SUSTAINABLE TROPICAL BUILDING DESIGN

Guidelines for Commercial Buildings

Cairns Regional Council

ACKNOWLEDGEMENTS

These Guidelines have been developed by Council staff with assistance from local experts and industry groups.

In developing this document, we have drawn on the extensive work undertaken by several other organisations and would like to acknowledge their work in this area. In particular we would like to acknowledge the Green Building Council of Australia, CoolMob, the Your Home Technical Manual and Ecospecifier Global.

We would also like to thank the Tropical Green Building Network and members of Council's Urban Design Advisory Board for reviewing this document.

PHOTOGRAPHY CREDITS

Troppo Architects

Total Project Group Architects

Arup

WSP Group

Studio Mango Tropical Architecture and Planning

Kym Joseph, Photography 4 Real Estate

MGF Consultants NQ

City of Melbourne

Department of Public Works, Queensland

COVER IMAGE

Tyto Wetlands Cultural Centre, Ingham.
Building designed by Troppo Architects, illustration by Hot Croc.

DISCLAIMER

This document is printed on 100% recycled paper.

CONTENTS

1. INTRODUCTION

This document has been prepared by Cairns Regional Council to assist in meeting the requirements of the Sustainable Building Design Policy when designing, constructing and renovating Council buildings. These guidelines are also intended as a general reference guide for sustainable design and construction of commercial buildings in the tropics.

How we design and construct buildings can affect the natural environment, both directly – by placing buildings and paved surfaces on previously vegetated areas, and indirectly – through extracting resources to create building materials; emitting greenhouse gases in the manufacturing and transportation of materials to the site; and through using energy sources such as electricity once the building is operating.

Sustainable building design is about reducing these impacts by designing and constructing buildings that are appropriate for the climate, have minimal environmental impacts, and are healthy and comfortable for building users.

Sustainable building design for the tropics differs considerably from sustainable building design for temperate areas. The majority of available information on sustainable design has been produced for temperate climates and is not applicable in the tropics. These guidelines have been developed specifically for the wet tropical climate of the Cairns region, and provide information on the key sustainable building design elements for the tropics. They can be used in conjunction with Council's *Sustainable Design Checklist* to plan the design and construction of sustainable buildings in tropical climates.

1.1 SUSTAINABLE TROPICAL BUILDING DESIGN PRINCIPLES

Council is committed to implementing the below sustainable building design principles.

Energy and emissions

1. Incorporate passive design measures to maximise the use of natural ventilation, cooling and lighting.
2. Maximise energy efficiency and surpass minimum statutory requirements for energy efficiency.
3. Strive for long-term sustainability and energy security by installing renewable energy generation systems.
4. Maximise opportunities for public and active transport access to the building.

Water and wastewater

5. Maximise water efficiency and surpass minimum statutory requirements for water efficiency.
6. Access alternative water sources to reduce consumption of potable water.
7. Phase out use of potable water in landscaping.

Indoor environment quality

8. Incorporate materials and fittings that are not harmful to the health, safety and well being of building users.
9. Use air-handling and temperature control systems that provide a comfortable and healthy indoor environment.
10. Ensure work areas have access to natural light and external views.

Waste and construction materials

11. Select materials with the lower embodied energy and environmental impacts.
12. Maximise reuse and recycling of construction and demolition waste.
13. Allow adequate space for recycling, waste storage and composting by building occupants.

Local environment

14. Restore habitat and improve community spaces surrounding buildings.
15. Minimise the impact during and post development on biodiversity, water and soil quality, soil erosion and visual amenity.

2. ENERGY AND EMISSIONS

Related sustainable design principles:

1. Incorporate passive design measures to maximise the use of natural ventilation, cooling and lighting.
2. Maximise energy efficiency and surpass minimum statutory requirements for energy efficiency.
3. Strive for long-term sustainability and energy security by installing renewable energy generation systems.
4. Maximise opportunities for public and active transport access to the building.

2.1 PASSIVE DESIGN

'Passive design' is design that works with the environment to exclude unwanted heat or cold and take advantage of sun and breezes, therefore avoiding or minimising the need for mechanical heating or cooling. Passive design in the tropics means designing a building to make the most of natural light and cooling breezes, and using shading, orientation and appropriate building materials to reduce heat gain and storage. The use of passive design principles in the tropics results in a building that is comfortable, energy efficient and results in substantial savings in running costs of both cooling and lighting.

The main principles of passive design for buildings in the tropics are summarised below.

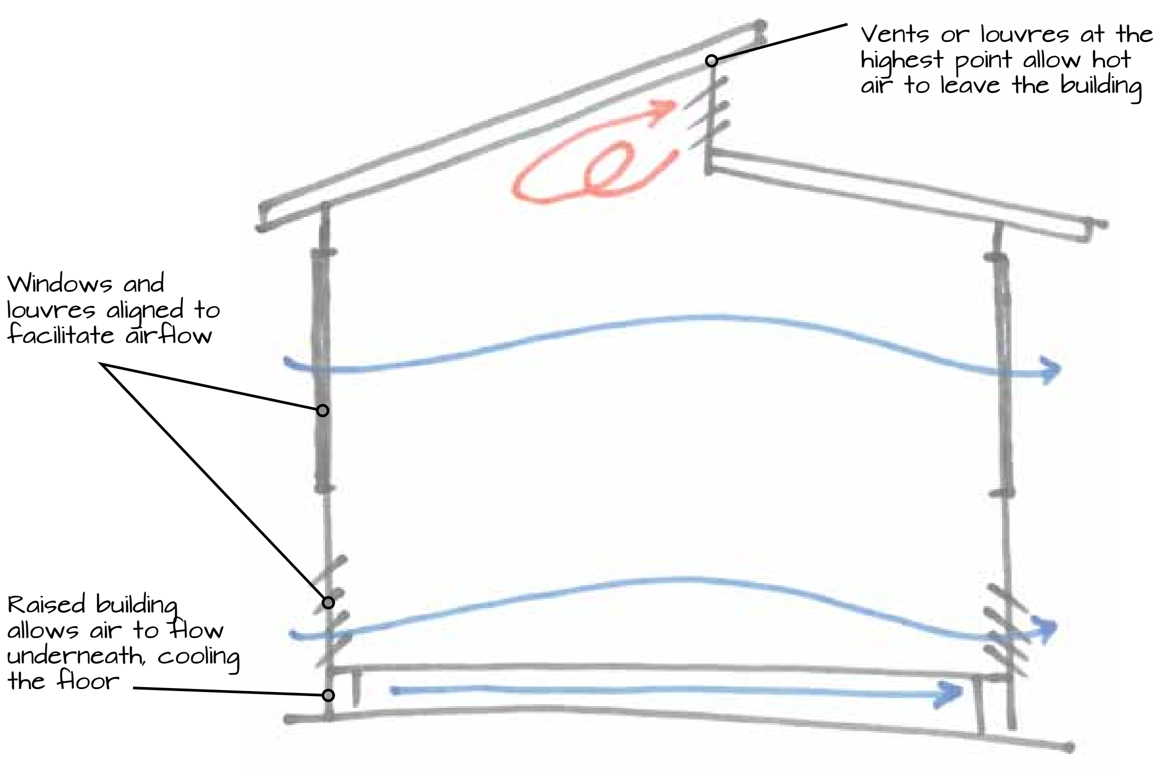
- Avoid heat gain
  – Orient the building to reduce exposure to midday sun, particularly summer sun.
  – Use materials with low thermal mass (as a general rule).
  – Shade walls and windows, particularly any walls with high thermal mass.
  – Use glazing on windows that cannot be effectively shaded.
  – Use insulation, light colours and heat reflective surfaces.
- Encourage natural ventilation
  – Orient the building and windows towards prevailing easterly winds.
  – Include operable windows and ceiling vents that enable the building to naturally ventilate.
- Make use of natural light
  – Install shaded windows.
  – Install shaded skylights, light tubes and other natural lighting devices.
- Create cool outdoor areas
  – Use verandahs and deep balconies to shade and cool incoming air.
  – Use landscaping to provide shade without blocking cooling breezes and use planting to reduce ground temperature and minimise reflected heat.

The elements to consider for implementing these principles are orientation, thermal mass, insulation, ventilation and lighting. These are outlined below in more detail.

2.1.1 Orientation

Understanding the daily and seasonal movements of the sun and the wind assists in orientating a building for optimal efficiency and comfort. Orientation concerns the position of the building on the site as well as the arrangement of the rooms within it. In the tropics, a building should be oriented so that the majority of walls and windows can easily be shaded from direct sun, while allowing maximum airflow and input of natural light (see Figure 1).

Figure 1. Passive Ventilation (cross-section)



2. ENERGY AND EMISSIONS

Orientation for minimal solar heat gain

The path of the sun changes gradually throughout the year between summer and winter. See Figure 2 for a sun path diagram for the Cairns Region. Generally the best approach in the tropics is to design so that all walls are shaded from the sun all year round. Depending on the building use, it may be desirable to admit some northern (mid-day) sun in the period May-July, which can be done by planning the width of eaves and awnings as shown in Figure 5B. It is also important to remember that in the Cairns region the sun is in the south during summer months and so shading is also needed on the south of buildings.

Orientation to maximise air flow

In Cairns, prevailing winds are south-easterly in the winter months and north to north-easterly during the summer months. Stronger breezes typically occur around April and October. The lack of breeze during the hottest days can pose challenges for achieving effective natural ventilation, and designing to encourage convection flow is very effective at these times. Refer to the Passive Ventilation section (2.1.2) for more information.

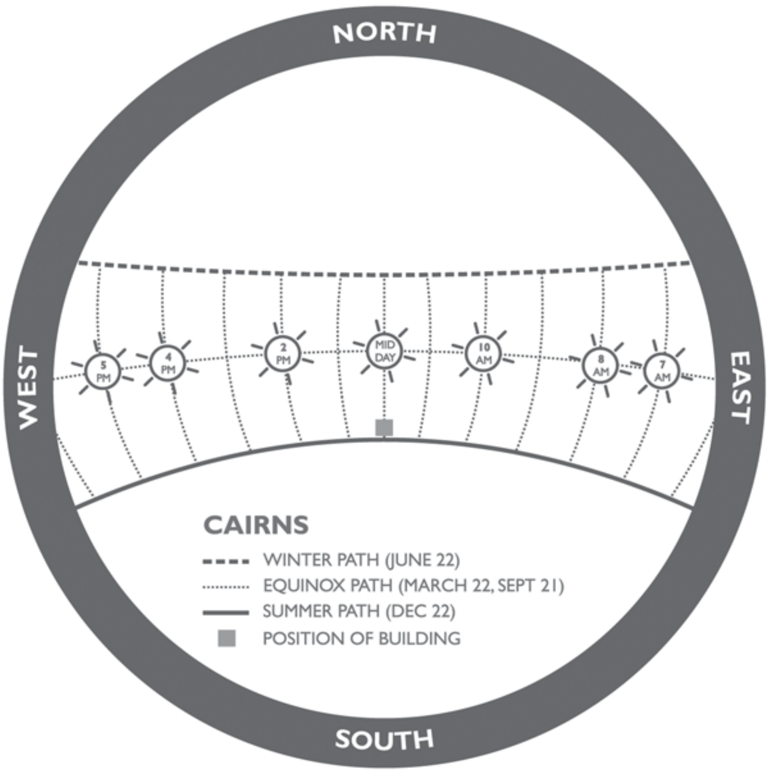


Figure 2. Sun path diagram for the Cairns Region

To use this sun path:

1. Find the black square at the centre of the diagram. This symbolises the building, shown from above.
2. To find where the sun will be at 7am in summer, locate 7am on the diagram.
3. Follow the curved line down until it meets the solid line (the summer path).
4. Next draw an imaginary line from this point to the building, and this is the compass direction for where the sun will be at that time in summer.

2.1.2 Passive Ventilation

Designing a building in a way that maximises natural ventilation will greatly reduce the need for energy-intensive air conditioning. Air movement over the body, even if the air is not much cooler, creates a feeling of cool due to the evaporation of moisture from the skin.

The following methods of passive ventilation are most effective in the tropics.

