures could be maintained and intermediary zones managed.

#### 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.



Figure 63. Reading room, use of natural light, State Library Victoria.

44 J Allen [Frederick R. Weisman Art Museum] 2005, pers.comm., 23 March.

45 National Museum of Australia, 2003, *Land Nation People: The Annual Report of National Museum of Australia 2002-2003*, National Museum of Australia Press, Canberra.

## Galleries, Museums and Libraries

### 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 percent 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 are:

- 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.
- Cleaning materials used should meet AS/NZ ISO 14001:1996 'Environmental Management Systems – specifications with guidance for use' and AS/NZ 14004:1996 'Environmental Management Systems - general guidelines of principles, systems and supporting techniques.'<sup>46</sup> These systems specify good practice processes and systems rather than specific product selection.

### 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 minimized, 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.

### 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.

#### 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 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.

<sup>46</sup> National Museum of Australia, 2004, *National Museum of Australia Annual Report 2003-2004*, National Museum of Australia Press, Canberra.

## Galleries, Museums and Libraries

### PROJECT MANAGEMENT

#### The 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.

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*The National Museum of Australia*  
[www.nma.gov.au](http://www.nma.gov.au)

*National Gallery of Victoria, International*  
[www.ngv.vic.gov.au/ngvinternational/](http://www.ngv.vic.gov.au/ngvinternational/)

*State Library of Victoria*

[www.slv.vic.gov.au](http://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](http://www.doi.vic.gov.au/web3/majorproj.nsf)

*East Melbourne Library*

For information see the City of Melbourne's website:

[www.melbourne.vic.gov.au/info.cfm?top=146&pg=1139](http://www.melbourne.vic.gov.au/info.cfm?top=146&pg=1139)

*Peckham Library*

Architects

[www.alsoparchitects.com](http://www.alsoparchitects.com)

Consulting Engineers

[www.battlemccarthy.com](http://www.battlemccarthy.com)

*Mark Twain House Museum*

[www.marktwainhouse.org/themuseum/index.shtml](http://www.marktwainhouse.org/themuseum/index.shtml)

*Frederick R Weisman Art Museum, University of Minnesota*

For the interactive learning site about the architecture of the building see:

[www.weisman.umn.edu/architecture/surprises/home.html](http://www.weisman.umn.edu/architecture/surprises/home.html)

*LEED* (Leadership in Energy and Environmental Design – program and rating system administered by the U.S. Green Building Council)

[www.usgbc.org/](http://www.usgbc.org/)



**Figure 64.** National Gallery of Victoria, John Gollings.

# glossary

## A

### ABGR

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. (DEUS, 2005).

### Adaptive Comfort

Adds Human behaviour to the comfort analysis. It assumes that, if changes occur in the thermal environment to produce discomfort, then people will generally change their behaviour and act in a way that will restore their comfort. Such actions could include taking off clothing, reducing activity levels or even opening a window. The main effect of such models is to increase the range of conditions that designers can consider as comfortable, especially in naturally ventilated buildings where the occupants have a greater degree of control over their thermal environment. (Andrew Marsh Square one - <http://www.squ1.com>).

### Adhesives

A substance capable of holding materials together by surface attachment. Adhesives are one source of off-gassing in indoor environments. (Property Council of Australia, Sustainable Development Guide, 2001).

### AGO

Australian Greenhouse Office, now part of the Australian Government's Department of the Environment and Heritage.

### Air quality

To do with the level of particulate, gases, vapours, pollens and micro-organisms in the air. (Property Council of Australia, Sustainable Development Guide, 2001).

### 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

Australian Council of Building Design Professionals – BPD has published a multi-volume Environment Design Guide containing literature on how to reduce environmental impact of the built environment. (Melbourne Docklands ESD Guide, Oct 2002).

### 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](http://www.corusconstruction.com/page_9041.htm)).

### Building monitoring systems or Building Management System (BMS)

Also referred to at times as the Building Management System. 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 maximize safety, security, operational performance and for overall cost minimization 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).

### Carbon dioxide equivalent gases

Greenhouse gases that contribute to the greenhouse effect are referred to as carbon dioxide equivalent gases since this is the most abundant greenhouse gas. (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](http://www.corusconstruction.com/page_9041.htm)).

### Cogeneration

Generation of electricity combined with the production of heat for commercial or industrial use. Excess electricity produced can be fed back into the power grid. Cogeneration is an energy efficient way of using fossil fuels. (National Greenhouse Strategy <http://ngs.greenhouse.gov.au/glossary/>).

# glossary

## Commercial buildings

Typically refers to any non-residential building such as a shopping center, 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).

## D

### Deconstruction

A technique which is based on the old practice of dismantling buildings to enable redundant materials to be salvaged for reuse and recycling. (Corus Construction Centre glossary, [http://www.corusconstruction.com/page\\_9041.htm](http://www.corusconstruction.com/page_9041.htm)).

## Demountable

Components or whole buildings which can be dismantled and re-erected elsewhere. (Corus Construction Centre glossary, [http://www.corusconstruction.com/page\\_9041.htm](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](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).

## E

### 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](http://www.corusconstruction.com/page_9041.htm)).

### EMP

Environmental Management Plan – this document outlines the environmental requirements and responsibilities (of developers and the Docklands Authority 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).

## Environmentally 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](http://www.australianpaper.com.au/environs/glossary.asp)).