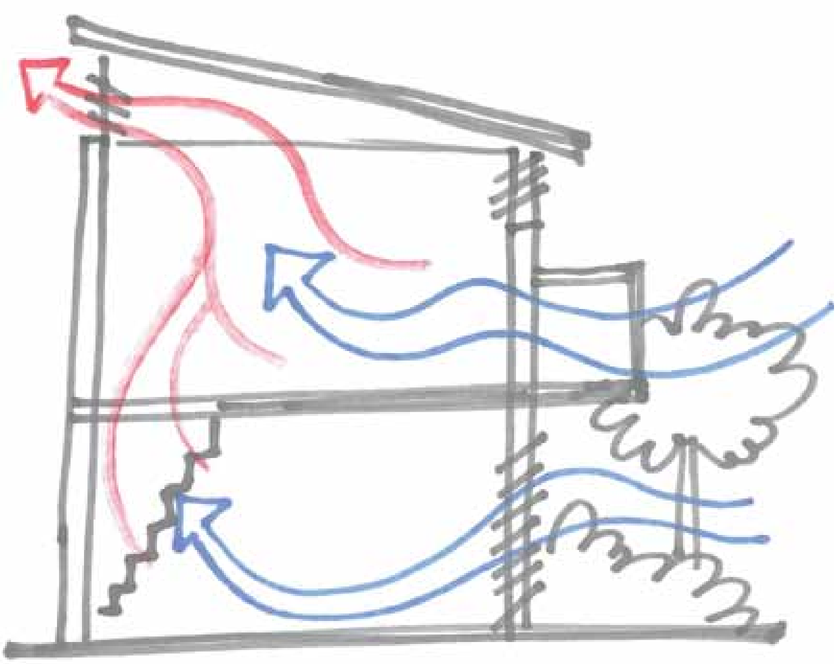
Maximising breezes

- Orient the building to make the most of prevailing winds.
- Align vents, windows and doors to allow air flow through the building – these should be aligned in a reasonably straight line for maximum effectiveness.
- Minimise internal obstacles or blockages such as internal walls in major flow through areas to allow for unimpeded ventilation.
- Raise the building off the ground to catch breezes.

Removing hot air

- Design for convection air flow to remove hot air from the building. Convection air flow is created by hot air rising and exiting at the highest point, which naturally draws in cool air from outside. This natural cycling of air can be created by placing low window openings across a space from high window openings. This will be even more effective at cooling if incoming air is being drawn from a shaded area where plants are growing (see section 2.1.3).

Figure 3. Convection Air Flow



2. ENERGY AND EMISSIONS

Designing for "mixed-mode" use

In Cairns it is feasible to design a "mixed-mode" building that relies on passive, natural ventilation in cooler months and energy efficient air conditioning in hotter months. Low thermal mass materials are particularly suitable for mixed mode design, provided the building is well-insulated.

Ideally passive and mechanical cooling systems should be controlled so that they cannot be in use simultaneously to avoid energy wastage. For example, the use of Reed Switches connected to air-conditioning controls or a building management system can prevent the air-conditioning system from operating while doors or windows are open.

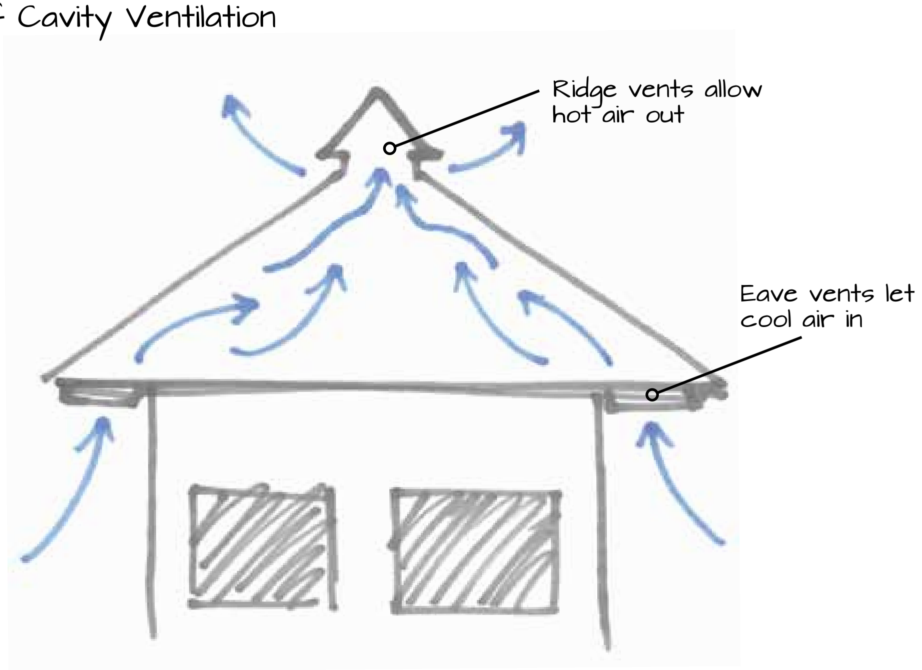
Roof ventilation

Ventilating the ceiling cavity of a building is an effective way of replacing accumulated hot air with cool air from outside using convection. It also reduces heat radiated from the ceiling cavity to the inner parts of the building. Controls can be installed to stop ventilation during the cooler months if necessary.

Examples of roof ventilation systems include spinning vents placed on the roof top which draw hot air out of the ceiling cavity by their spinning motion. Another type is a ridge vent, a non-moving vent that can be placed at the highest ridge point of the roof. The ridge vent allows hot air, which collects at the highest point, to flow out.

Both of these examples operate most effectively when vents are installed in building eaves or in ceilings to allow cooler air to be drawn in through the eave vents, promoting greater flow of air through the roof vent.

Figure 4. Roof Cavity Ventilation



2.1.3 Landscaping for a cool building

The hard surfaces of streets, driveways, parking areas and paving around buildings, absorb heat and then re-radiate it, creating a hotter microclimate. The combined effect of hard surfaces in our cities is known as the urban heat island effect. It is responsible for noticeable increases in temperature in cities compared to surrounding areas.

Reducing the extent of paving and other hard surfaces that reflect and/or store heat and replacing these with vegetation will result in a cooler building and more enjoyable outdoor areas. Planting areas around the building creates a cooler environment due to a plant's ability to transpire, or lose moisture, which cools the air. External temperatures can be reduced by over 5°C by using ground cover or lawn instead of paving. Planting areas with dense vegetation and creating shaded areas will achieve even greater temperature reductions. Air that is drawn into buildings via planted areas can have significant cooling benefit (see Figure 5).

For more information see the Landscaping section (6.4).

Figure 5A. Shading and Landscaping

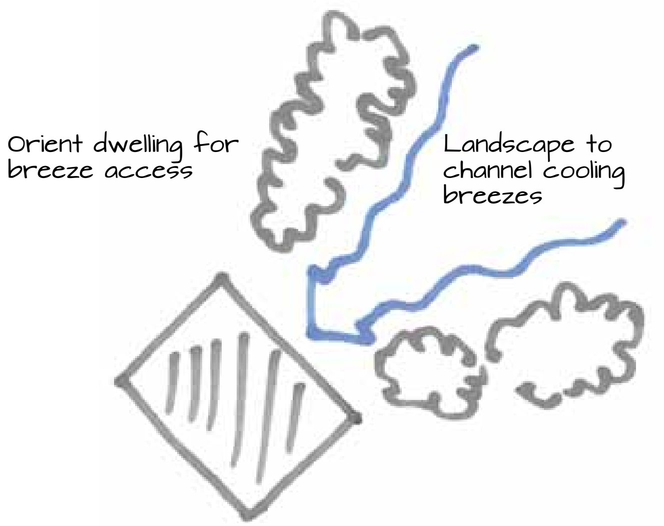
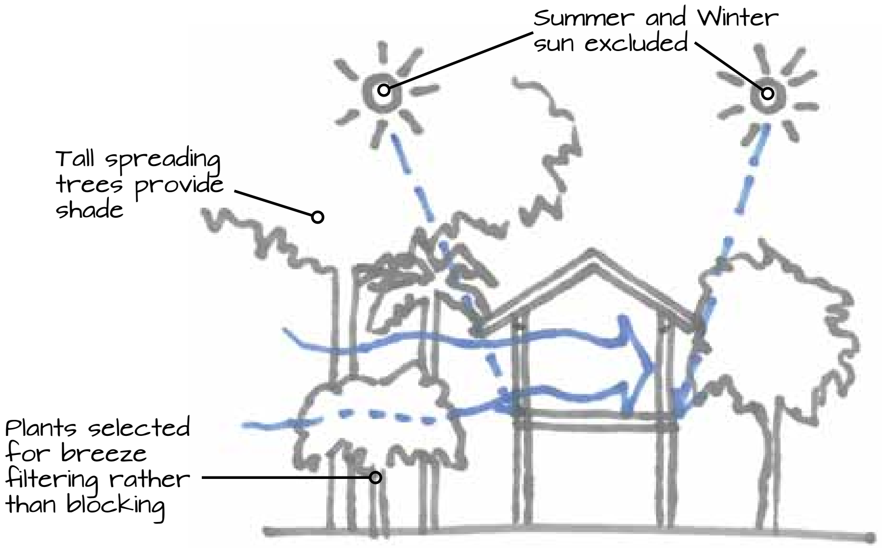


Figure 5B. Shading and Landscaping



2. ENERGY AND EMISSIONS

2.1.4 Thermal mass

Thermal mass refers to the ability of building materials to absorb, store and release heat.

In tropical climates, the use of lightweight construction materials with low thermal mass is preferable, particularly on walls that are exposed to the sun. This is because lightweight construction materials such as timber, respond quickly to cooling breezes allowing the building to cool faster. These materials still require insulation to prevent direct heat transfer and to improve the efficiency of mechanical cooling if used.

High thermal mass materials work best in temperate climates where there is a significant change in temperature between night and day. During summer, the heat stored in thermal mass during the day is flushed out by the cooler night temperatures, and the cool stored in the mass over night is released into the building during the day.

Warm nights in the tropics mean that heat is not flushed from the thermal mass and instead radiates back into the building.

Use of high thermal mass construction materials is therefore generally not recommended in the tropics. If high thermal mass materials are used, the building should be well shaded to avoid heat gain and insulated internally to reduce heat transfer. Recent research has shown that innovative, well insulated and shaded thermal mass designs have been able to lower night time temperatures by 3 to 4°C in tropical areas with a low level of temperature fluctuation between day and night.[1]

Figure 6. Diurnal temperature range and response of low and high thermal mass materials

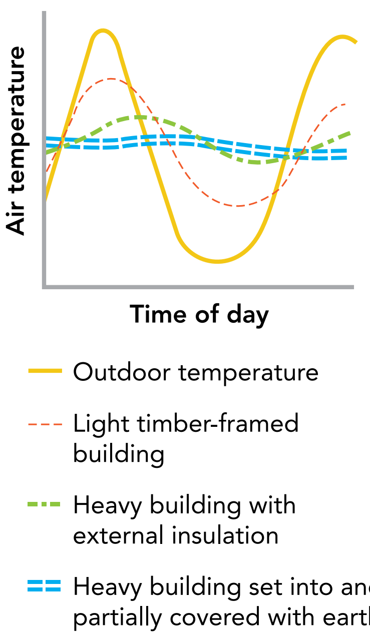


Figure from www.yourhome.gov.au

[1] http://www.yourhome.gov.au

2.1.5 Insulation

Insulation is one of the most effective ways to reduce heat input to a building and can be installed in the roof, ceiling and walls of the building. Insulation controls the rate at which a building loses or gains heat, keeping warmer air in during winter and excluding external heat in summer. There are generally two types of insulation: bulk insulation and reflective insulation. In the tropics, reflective insulation installed under roof sheeting is highly effective as it does not trap heat inside the building. However bulk insulation is more effective at preventing loss of cool air from the building and so improves the efficiency of air-conditioning. Insulation that absorbs moisture should be avoided as this will become mouldy in the tropical environment. Ventilating the ceiling cavity can also help to dry the area out, reducing the chances of mould growth.

R values

Insulation materials are given an 'R' value, which rates the material's resistance to heat flow and therefore indicates its effectiveness. The higher the 'R' value the greater the insulating effect. However an R value is not a measure of reflectivity and so is less effective as a measure of the capacity of insulation to reflect external heat.

The Queensland Government's Climate Smart website recommends a minimum of R 2.5 insulation in naturally ventilated house ceilings, and a minimum of R 3.5 insulation in ceilings and walls of air conditioned houses in the tropics.[2]

Insulation types

Bulk insulation in effect acts as thermal mass and resists the transfer of conducted and convected heat by relying on pockets of trapped air within its structure. Its thermal resistance is essentially the same regardless of the direction of heat flow through (i.e. in or out of the building). Bulk insulation includes materials such as glasswool, wool, cellulose fibre, polyester and polystyrene. The R value of the products varies according to material and thickness.

Reflective insulation mainly resists radiant heat flow due to its high reflectivity and low ability to re-radiate heat and is more effective when installed with an air layer next to the shiny surface. Because it works via reflection, the thermal resistance of reflective insulation varies with the direction of heat flow through it unless it is designed to be reflective on both sides. Reflective insulation is usually shiny aluminium foil laminated onto paper or plastic and is available as sheets (sarking), concertina-type batts and multi-cell batts. Concertina batts and multi-cell batts also have a small resistive capacity and therefore have a higher R value than sarking.

[2] http://www.climatesmart.qld.gov.au/your_home/building/insulation.html

2. ENERGY AND EMISSIONS

2.1.6 Windows

Encouraging natural air flow is integral to passive design in the tropics. Windows are an important way to encourage and direct air flow into a building.

For many commercial buildings, air-conditioning will be used throughout the year, however buildings can be designed to operate without air-conditioning in cooler months. This allows for greater flexibility in catering to the needs of building users, and will save energy and money by switching air-conditioning off for part of the year.

Louvres and casement style windows allow building users to control how much natural air enters the building. Well-placed louvres or windows, at floor level and at the highest point of the room, create convection air flow which draws air into the building and creates breezes to cool occupants. See the Passive Ventilation section (2.1.2) for more information.

In a tropical climate, windows should ideally be shaded from direct sunlight all year round and should open to allow air flow. Where effective shading cannot be achieved, insulating windows against heat transfer can reduce cooling costs. The following measures can help reduce heat input through glass:

Tinted glass

Tinted glass has a tint applied to the glass during manufacture, to reduce the amount of heat transmitted through it.

Reflective coatings

Reflective coatings are thin films of metal or metal oxide that are applied to standard glass. They stop greater amounts of heat gain than some toned glass, however, they have the potential to create glare problems for neighbouring properties, and can significantly reduce the quantity of light admitted through the glass.

Advanced glazing technologies

Glass can be treated to reduce the amount of solar energy transmitted through it. This can be an alternative method of preventing summer heat gain where external shading devices are inappropriate, such as western facing windows that are difficult to shade.

2.1.7 Natural lighting

Buildings should be designed to maximise the amount of natural light that enters the building, particularly workplaces. This can lead to significant energy savings by reducing the need for artificial lighting and has been shown to improve productivity.[3]

In a naturally well lit space, artificial lighting should not be required for general activities during daylight hours. In larger buildings, task lighting may be required at work areas not directly near a window, as windows are only effective for letting natural light into a building up to a distance of 4-5 metres. It is therefore recommended that light switching be designed to allow perimeter lights to be adjusted separately from other lighting so that the benefits of natural light can be realised.

The effectiveness of natural light can be improved by using light colours on walls, floors and horizontal surfaces, and by aligning internal walls and ceilings to maximise light reflection from light sources. The benefits of natural light must be balanced with strategies to manage glare and heat gain. For this reason, all glass should be shaded from direct sun or incorporate glazing technologies that reduce heat transfer.

In addition to windows, natural light access can be obtained through skylights, light reflectors and similar installations. Common solutions are described below.

Skylights

Skylights can provide good quality light to work spaces that are away from windows. As mentioned above, they need to be shaded and glazed to prevent heat transfer. Some skylights are also vented to allow hot air to escape.

Atria

An atrium is a large open space, often several stories high and having a glazed roof and/or large windows. Atria are popular in commercial spaces because they give a sense of spaciousness and allow natural light to enter the building. The benefit of an atrium is that hot air can be vented at the top rather than accumulating near the building users.

Light shelves

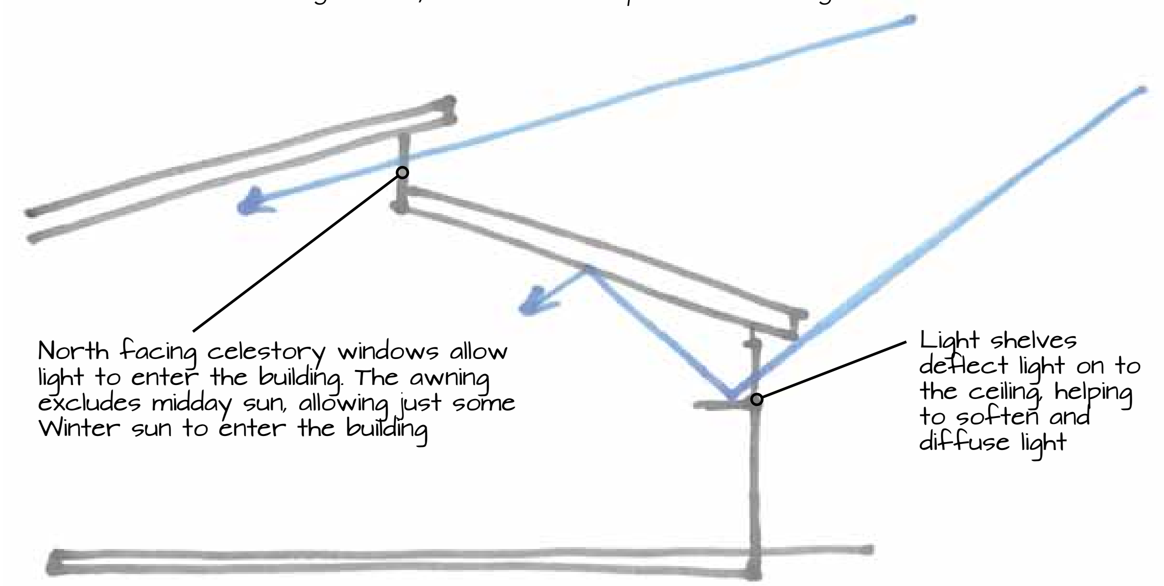
A light shelf is an architectural element that allows daylight to penetrate deeper into a building. A light shelf is a horizontal light-reflecting overhang which is placed above eye-level and has a high-reflectance upper surface. This surface is then used to reflect daylight onto the ceiling and deeper into a space. In the tropics, light shelves may be most effective on the north side of the building to exclude summer sun, and awning width should be designed to exclude unwanted sun.

[3] Fisk, J.W. (2000) Health and productivity gains from better indoor environments and their relationship with building energy efficiency. Annual Review of Energy and the Environment, Vol. 25: 537-566

2. ENERGY AND EMISSIONS

Figure 7. Diagram showing clerestory windows and light shelves

Adapted from John C. Clem Building a Better, Greener Home http://www.clemdesign.com



Clerestory windows

Another important element in natural lighting is the use of clerestory windows. These are high, vertically-placed windows that are ideally north facing. The benefit of clerestory windows can be enhanced by using light-coloured interior walls to further reflect light into interior areas. Clerestory windows can be a good source of diffuse light, and can also be useful in allowing hot air to leave the building. In the tropics, north facing clerestory windows will work most effectively, as they will exclude summer sun. As with light shelves, awning width should be designed to exclude unwanted sun. East or west facing clerestories are not recommended as they cannot be effectively shaded.

Light tubes

Solar tubes, light tubes or light pipes are used for transporting or distributing natural or artificial light. Installed between the roof and interior ceiling, solar tubes capture daylight, refract and reflect it through a tube, and disperse the light to an interior space using a diffuser. The concept was originally developed by the ancient Egyptians. The exposed portion of the light tube consists of a dome that collects and refracts as much sunlight as possible from as many different directions as possible. The tube itself is lined with a highly reflective material to help light travel through with minimal loss. At the other end of the tube, the light passes through a diffuser that disperses it throughout the interior space.

2.2 ENERGY EFFICIENT SYSTEMS AND APPLIANCES

In fitting out the building, efforts should be made to install the most energy efficient systems and appliances available to reduce operating costs of the building.

Air-conditioning, lighting and hot water systems will have particularly significant implications for reducing a building's energy requirement.

2.2.1 Efficient air-conditioning

Wherever possible air-conditioning systems should incorporate zoning controls which enable the system to be adjusted to different heat loads in different parts of the building and to be shut off when areas are not in use. This reduces the amount of energy used in cooling or heating air unnecessarily and improves the comfort of building users.

It is recommended that air-conditioning supply to contained spaces, for example meeting rooms, be fitted with user operated timed controls to reduce use of the system when spaces are not in use. It is also recommended that air-conditioning ducting is insulated to at least R1.5 and that any refrigerant lines are insulated with at least 20mm of foam insulation. This will minimise the potential for heat gain between the air conditioning unit and targeted areas.

Design of air conditioned spaces

As mentioned in section 2.1.2, the design features for an entirely mechanically cooled building are typically different to those of an entirely passively cooled building.

Below are some examples of building design features that will help to improve the efficiency of mechanical cooling.

- High insulation levels in walls, ceiling and floors.
- Glass is shaded and glazed/treated for reduced heat exchange.
- Total volume of air space is reduced (e.g. low ceilings).
- Cracks and gaps are sealed to minimise external air infiltration.

Design of a mixed mode building needs to include intelligent solutions to achieve these conditions when the building is operating in mechanical cooling mode. For example, using doors and windows that seal effectively when closed is important.

Some additional factors that can be considered to increase the energy efficiency of air-conditioning systems are included below.

- Use advanced control systems, sensors and timers to reduce total operating hours.
- Set thermostats to warmest setting that still achieves comfort and include ceiling fans to improve personal comfort.
- Avoid air-conditioning rooms that have high level indoor – outdoor traffic or use air-locks to minimise hot air infiltration.
- Ensure that rooms not requiring mechanical cooling have maximum passive cooling as described above and use them as a thermal buffer to cooled spaces.
- Use heat recovery systems to extract heat from waste air and use this to reduce the cooling load on fresh air.
- Investigate energy efficient heat exchange options including heat exchange to ground or water.

2. ENERGY AND EMISSIONS

Selecting an efficient air-conditioning system

The energy requirements for air-conditioning can be greatly reduced by use of passive design. There are some options for mechanised cooling systems that are more energy efficient and generate less carbon emissions.

Solar air-conditioning
Reliable, efficient solar air-conditioning systems are now becoming available on the commercial market. These systems run almost entirely on solar energy, with only a small amount of additional mains power needed to run the control system, pumps, valves and other devices.

The basic operating principle of these solar air-conditioning systems is that water is heated by the sun in vacuum tube solar collectors (similar to solar hot water system tubes); this hot water is fed into a thermally driven solar chiller, which is used to cool the water which then in turn cools the air inside the building. The higher the water temperature supplied to the solar chiller, the more efficiently the cooling system will perform. This means that the system will function most effectively on the hottest days.

Gas air-conditioning
Gas air-conditioning systems are generally fairly efficient and have the added benefits of not contributing to the problem of peak electricity demand and being less vulnerable to rising electricity prices. The gas motor is also extremely quiet and easy to maintain.

Chilled water plant with thermal storage
Chilled water plants are systems where water is chilled and stored in a large, insulated tank. This chilled water is then used throughout the day to cool the building. The chiller can operate off-peak during the night to cool water that is held in a thermal energy storage tank for later use. Using off-peak tariffs results in cost savings and reduced contribution to peak demand.

The environmental benefits of using this system may be minimal depending on the efficiency of the system. A cost-benefit analysis should be done before investing in this type of system.