# glossary

## Fuel Cells

Used in electrical generation. This is an apparatus used for combining fuel and oxides to generate electricity. It is the conversion of chemicals to electrical energy. (Energy Australia [www.energy.com.au](http://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 310
- 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.htm](http://www.corusconstruction.com/page_9041.htm)).

### Greenhouse gases

Gases which contribute to global warming by preventing the outward radiation of heat from the Earth which increases the atmosphere's absorption of sunlight (the greenhouse effect). Greenhouse gases are measured in carbon dioxide equivalent units. Some greenhouse gases are naturally occurring (water vapour, carbon dioxide, methane, nitrous oxide and ozone). Others result from human activities, the most powerful of which are: hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF<sub>6</sub>). (Property Council of Australia, Sustainable Development Guide, 2001).

### Green lease schedule

A lease schedule that sets out the mutual obligation for building owners, managers and tenants regarding environmental performance.

### Green power

Electricity generated from clean renewable sources, such as the sun, wind, water and organic matter. The electricity is bought

by energy suppliers on behalf of their customers. (Property Council of Australia, Sustainable Development Guide, 2001).

### 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.).

### 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

### Hydro-chlorofluorocarbons (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).

### Hydro fluorocarbons (HFCs)

Transitional 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 organizations, the World Meteorological Organization (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.

Its reports are widely cited and have been highly influential in forming national and international responses to climate change, yet some of the scientists whose work is summarized in these reports have accused the IPCC of bias.

### Indoor air quality (IAQ)

Includes the introduction and distribution of adequate ventilation air, control of airborne contaminants and maintenance of acceptable temperature and relative humidity. (Property Council of Australia, Sustainable Development Guide, 2001).

### 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

International standards for EMS' - ISO14001 and ISO14004 are international standards concerning Environmental Management Systems, and include specifications and guidelines. (Melbourne Docklands ESD Guide, Oct 2002).

### 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).

## J

## 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).



## glossary

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).

**L****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.

**M****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).

**N****NABERS**

National Australian Built Environment Rating System – an environmental rating tool for non-residential buildings that is now being developed by the Commonwealth Government. (Property

Council of Australia, Sustainable Development Guide, 2001).

**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).

**NESD**

National Strategy for Ecologically Sustainable Development, it 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.

**O****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**

The energy consumed in heating, cooling, lighting and powering equipment and appliances in buildings. (Corus Construction Centre glossary, [http://www.corusconstruction.com/page\\_9041.htm](http://www.corusconstruction.com/page_9041.htm)).

**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](http://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).

**P****Photo Electric Cell (PE)**

These are used to monitor the amount of light in a room.

**Phase Change Materials**

materials which turn from one phase to another (for example liquid to gas, or solid to liquid) at a certain temperature – such as waster at zero degrees Celsius.

**Photovoltaic**

Generation of electricity from the energy of sunlight using photocells. (Property Council of Australia, Sustainable Development Guide, 2001).

**PMV**

Predicted Mean Vote. This international measure, used for determining thermal comfort, is based on surveys of the most acceptable levels of indoor temperature, humidity and radiant heat for different clothing and activity levels. (Melbourne Docklands ESD Guide, Oct 2002).

**Polychlorinated biphenyls (PCBs)**

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

**Poly-vinyl 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**

Water that is fit for human consumption. (Property Council of Australia, Sustainable Development Guide, 2001).

**PPD**

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).

# glossary

## Q

## R

### 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 your 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

Site Environmental Management Plan – this document guides and sets standards for construction and operation of new developments. It includes strategies and processes to manage and minimise environmental impacts. (Melbourne Docklands ESD Guide, Oct 2002)

### 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).

### WMP

Waste management plan the waste requirements and responsibilities of project, it is usually site specific and looks at the minimisation, recycling and reuse of waste through all onsite processes. It usually forms part of an EMP.

## 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. (Ecological <http://ecological.yourhomeplanet.com/glossary.php>).

## Y

## Z

## ABGR and NABERS<sup>47</sup>

### 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's 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 manage the two key performance benchmarks for commercial property:

#### **The Australian Building Greenhouse Rating scheme (ABGR)**

[www.abgr.com.au](http://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.

#### **The National Australian Built Environment Rating System (NABERS)**

[www.nabers.com.au](http://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.



<sup>47</sup> Text for this page supplied by the Department of Energy, Utilities and Sustainability (DEUS).

## GBCA and Green Star accredited buildings<sup>48</sup>

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 Green Building Council aims to drive the transition of the Australian property industry towards sustainability by promoting green building programs, technologies, design practices and operations. Central to achieving these aims the Green Building 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 all building types (office, retail, education, health, residential etc.). Green Star builds on existing environmental rating systems for buildings, including the UK's 'BREAAAM' (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. Projects that obtain a self-assessed 4 Star rating (or above) are eligible to apply for formal

certification. 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 weighing 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. Projects that obtain a self-assessed 4 star rating (or above) are eligible to apply for formal certification, whereby a:

- 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

Council House 2 - 6 Star, Green Star - Office Design v1  
8 Brindabella Circuit - 5 Star, Green Star - Office Design v1  
40 Albert Road - 6 Star, Green Star - Office Design v1

For updated information see [www.gbca.org](http://www.gbca.org)

<sup>48</sup> Text for this page supplied by the Green Building Council.



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