Split system air-conditioning
When purchasing smaller, split system air-conditioning units priority should be given to those with high energy efficiency. A minimum energy efficiency rating of five stars is recommended. More information is available on the energy ratings website.[4]

[4] http://www.energyrating.gov.au

2.2.2 Efficient lighting

Lighting is directly responsible for around 20% of commercial-sector greenhouse gas emissions. As discussed in the Natural Lighting section (2.1.7), the most efficient way to reduce lighting in a building is to maximise the use of natural light. Use of lighting zones and switching, efficient bulbs, and automatic shut off systems can all help to further reduce lighting energy use and costs.

An efficient and effective lighting system will:

- Provide a high level of visual comfort;
- Make use of natural light;
- Provide the best light for the task;
- Provide controls for flexibility;
- Produce less waste heat; and
- Have low energy requirements.

Using an efficient light type

The evolution of ultra efficient lamps and luminaires means that required lighting levels can be met with fewer watts per square metre. Table 1 shows the efficiency of different lamp types.

Lighting control

Locating switches at exits to rooms is a simple way of encouraging occupants to switch lights off when the room is not in use. Dimmers, motion detectors and automatic shut-down systems should be installed where appropriate to improve energy efficiency. Where possible, lighting control zones should be no larger than 100m², allowing zones within a larger area to be switched off when unoccupied.

Solar lighting

Solar-powered lighting systems may also be considered. Even in suburban areas, they can be cost-effective where they avoid the cost of running electrical cable to barbecue shelters, pathways or other points where relatively small amounts of electricity are required.

Table 1. Lamp characteristics and efficiency

From www.resourcesmart.vic.gov.au

Characteristics	INCANDESCENT		INCANDESCENT		HIGH INTENSITY DISCHARGE		
	Light Globes	Quartz Hallogen	Flourescent Tube	Compact Flourescent	Mercury Vapour	Metal Halide	High Pressure
Installation cost	Low	Low	Low	Low	Moderate	Moderate to High	Moderate to High
Efficacy* (Lumens/Watt)	Low (8-17)	Low (20-30)	Moderate to High (60-100)	Moderate to High (40-65)	Low to High (15-70)	High (60-100)	High 60-120)
Normal Wattage Range	up to 1,500W	up to 1,000W	8-120W	7-20W	40-10,000W	70-200W	35-1,000W
Running Cost	Highest	Highest	Moderate to Low	Moderate to Low	High to Moderate	Moderate to Low	Low
Lamp Life (Hours)	Shortest (less than 1,000)	Short (2,000-3,000)	Moderate (6,000-8,000)	Moderate (6,000-8,000)	Moderate to Long (6,000-24,000)	Moderate (8,000-10,000)	Long (14,000-24,000)
Replacement Costs	Low	Medium	Low	Medium	Low	High	High
Colour Rendering	Excellent (100)	Excellent (100)	Medium to Good (50-98)	Medium to Good (50-80)	Poor (15-50)	Medium to Good (60-90)	Poor (17-25)
Best Applications	Areas where lighting is on for short periods. Task lighting for rotating machinery, or in areas where colour rendering is important.	Small reflector lamps can be used for spot lighting displays. High wattage linear lamps can be used for security lighting if controlled by a movement sensor.	Areas where lighting is on for long periods, and ceiling height is below 5 metres. Exterior lighting for small areas.	To replace light globes in suitable fittings. Uplighting and lighting small rooms in areas where lights are on for long periods.	Exterior lighting, and lighting factories and warehouses where colour rendering is not important. High pressure sodium is usually a better choice.	Lobby lighting, lighting in offices and shops where ceiling height is greater than 4 metres.	Exterior lighting, continuous security lighting, and lighting in factories and warehouses where colour rendering is not important, and ceiling height is greater than 4 metres.

** Includes power consumption of control gear, or ballast, as well as power consumption of the lights*

2. ENERGY AND EMISSIONS

2.2.3 Hot water

Supplying hot water in large facilities can be expensive and energy-intensive. The type of water heater used, where the unit is installed, and how the water is used all affect the costs and emissions associated with supplying hot water. Far north Queensland has an excellent climate for solar hot water, which is a good way to can save money and reduce greenhouse gas emissions. Solar hot water systems generally have the lowest greenhouse gas emissions of available system types.

Hot water storage systems should be located as close as possible to the point of water use. This helps to keep pipe lengths short, which minimises heat loss from pipes, reduces installation costs, and reduces water wastage as users wait for water to heat up at the outlet. Hot water pipes should also be insulated to minimise heat loss from pipes as hot water travels to the taps.

2.2.4 Monitoring energy use

The ability to monitor energy use assists in reducing energy waste and assessing the effectiveness of energy efficiency measures. Smart meters can be installed to keep track of energy used in a building. They record consumption in intervals of an hour or less and communicate that information at least daily back to the utility (or information system) for monitoring and billing purposes.

Smart meters enable two-way communication between the meter and the central system. Unlike home energy monitors, smart meters can gather data for remote reporting.

2.3 RENEWABLE ENERGY

In the current context of rising electricity prices and the ongoing issue of energy security, investing in renewable energy generation systems is increasingly appealing. These systems help to reduce greenhouse gas emissions and improve energy security.

If possible, incorporate considerations for solar panel installation at the design stage, as this ensures that roof aspect and slope angle can be designed for maximum power generation. When designing a building for solar power generation it is important to consider solar access for the panels and the slope of the roof. The ideal angle for solar panels in the Cairns region is 38° and within 15 degrees of North. If a roof is designed to pitch at this angle, solar panels will not need to be elevated from the roof surface and will be less noticeable.

2.4 TRANSPORT

A sustainable building is designed to encourage public transport use and active transport (walking, cycling, etc) by building users. This helps to reduce the carbon footprint of the building and its workers and visitors, and also encourages a healthy lifestyle.

The elements of designing a building for low- or zero-carbon transport by building users are listed below.

- Situate the building close to public transport routes.
- Provide safe, user-friendly walking and cycling access to the building.
- Provide showers and lockers to encourage cycling or walking to work.
- Provide bike parking facilities for staff and visitors.

Further resources

Clean Energy Council
http://www.cleanenergycouncil.org.au

Living Green, Federal Government information on renewable energy installation and rebates
http://www.livinggreener.gov.au/energy

Office of the Renewable Energy Regulator
http://www.orer.gov.au/

3. WATER AND WASTEWATER

Related sustainable design principles:

5. Maximise water efficiency and surpass minimum statutory requirements for water efficiency.

6. Access alternative water sources to reduce consumption of potable water.

7. Phase out use of potable water in landscaping.

Treating and pumping water uses substantial amounts of electricity. Over 50% of Council's annual electricity consumption is used by water pumping stations and water and wastewater treatment plants. Reducing the amount of potable water used, and reducing the amount of wastewater going to treatment plants will reduce greenhouse gas emissions as well as reducing Council's electricity costs.

The water that comes out of our taps has undergone a high level of treatment and disinfection to render it suitable for human consumption. This level of treatment is not required for the majority of water uses associated with a building. Thoughtful building design can greatly reduce demands on potable (drinking) water sources. Water consumption can be reduced within buildings through a combination of water efficiency, rainwater capture and storage and water reuse. These are outlined below.

3.1 WATER EFFICIENCY

All fixtures and fittings should be highly water efficient, with at least a 5 star rating. The Water Efficiency Labelling and Standards (WELS) scheme is a government initiative which aims to ensure that products are clearly labelled with information about their water efficiency. The WELS scheme gives a water efficiency rating of between 1 and 6 stars for each product, with more stars meaning the product is more water-efficient. Products can be compared online on the water ratings website.[6]

3.2 RAINWATER TANKS

Rainwater can be collected for indoor and outdoor use depending on the building location and roof condition. It is now mandatory for commercial buildings in Queensland to collect rainwater for toilet flushing within the building. Consider exceeding these requirements and connecting tanks to supply external taps for irrigation also.

Tank maintenance in north Queensland requires some special measures. First flush diversion devices should be fitted to divert dust, bird droppings and other contaminants that have accumulated in gutters and on the roof surface between rain events.

The overflow from the tank should be directed so that it does not adversely affect adjoining land areas or buildings. When possible, the overflow should be connected to the stormwater system or an on-site filtration system. Mesh should be placed over all openings to prevent mosquitoes from breeding in the tank.

[6] Water Ratings Website http://www.waterrating.gov.au

3.3 RECYCLED WATER

Recycled water can be used instead of drinking quality water for non-potable uses such as irrigation, air-cooling towers and toilet flushing. Installing a recycled water supply is therefore an effective method for reducing potable water consumption and reducing environmental impacts. Greywater (waste water from fixtures such as showers, basins and taps) can be treated on site and used for toilet flushing and for the irrigation of landscaped areas. In some areas reticulated recycled water is available. Over time, the amount of reticulated recycled water available in the region will increase.

For more information

Queensland Development Code Part 4.2 – Water Saving Targets

Queensland Development Code Part 4.3 – Alternative Water Sources – Commercial Buildings

Water saving targets
For councils, plumbers, builders and developers: A guide to the Queensland Development Code part MP 4.2, Effective August 2008

Alternative water sources – commercial buildings
For councils, plumbers, builders and developers: A guide to understanding the Queensland Development Code part MP 4.3, Effective August 2008

Alternative Technology Association
http://www.ata.org.au

3.4 MANAGING STORMWATER

The average annual rainfall of Cairns is around 1990mm. The region experiences periods of heavy rainfall during the wet season, with large volumes of water falling on urban areas. The rainforests in the area are adapted to this high level of rainfall and rainforest plants and soils absorb large volumes of water relatively quickly. This natural absorption and filtration means that native vegetation in these catchments acts as a sponge which slows water flow, catches sediment and removes nutrients before the water reaches the sea.

In urban areas we have replaced vegetation with non-porous surfaces such as concrete and metal. The majority of rain falling on urban areas cannot soak into the soil and is instead diverted into stormwater drainage systems which speed up the flow of the water and do not allow for sediments and nutrients to be removed. Reducing stormwater runoff by capturing this water for use, or by filtering it through vegetation and soil, improves reef health and also decreases our dependence on the mains water supply.

To most effectively manage stormwater on site, efforts should be made to minimise the amount of impervious (non-porous) surfaces and maximise the potential for filtration, storage and infiltration, so that the least amount of water flows off-site into the stormwater system. Retaining stormwater onsite temporarily stores surface runoff and releases it at a reduced rate to receiving waters. This reduces peak storm flows through natural drainage systems and minimises flooding potential.

The following design principles can be incorporated to reduce stormwater runoff and limit a building's impact on water quality.

Avoid changes to topography, vegetation and landforms
Most disturbances to a site, and removal or disturbance of vegetation, will compact soils and increase stormwater flows by reducing the ability of soils to absorb water. Preserving the original topography and drainage channels is generally recommended. However if changes are unavoidable, re-contouring the land, if carefully planned and executed, can also slow water runoff and improve infiltration in some cases.

Minimise impervious areas
The negative effects of impervious surfaces on a site can be minimised by:

- Limiting the clearance of vegetated areas;
- Installing porous pavements (e.g. gravel or permeable paving) on low traffic areas such as driveways, car parks and footpaths;
- Reducing the sealed area to the minimum required to accommodate an activity
- Building pedestrian surfaces, such as walkways and patios, with loose aggregate, wooden decks, or well-spaced paving stones;
- Separating impervious surfaces with turf, gravel or vegetation to increase infiltration between the areas; and
- Redirecting runoff from impervious surfaces on to vegetated areas or gardens designed for water capture.

Install rainwater tanks
(see section 3.2)

Use Green Walls and Green Roofs
A green roof is a vegetated roof system consisting of an impermeable membrane, insulation, gravel, soil and plants. Typically, green roofs range from 5cm to 15cm in soil depth and are planted with a variety of low-growing ground cover plants.

Vegetated green roofs on conventional buildings such of offices now account for 20% of the new roofs in Germany, and Tokyo has mandated them on all new commercial buildings over 1000m^2.

Green roofs are also increasingly popular in Singapore, which has a similar tropical climate to Cairns, where research is being conducted into effective green roofs for the tropics.

Green roofs result in significant energy savings by providing insulation as well as reducing water runoff by retaining and slowly releasing water. They are attractive natural features that also help to reduce the urban heat island effect in larger cities (re-radiated heat from concrete and other building materials that creates a hotter environment in heavily built-up areas).

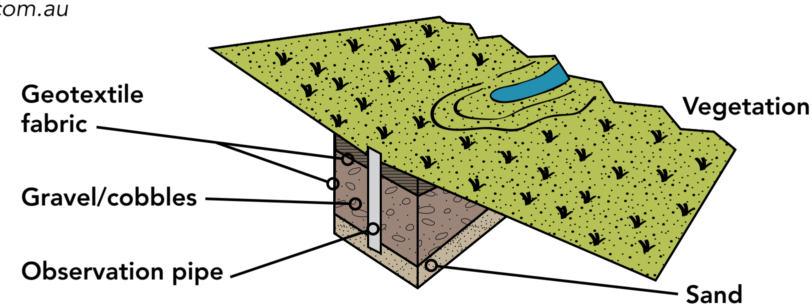
Use Water Sensitive Urban Design
Water Sensitive Urban Design (WSUD) is an approach to stormwater management that replaces in-ground stormwater pipes with drains, swales and detention areas that mimic natural processes. The purpose of WSUD is to improve absorption of rainwater into the soil and to slow and filter any water which is not absorbed so that high quality water leaves the site.

Key components of WSUD include infiltration trenches, swales and bioretention systems. They are each described below.

Infiltration Trenches
An infiltration trench is a shallow trench filled with gravel, rock or porous material, which is placed to collect stormwater runoff. Stormwater slowly filters from the trench through the surrounding soil, while particulate and some dissolved pollutants are retained in the trench. The trench discharges the treated stormwater into a conventional pipe system.

The trench is lined with a layer of geotextile fabric, to prevent soil migration into the rock or gravel fill. The top surface of the fill is also covered with a layer of fibre fabric, then finished with a shallow layer of topsoil. The trenches can increase the soil water levels, groundwater flow rates and can reduce stormwater flow velocities.

Figure 8. Workings of the infiltration trench
Based on a diagram from Melbourne Water
www.melbournewater.com.au



3. WATER AND WASTEWATER

Swales
Swales are deliberately formed undulating terrain creating raised banks and open channels that are designed to slow water flow and allow plants growing in the channels to take up nutrients and filter the water. Soil micro-organisms also help to remove some pollutants from the water. Swales also help with the screening or removal of gross pollutants, such as litter and coarse sediment, from stormwater runoff.

Swales may be used as an alternative to the conventional street nature strip or in central median strips of roads, through to runoff collection points in car park areas. Hydraulically swales can reduce run-off volumes and peak flows.[7] Current designs involve the use of grass or other vegetation (such as rushes) to carry out this function.[8]

Bio-retention systems
Bio-retention systems combine various WSUD treatment types in one system. They are designed to carry out primary and/or secondary treatment of stormwater and to slow flows. The current types of treatments used include grassed swales (primary treatment) in combination with infiltration trenches (secondary treatment). Reducing velocities and retarding water reduces the flow of stormwater during the infiltration process.

Create rain gardens
Rain gardens are designed to retain runoff from the site and can be used in conjunction with WSUD or as a stand-alone design response. They may be container gardens, or sunken pits that are filled with gravel, sand, soil and appropriate plants. Depending on the amount of water entering, these gardens may need to be fitted with a low flow outlet and an overflow device for high flows.

Rain gardens will require periodic maintenance to remove sediment that has built up in the gravel and plants need to be cut back to encourage new growth.

[7] Horner R.R., Skupien J.J., Livingston E.H. & Shaver H.E., 1994, Fundamentals of Urban Runoff Management

[8] Melbourne Water – What is Water Sensitive Urban Design, from http://wsud.melbournewater.com.au

4. INDOOR ENVIRONMENT QUALITY

Related sustainable design principles:

8. Incorporate materials and fittings that are not harmful to the health, safety and well being of building users.

9. Use air-handling and temperature control systems that provide a comfortable and healthy indoor environment.

10. Ensure work areas have access to natural light and external views.

There is an increasing body of evidence to support that idea that creating an enjoyable and comfortable work environment will create a healthier and more productive workforce.[9] The existing literature contains strong evidence that characteristics of buildings and indoor environments significantly influence rates of respiratory disease, allergy and asthma symptoms, sick building symptoms, and worker performance.[10 11] Poor indoor environmental quality is considered to be the main cause of Sick Building Syndrome, which a NSW government report estimated to costs the Australian economy over $125 million per year through absenteeism and reduced productivity.[12]

A healthy indoor environment incorporates good air and light quality, views to outside, comfortable temperatures, minimal noise pollution and a low-toxicity environment.

4.1 AIR QUALITY

It is important that air inside the building is of a high quality, and free of indoor air pollutants such as Volatile Organic Compounds (VOCs – see section 4.5) and ozone. Some options for ensuring good air quality in the building are:

- Allowing adequate intake of fresh air through operable windows or high rates of fresh air supply through mechanical air handling systems.
- Isolating printers from work stations as they release ozone which is harmful in high concentrations.
- Avoiding the use of materials that include VOCs and formaldehydes.
- Placing plants indoors or installing "breathing walls".

Indoor plants and "breathing walls"

From Ecospecifier Global www.ecospecifier.com.au
Studies in Norway and the Netherlands have shown that health complaints at work can be significantly reduced by the presence of plants. Whether these effects are physical or psychological (or a combination of the two) is uncertain. What is clear, though, is that symptoms associated with Sick Building Syndrome (SBS) can be dramatically reduced by the addition of good plant displays.

Another effective plant based air improvement is the "breathing wall". In this system, air is drawn through a porous wall kept constantly wet and covered with mosses and ferns, removing low levels of indoor air pollutants.

[9] 500 Collins Productivity Report, Sustainability Victoria

[10] William J. Fisk and Arthur H. Rosenfeld (1997) Estimates of Improved Productivity and Health from Better Indoor Environments. Indoor Air, Volume 7, Issue 3, pages 158–172

[11] Fisk, J.W. (2000) Health and productivity gains from better indoor environments and their relationship with building energy efficiency. Annual Review of Energy and the Environment, Vol. 25: 537-566

[12] Sick Building Syndrome, Standing Committee on Public Works, April 2001, http://www.parliament.nsw.gov.au/Prod/parlment/committee.nsf/0/C73BB66B35386533CA256AA80007541D Accessed February 2011

4.2 LIGHT QUALITY AND VIEWS TO OUTSIDE

Indoor light levels in the work environment need to be of a quality that provides an environment in which it is easy to see so that tasks can be safely performed without eye strain. Windows can assist in avoiding or reducing eyestrain by allowing an individual to focus on distant objects rather than prolonged viewing of close objects such as computer screens. In general, evidence suggests that most people prefer to work by natural light and have access to views.[13]

The most effective way to improve light quality and visual amenity for building users is to maximise the input of natural light (incorporating measures to reduce glare and heat input) and aim for the highest possible proportion of workspaces with views to outdoors. In addition, the installation of task lighting allows individuals to adjust the light needed for their work and means unoccupied areas do not need to be fully lit.

4.3 TEMPERATURE CONTROL

Many studies have revealed that the optimal comfort range for office work is 22-25°C.[14] Buildings should be designed to operate within this temperature range (ideally without artificial cooling for at least part of the year, see section 2.1.2). Where possible, individuals should have the ability to regulate or request changes to the temperature in their work area.

4.4 NOISE

Noise can interfere with concentration and conversation and cause fatigue, irritability, headaches and stress. It is important to minimise noise in order to create a workable and pleasant work place. Thoughtful building design can reduce the impact of noise and improve the quality of our living environment.

It is usually easier and cheaper to integrate noise reduction and acoustic control components into a building at the design stage than it is to make changes once the building is complete. Therefore, building designers should be fully informed of the intended use of the building and the acoustic impact of these activities.

4.5 LOW TOXICITY INDOOR ENVIRONMENT

Volatile organic compounds (VOCs) are emitted by many of the paints, finishes and other products that are used inside buildings, and are toxic to humans. To create a low toxicity indoor environment, the best option is to select products that emit less VOC's. Products that are low in VOCs are now readily available and clearly labelled. Table 3 indicates the maximum acceptable VOC content for common products, as outlined in Council's Sustainable Building Design Checklist (see Appendix 1).

[13] Brown, Stephen K (2006) High quality indoor environments for office buildings. In: Clients Driving Innovation: Moving Ideas into Practice, 12-14 March 2006

[14] Seppanen, Olli, Fisk, William J., & Faulkner, David. (2004). Control of temperature for health and productivity in offices. Lawrence Berkeley National Laboratory: Lawrence Berkeley National Laboratory. Retrieved from: http://escholarship.org/uc/item/39s1m92c

4.5.1 Paints

The VOCs in paints are generally emitted most quickly as the paint dries, but paints may continue to release VOCs for some time after application. VOCs from paint include benzene, formaldehyde, kerosene, ammonia, toluene, and xylene, all of which are known carcinogens and neurotoxins. There is mounting evidence that exposure to VOCs can worsen asthma symptoms and cause nose, skin, and eye irritation; headaches, nausea, convulsions, and dizziness; respiratory problems; nerve damage; and, in some cases, liver and kidney disease.

Due to increased awareness of the impacts of these VOCs on human health, almost all major paint manufacturers now produce low VOC products. There is also a growing range of natural paint products produced from plant derived or clay-based ingredients with very low VOC content.

In addition to this, heavy metals such as cadmium, chromium and mercury are still used in the manufacture of synthetic paints and finishes. A range of other restricted substances are also used in many conventional paint products including resins, binders, preservatives, driers, fungicides and odour suppressants. These toxins may be carcinogenic or result in a variety of adverse health conditions including nose and throat irritation, lung damage and kidney dysfunction.

The presence of heavy metals in paint products can also result in long term environmental impacts such as sediment contamination and poisoning throughout the food chain if incorrectly disposed of down stormwater drains or sewers. As a result, natural paints are widely regarded as the healthiest option for both humans and the environment as they are manufactured from ingredients of plant and mineral origin.

More information on low toxicity paint products is available on the Good Environment Choice Australia[15] or Ecospecifier Global[16] websites. The online product registers developed by these companies provide details on specific paint products that meet established performance criteria.

[15] http://www.geca.org.au
[16] http://www.ecospecifier.com.au

4. INDOOR ENVIRONMENT QUALITY

4.5.2 Flooring

Many flooring products contain high levels of VOCs which can affect respiratory health. The underlays, glues and adhesives used to install flooring may also contain VOCs. Seek out low VOC flooring products such as linoleum, recycled rag carpet underlays, and wool carpets that are not latex backed.

Clear floor finishes and stains may also include VOCs, and low VOC products based on natural oils or water based products are preferred. Alternative floorings you may wish to consider include wood, cork, bamboo, linoleum, and 100% wool carpets and wool carpet tiles.

Table 2. Maximum Total VOC content for paints, finishes, adhesives and sealants

From Green Star Office Design and Office As Built Version 3, 2008

Product type/Sub Category	Maximum acceptable Total VOC content (g/l of ready to use product)
Paints and finishes	
Walls and ceilings – interior semi gloss	16
Walls and ceilings – interior low sheen	16
Walls and ceilings – interior flat washable	16
Ceilings – interior flat	14
Trim – gloss, semi-gloss, satin, varnishes and wood stains	75
Timber and binding primers	30
Latex primer for galvanized iron and zincalume	60
Interior latex undercoat	65
Interior sealer	65
One and two pack performance coatings for floors	140
Any solvent-based coatings whose purpose is not covered in table	200
Adhesives and sealants	
Indoor carpet adhesive	50
Carpet pad adhesive	50
Wood flooring and Laminate adhesive	100
Rubber flooring adhesive	60
Sub-floor adhesive	50
Ceramic tile adhesive	65
Cove base adhesive	50
Dry Wall and Panel adhesive	50
Multipurpose construction adhesive	70
Structural glazing adhesive	70
Architectural sealants	250

4.5.3 Formaldehyde emissions

Formaldehyde is an important chemical used widely by industry to manufacture building materials and numerous household products. Formaldehyde is used as a component of glues and adhesives, and as a preservative in some paints and coating products. Formaldehyde emissions can be harmful to human health.

In buildings, the most significant sources of formaldehyde are likely to be pressed wood products made using adhesives that contain urea-formaldehyde (UF) resins, including particleboard; hardwood plywood panelling; and medium density fiberboard. Many manufacturers now offer no or low formaldehyde products. These are labelled as E0 and E1 and should be specified for interior uses.

For more information visit the Australian Green Procurement Database[17] or Good Environmental Choice Australia.[18]

4.5.4 PVC

During the manufacture of the fundamental ingredients of PVC (such as vinyl chloride monomer), dioxin and other persistent pollutants are emitted into the air. These pollutants both present acute and chronic health hazards for humans. During use, PVC products can leach toxic additives. For example, flooring can release softeners called phthalates which can affect humans by disrupting the endocrine system. When PVC reaches the end of its useful life, it can be either disposed of in landfill, where it releases harmful chemicals, or incinerated, again emitting dioxin and heavy metals.

PVC is used in such products as pipelines, wiring, siding, flooring and wallpaper. It is possible to reduce the use of PVC by replacement with other materials. For example, polyethylene and terracotta pipes can be used instead of PVC pipes and linoleum floor covers can be used instead of vinyl.

Use of certified PVC can reduce the impacts of using this material. A comprehensive database listing alternatives to PVC can be found on the Healthy Building and Greenpeace websites.[19]

4.5.5 Pest treatment

Chemical pest treatments use toxic substances to manage termites and other pests. To avoid or reduce the need for these treatments, structural pest management measures need to be considered at the design stage of the building process. Australian Standards AS 36601.1:1995 specifies physical barriers that can be used to prevent termite intrusion include steel mesh, stone and concrete barriers.[20]

[17] http://www.greenprocurement.org
[18] http://www.geca.org.au
[19] http://www.healthybuilding.net/pvc/alternatives.html, http://archive.greenpeace.org/toxics/pvcdatabase/
[20] Australian Standards AS 36601.1:1995 Protection of Buildings from Subterranean Termites: Part 1 – New Buildings

5. WASTE AND CONSTRUCTION MATERIALS

Related sustainable design principles:

11. Select materials with the lower embodied energy and environmental impacts.

12. Maximise reuse and recycling of construction and demolition waste.

13. Allow adequate space for recycling, waste storage and composting by building occupants.

5.1 REDUCING WASTE

Waste from the building can be divided into two categories – waste generated during construction and waste generated during subsequent operation or habitation of the building. It is important to reduce the amount of waste going to landfill as this reduces the need for more landfill sites; also the production of new materials consumes natural resources and produces greenhouse gas emissions. Reducing, reusing and recycling waste materials is therefore the most sustainable option.

5.1.1 Reuse and recycling of construction waste

Construction and demolition waste accounted for 38% of Australia's total waste to landfill in 2006-2007.[21]

Many of the 'waste' materials from construction sites could have been reused or recycled. Reducing the amount of construction 'waste' going to landfill not only eases the pressure on landfill and reduces greenhouse gas emissions, it also reduces waste disposal costs for the builder and can create local business opportunities as products can be re-sold.

Unwanted materials should be sorted on site for reuse or recycling, and only materials that are not suitable for either reuse or recycling should go to landfill. A directory of local companies dealing with reuse and recycling of construction waste is included below.

Table 3. Directory of local companies dealing with recycling and reuse of building materials

Company	Phone	Service	Address
Anton's Demolitions Pty Ltd	4055 9461	Sells recycled building materials and fixtures and accepts reusable materials	62 Tucker Street, Machans Beach
Newport Recycling Group	0418 779 635	Accepts all metals for recycling	13 Marsh Street, Woree
NQ Recycling Agents	4051 6679	Accept brass, copper and aluminium for recycling	27 Federation Street, Bungalow
OneSteel Recycling	13 63 82	Accepts all metals plus car batteries for recycling (most scrap metal is purchased for set price based on weight)	http://www.onesteel.com
RecycleBuild	4053 1274	Online display yard of local recycled building materials available for purchase	http://www.recyclebuild.com.au
Down to Earth Demolitions	4035 2555	Sells recycled building materials and fixtures and accepts reusable materials	http://www.dtedemo.com.au

Please note: This is not a definitive list of service providers. If you would like to add your business to this list please contact Council's Sustainability Officer on 4044 3044.

[21] Environmental Protection and Heritage Council (EPHC) *National Waste Overview 2009*

Simple steps you can take to minimise waste from the building site during construction are listed below:

- Reuse or recycle as many of the unwanted materials as possible.
- Use building designs that are designed to minimise off cuts.
- Avoid over ordering and materials being damaged onsite.
- Return over-supplied quantities to the supplier.
- Create an area within the site for the storage and removal of different waste types.
- Ensure waste is clearly separated into recoverable and non-recoverable streams.
- Keeps records of movement of waste and recovered waste materials on and off site.
- Store off-cuts that are of a reasonable size and condition for use in maintenance.
- Organise with suppliers for pallets to be returned with follow on deliveries.
- Crush large quantities of concrete, bricks and hard materials and use for road base, retaining walls, drainage etc.
- Design and select materials for ease of deconstruction, reuse and recycling, either upon major refit or demolition.

5.1.2 Reducing and recycling operational waste

It is possible to influence the waste disposal habits of building users during the design phase of a building. Some methods for reducing operational waste are listed below.

- Provide bins and adequate space for general recycling, paper recycling and general waste.
- Provide public place recycling bins outside building.
- Locate recycling containers or space for containers near the point of use.
- Allow for composting of food and garden waste.
- Install worm farms, which are an effective method of processing food scraps.
- Mulch green garden waste. This provides an excellent ground cover material for landscaped areas, helping to conserve soil moisture, reduce weed growth, and improve soil condition.

5.2 SELECTING LOW IMPACT CONSTRUCTION MATERIALS

Careful choice of building materials can greatly improve energy efficiency, increase the comfort and health of building users, and reduce overall environmental impacts of a building. For best environmental outcomes, construction materials that have the below characteristics should be prioritised.

Sustainable construction materials are:

- Manufactured from renewable or recycled resources.
- Energy efficient and have low embodied energy.
- Non-polluting.
- Manufactured using environmentally acceptable production methods.
- Durable and have low maintenance requirements (painting, re-treatment, waterproofing etc), or whose maintenance will have minimal environmental effects.
- Recyclable.

5.2.1 Sustainable timber

Cairns Regional Council does not support the use of illegally or unsustainably logged timbers. Timber extraction from native forests has the potential to cause habitat loss, species extinctions and to displace indigenous peoples from their lands. Careful selection of timber products is required to minimise environmental and social impacts.

At the global level, the proportion of the world's wood products sourced from illegal logging is estimated to be between 20% and 40%.[22] A 2005 report commissioned by the Australian government estimated that around $400 million worth of illegally logged timber imports enter Australia and are sold to consumers each year.[23] These timbers are from unsustainably logged forests in places such as Indonesia, Borneo and Papua New Guinea, where habitat is being destroyed at a fast rate and many species face the risk of extinction. In areas of South East Asia, rainforest is being cleared at a rate of five million hectares per year, and once an intact rainforest has been clear-fell logged, it will not recover for many hundreds of years.

The timber products that produce the best environmental and social outcomes are recycled timbers and plantation timbers from within Australia. Imported plantation timbers with certification are also acceptable, but buying Australian timber is preferable as transport emissions will be lower. As a last resort, in situations where recycled or plantation timber will not suffice, FSC or Ecotimber certified products should be used.

Refer to Table 4 for recommended plantation and certified timbers and timbers not recommended for use.

Table 4. Sustainable timber directory

For further information visit http://www.goodwoodguide.org.au

RATING	COMMENTS
FIRST CHOICE	
Recycled timbers	An ideal way to reduce waste and make use of used materials
Australian softwood and hardwood plantation timbers certified by Forest Stewardship Council (FSC)[24]	There are many softwood and hardwood plantation timbers available from Australian plantation sources
SECOND CHOICE	
Non-certified Australian plantation timbers	
FSC certified Australian native forest timbers	While considerable effort has gone into ensuring the integrity of these certification schemes, some doubts have been raised both in Australia and overseas about the effectiveness of this scheme
FSC certified timbers from other countries	
TIMBERS TO AVOID	
All native Australian timbers unless plantation-grown or certified by FSC	Logging of old-growth forests in Australia is responsible for species loss and severe habitat degradation
Imported timbers without FSC certification Commonly imported South East Asian rainforest timbers to avoid include: **Meranti** – used for all mouldings, dowels, architraves **Merbau** – used for skirting, joinery **Ramin** – mostly used for picture frames and fine joinery **Pacific Maple** – all mouldings, dowels, architraves **Philippine Mahogany**, **Calantas Pretend** red cedar – fireplaces, stairs, furniture **Keruing, Naytoh, Narra, Kapur** – used for joinery **Teak** – outdoor furniture, carved beams, cabinet work **Jelutong** – joinery, carved work, toys **Motoa, Merawan, Batu** – house posts	

[22] WWF, 2008, Illegal wood for the European market

[23] Poyry Forest Industry, 2005, *Overview of illegal logging, DAFF*

[24] Forest Stewardship Council – International website http://www.fsc.org and Australian website http://www.fscaustralia.org/

5.2.2 Embodied energy

All materials have embodied energy and emissions. The embodied energy is the energy used in the extraction and processing of raw materials to make building materials and transport and processing of those building materials. The embodied energy per unit mass of materials used in building varies enormously, from about two gigajoules per tonne for concrete to hundreds of gigajoules per tonne for aluminium. However, other factors also affect environmental impact, such as differing lifetimes of materials, differing quantities required to perform the same task and different design requirements.

Selecting materials with low embodied energy greatly reduces the greenhouse gas emissions associated with a building project. Refer to Table 6 for approximate embodied energy values of different building materials. These figures are estimates only, and do not include transport emissions. Therefore these materials used at sites near production will have lower embodied energy than the same materials used at sites further away.

Recycled materials generally have much lower embodied energy levels. For example, aluminium from a recycled source will contain less than ten per cent of the embodied energy of aluminium manufactured from raw materials.

While it is important to strive for the lowest possible embodied energy materials, in some cases, a higher embodied energy level can be justified. For example, a material with higher embodied energy may be the best choice if the material:

- contributes to lower operating energy requirements;
- can more easily be reused in new buildings after demolition;
- will significantly extend the building's life; or
- is recycled.

More information on embodied energy is available on the Your Home website.

Case studies

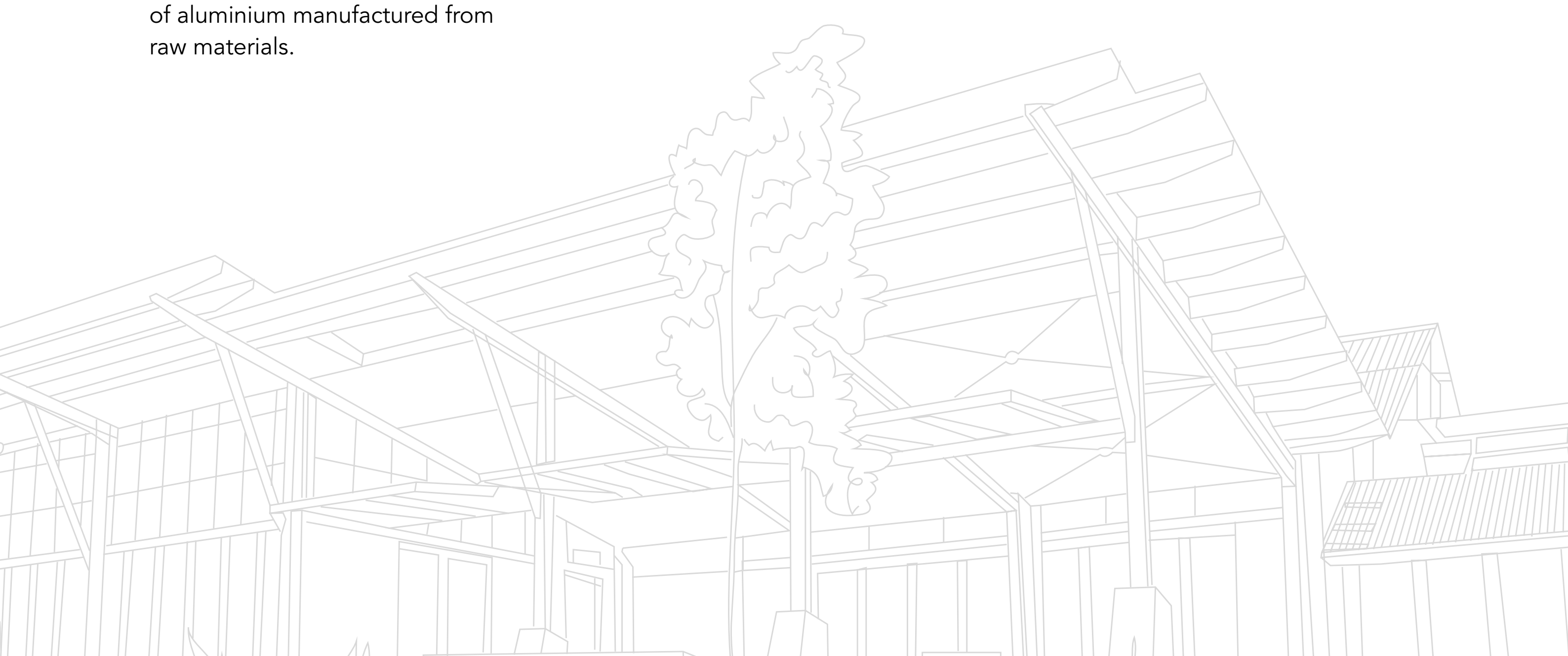
Two examples of building materials commonly used in large quantities are concrete and steel. While these are important building materials, their use should be minimised where possible and alternatives such as recycled or partially recycled products should be considered.

Concrete is a vital component in building construction. Concrete has many advantages including durability and longevity, but the production of concrete emits greenhouse gases and causes many environmental problems.

The majority of these problems are associated with the production of cement, a component of concrete. Cement is among the most energy-intensive materials used in the construction industry and is responsible for about 1% of Australia's greenhouse gas emissions.

The environmental impacts of concreting can be reduced by giving preference to concretes which substitute a proportion of the cement binder for alternative cementing agents such as fly ash or ground blast furnace slag. This not only reduces greenhouse gas emissions but can help deal with industrial waste problems as well.

Steel has high embodied energy, due to the energy-intensive mining and refining processes. It is however, a strong and durable material that can extend the life of a building. Using steel sparingly in the design and using recycled steel are some options for reduce the embodied energy of the building.



5. WASTE AND CONSTRUCTION MATERIALS

Table 5. Embodied energy of building materials

This table is an indication only. It is important to remember that the weight of a product, rather than its usefulness, will affect its Mj/kg rating. In addition, energy used to transport products is not considered in this table.

MATERIAL	PER EMBODIED ENERGY MJ/kg
Kiln dried sawn softwood	3.4
Kiln dried sawn hardwood	2.0
Air dried sawn hardwood	0.5
Hardboard	24.2
Particleboard	8.0
MDF	11.3
Plywood	10.4
Glue-laminated timber	11.0
Laminated veneer lumber	11.0
Plastics – general	90
PVC	80.0
Synthetic rubber	110.0
Acrylic paint	61.5
Stabilised earth	0.7
Imported dimension granite	13.9
Local dimension granite	5.9
Gypsum plaster	2.9
Plasterboard	4.4
Fibre cement	4.8*
Cement	5.6
Insitu Concrete	1.9
Precast steam-cured concrete	2.0
Precast tilt-up concrete	1.9
Clay bricks	2.5
Concrete blocks	1.5
AAC	3.6
Glass	12.7
Aluminium	170
Copper	100
Glavanised steel	38

Source: Lawson Buildings, Materials, Energy and the Environment (1996);
** fibre cement figure updated from earlier version and endorsed by Dr. Lawson*

6. LOCAL ENVIRONMENT

Related sustainable design principles:

14. Restore habitat and improve community spaces surrounding buildings.

15. Minimise the impact during and post development on biodiversity, water and soil quality, soil erosion and visual amenity.

The level of impact that a construction project has on the natural environment can be greatly reduced by adopting simple measures such as locating the building away from ecologically sensitive areas, protecting topsoil, landscaping with local native plants, revegetating areas of the site to create habitat, minimising soil runoff during construction, and landscaping to slow water flow across the site. Social and visual amenity can also be improved by allocating space for community gardens if the site is appropriate. Effective landscaping can also influence the indoor environment by channelling cool breezes into the building and shading sun-exposed walls.

6.1 MINIMISING ECOLOGICAL IMPACTS

Constructing a building will inevitably have some level of impact on the local environment. The level of impact will depend on the condition of the site before construction. For example, building and landscaping on a degraded, weed-infested site could increase the quantity and quality of habitat available to local species. The level of impact also depends on how the building is designed and constructed and how landscaping and earthworks are conducted on the site.

Below are some simple steps that can help to reduce the localised ecological impacts of a building project.

- Survey the site for native plant and animal species and plan to minimise impacts on the most sensitive areas.
- Locate the building in the least sensitive area of the site where possible, working around established native trees rather then removing them.
- Protect waterways and locate the building away from creeks and wetlands.
- Avoid light pollution of the night sky (which is detrimental to fauna) by designing outdoor lighting that shines down rather than out or up.

6.2 HABITAT RESTORATION

Even small patches of native vegetation provide important habitat for local plant and animal species. Landscaped areas around a building provide an excellent opportunity to create habitat for birds and insects. Native gardens are attractive, low-maintenance, suited to local climatic conditions and attract wildlife into the area.

The quality of habitat can be enhanced by selecting a variety of plants that provide favoured shelter or food for local animals. See section 6.4.1 for more information about selecting native plants.

If the site is large, consider setting aside an area for a larger revegetation planting. Wetlands and waterways are particularly good places to start with revegetation, as native vegetation on the water's edge helps to improve water quality, slow water flow and reduce erosion (see section 3.4).

Connectivity of habitat is particularly important, as it allows for dispersal of species and individuals between patches of intact vegetation. Habitat corridors, strips of vegetation that connect larger habitat areas, are of high value. If the building site lies between two habitat areas, consider planting a habitat corridor.

6. LOCAL ENVIRONMENT

6.3 COMMUNITY GARDENS

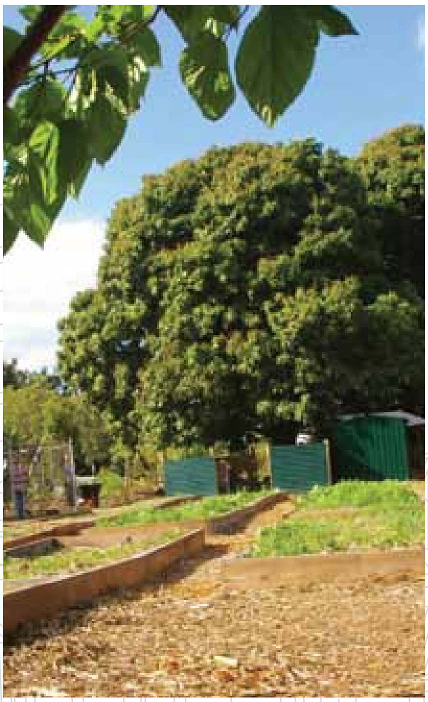
Allocating space for community food gardens on site is an excellent way to make use of space that may otherwise be unoccupied or place a burden on ground maintenance staff. Community gardens are developed and maintained by community members, who use the area to grow food or other plants that are harvested by those involved. These gardens provide a service to the community, build community cohesion and are productive, colourful and attractive.

Further information
The Australian City Farms and Community Gardens Network
http://communitygarden.org.au/

6.4 LANDSCAPING

Well planned landscaping can enhance the amenity and aesthetics of a building, while promoting biodiversity, filtering stormwater runoff and providing habitat for native species.

Landscaping can reduce the artificial cooling requirements of a building by providing shade and channelling cool breezes through the building. Well planned landscaping can help to lower temperatures in the vicinity of a building, reduce the ground temperatures around a building, and can be used to cool incoming air. See the Landscaping for a Cool Building section (2.1.3) for more information.



6.4.1 Selecting plant species for landscaping

Plant species that are indigenous to the area are best suited to the local climate and are therefore the most water efficient choice. They also provide the best habitat for local wildlife. Planting local species should eliminate the need for fertilisers and minimise the need for watering once plants are established. In the Cairns region, plants for landscaping around buildings should:

- Be suited to local climate, water availability and soils.
- Not shade solar panels.
- Not require pesticide or fertiliser application.
- Provide food and habitat for native wildlife.
- Not create a cyclone hazard.
- Not hold pools of water that provide breeding grounds for mosquitoes.
- Cover soil to prevent soil runoff during heavy rainfall.
- Not adversely affect the structure of the building or underground infrastructure.
- Not interfere with overhead powerlines.
- Not compromise public safety of the area.

Local native plant species are available from the following Council nurseries:

Stratford Nursery
Phone 4044 3971

Mossman Nursery
Phone 4098 2619

6.4.2 Landscaping to slow water runoff

Ideally a building and its surrounding area of landscaping will be designed to slow water movement across the site and encourage filtration through the soil rather than diversion into stormwater drains. Porous surfaces and gardens designed for water capture and filtration will help to reduce stormwater flow off the site (see section 3.4).

6.4.3 Protecting and retaining topsoil

Where possible, topsoil removed during construction should be reused onsite. Topsoil is usually high in organic matter which provides a good source of nutrients to new vegetation. Topsoil also has a much higher capacity to retain water. Topsoil should not be left without vegetation cover for any length as it will be washed away by rainfall events and pollute waterways.

7. GREEN BUILDING CASE STUDIES

7.1 CASE STUDY 1 - William McCormack Place Stage 2, Cairns

William McCormack Place Stage 2 is a Queensland Government office building that was completed in 2010. This stage involved the construction of a new 9,400m^2 office building that incorporates a number of energy efficiency and energy generation measures, including the installation of a 64 kilowatt solar photovoltaic array and a chilled water thermal storage system.

The building achieved a 6 Star Green Star Office Design rating and has set new standards for commercial property development in Cairns, significantly exceeding design requirements for a sustainable and effective office building with low lifecycle costs. The total project cost was around $79.5 million.

The building's energy-saving initiatives are expected to deliver cost savings of approximately $450,000 per year. Specific sustainability outcomes include a 60% (1,000 tonnes per year) reduction in CO^2 emissions (compared to a median 2.5 Star building), a 40% reduction in whole-building demand on the electricity grid, and a 75% (17ML/y) reduction in potable water use, (compared to a median 2.5 Star building).[27]

Local expertise was used in the design and construction of the building. Throughout this process, local builders, sub-contractors and suppliers have also discovered the benefits of sustainable design and in some cases raised their performance to help the project succeed.

[27] ARUP website http://www.arup.com

7. GREEN BUILDING CASE STUDIES

7.2 CASE STUDY 2 - TAFE Sustainability Precinct, Cairns[28]

The Sustainability Precinct (J Block) at the Tropical North Queensland Institute of TAFE received a five star Green Star rating under the Green Star Education v1 tool developed by the Green Building Council of Australia. This $8.5 million project was the first educational building to achieve a 5 star rating in a tropical or hot humid zone.

The building design incorporates the following sustainable design features.

- Passive ventilation through louvres at ground level.
- A building management system to maximise the efficiency of lighting and cooling and integrate passive and mechanical cooling.
- Solar hot water and solar photovoltaic panels for producing energy.
- Efficient gas air-conditioning.
- Water efficient appliances, rainwater tanks and on-site stormwater treatment.
- Low-impact construction materials.

[28] Information courtesy of Total Project Group Architects

7.3 CASE STUDY 3 - Council House 2 (CH2), Melbourne[29]

The Council House 2 (CH2) building provides office accommodation for the City of Melbourne. The City of Melbourne constructed a Green Star rated office building because they are committed to promoting the health and well being of staff and to meeting the key performance indicator of zero net emissions by 2020. They also aim to influence the market and act as a leader in sustainable development.

The following sustainable technologies are incorporated into this 10-storey development:

- a water-mining plant in the basement;
- phase-change materials for cooling;
- automatic night-purge windows;
- wavy concrete ceilings; and
- a façade of louvres (powered by photovoltaic cells) that track the sun.

The building is estimated to have:

- reduced electricity consumption by 85%;
- reduced gas consumption by 87%;
- produced only 13% of the emissions; and
- reduced water mains supply by 72%.

[29] Green Building Council of Australia, 2006 Edition. *The dollars and sense of green buildings: Building the Business Case for Green Commercial Buildings in Australia*

7. GREEN BUILDING CASE STUDIES

Description of project
City of Melbourne office building

Gross floor area: 12,536sqm (mixed Council office space and commercial space for letting).

Project cost
$77.14 million, CH2 building

Costs include:

- $29.9 million for the base building.
- $11.3 million for sustainability features.
- $2.8 million on education and demonstration process.
- $7.1 million on requirements specific to Council.

Premium
It is estimated that sustainability features added 22% to the construction cost. One of the reasons cited for the high cost was the inclusion of risk management additions such as the back up mechanical plant (chillers) and the Co-generational plant and commissioning for plant and equipment and environmental systems.

Payback
The City of Melbourne took a conservative estimate of an 11 year payback time for the sustainability features to pay for themselves.

However, they believe the payback period will be more in the realm of 8 years.

Figure 9A
A cross section of the CH2 building showing sustainable design features, by day. Source: © DesignInc

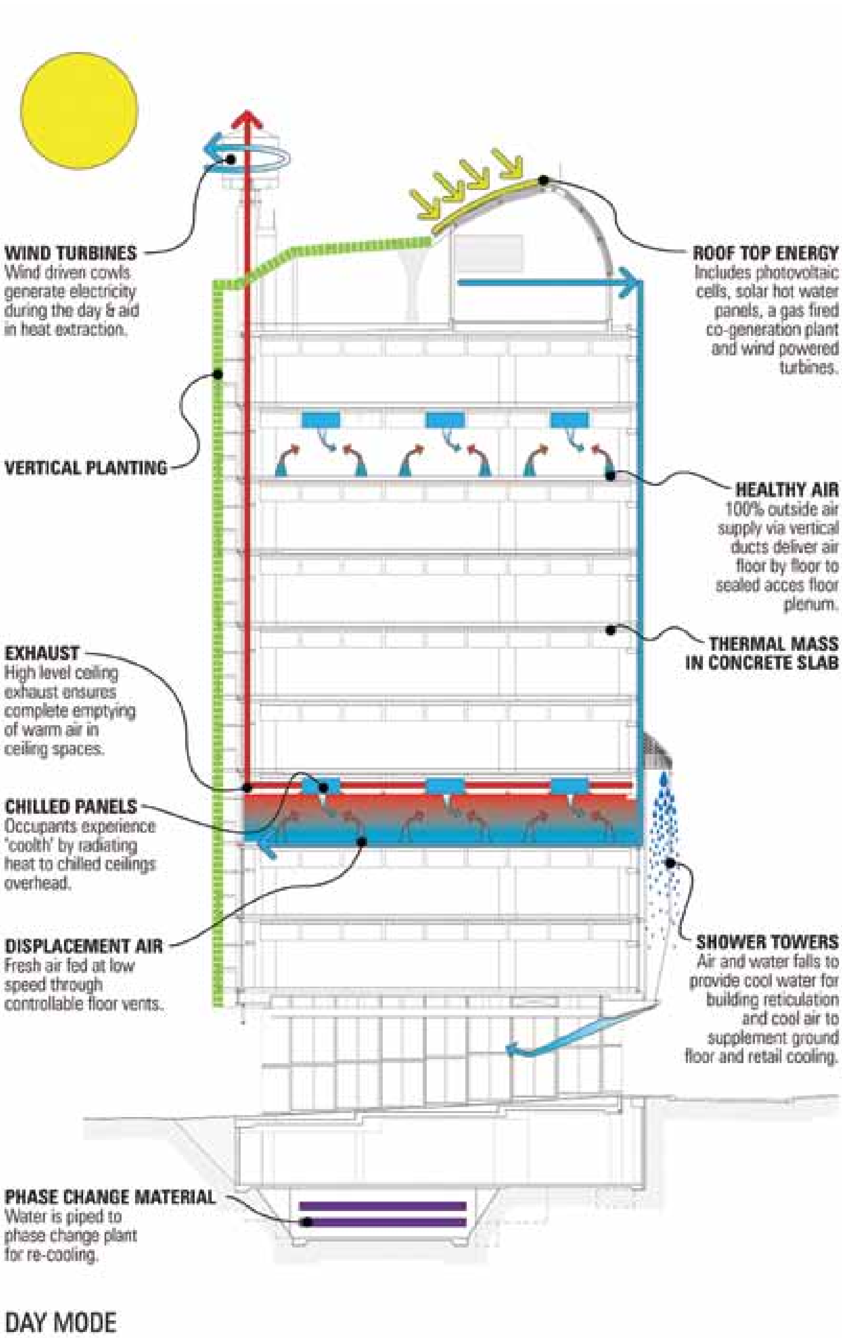
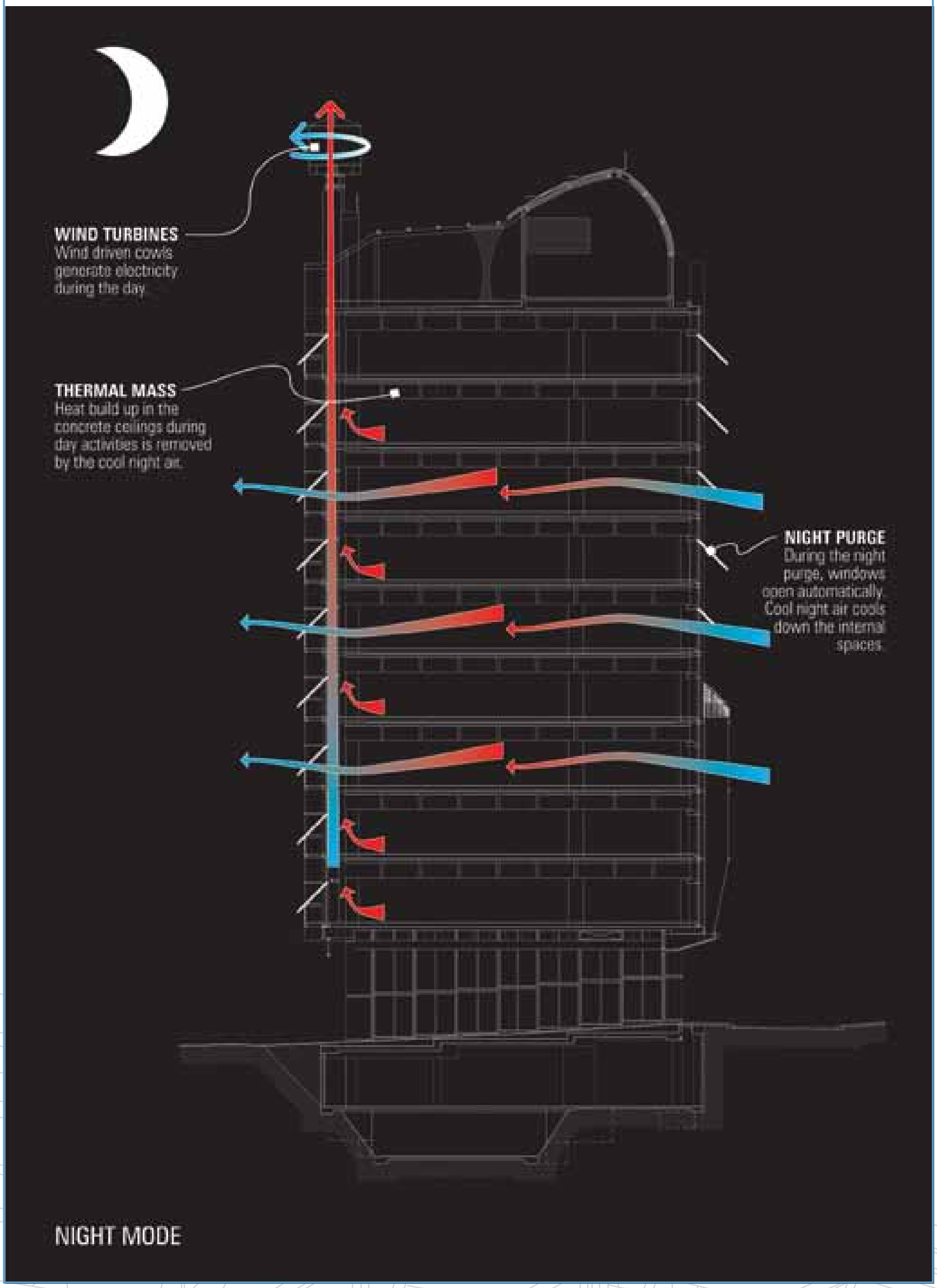


Figure 9B
A cross section of the CH2 building showing sustainable design features, by night. Source: © DesignInc



8. RESOURCES

Green Building Council of Australia
www.gbca.org.au

World Green Building Council
www.worldgbc.org

Ecospecifier Global
www.ecospecifier.com.au

CoolMob
Greenhouse Friendly Design for the Tropics
Available from www.coolmob.org

Your Home Technical Manual
www.yourhome.gov.au

APPENDIX 1 - Sustainable Design Checklist

The following is an overview of Council's Sustainable Building Design Checklist.
To download the complete version visit Council's website www.cairns.qld.gov.au.

	PERFORMANCE CRITERIA	
Energy and emissions	Average lighting power density is 10% lower than requirements of the BCA Section J for building class.	Mandatory
	All enclosed spaces are individually switched, and lighting zones (areas controlled by one switch) do not exceed 100m^2.	Mandatory
	Lights are fitted with movement detection and timed automatic shut off switching throughout, except in areas where security/safety requires fixed lighting arrangements.	Mandatory
	At least 50% of useable floor area is within 8 metres of a window, skylight, or other natural light input.	Mandatory
	The building includes the following: (i) roof overhangs with a minimum width of 45cm or 7.5% of the wall height, whichever is greater; and (ii) north and south facing glazing (windows/other glass) is shaded from midday sun by eaves, awnings and other shading; and (iii) east and west facing glazing is effectively shaded to protect from low angle sun; and (iv) dark colours are not used on roofs and walls exposed to the sun; (v) highly reflective ground surfaces are not used externally, or are fully shaded from high angle sun to reduce glare; and (vi) landscaping provides shade to exposed western walls, car parks and other solid surfaces.	Mandatory
	Buildings are designed to operate in natural ventilation mode including use of operable windows, ceiling fans and ceiling vents. Buildings are fitted with read switches or other automated controls that prevent air-conditioning units operating when the building is in natural vent mode.	*Optional*
	All work and meeting areas are fitted with ceiling fans AND air-conditioning units have a higher set temperature in summer which is assisted by the use of ceiling fans.	Mandatory
	Air conditioning units are fitted with timer switches programmed to switch the system off outside usual hours of building occupancy.	Mandatory
	For buildings with gross floor area of 500m^2 or more: Air-conditioning systems are designed to achieve a) 10% improvement on MEPS Energy Efficiency Ratio requirements for air-conditioners and heat pumps; and b) 10% improvement on current BCA requirements for Maximum Pump Power (W/m^2); and c) 10% improvement on current BCA requirements for Minimum Energy Efficiency Ratio for Packaged Air Conditioning Equipment (Wr/Winput power); and d) 10% improvement on current BCA requirements for Minimum Energy Efficiency Ratio for Refrigerant Chillers (Wr/Winput power).	Mandatory
	For buildings with gross floor area of less than 500m^2: Air conditioning units have a minimum energy efficiency rating of five stars.	Mandatory
	Hot water supply systems, excluding instantaneous tea/coffee boilers are: a) a solar hot water system; or b) a gas hot water system with an energy rating of at least five stars; or c) a heat pump system: or d) a heat recovery system.	Mandatory
	Instantaneous tea/coffee boilers are fitted with auto shut-off and sleep mode.	Mandatory
	Smart (electricity) meters are installed on buildings with a gross floor area of 500m^2 or over, are connected to all circuits and connected to electricity use displays in staff/public areas.	Mandatory
	Photovoltaic (solar panel) systems are installed (where solar access and roof surface permit), with system capacity in accordance with the guidelines in Table 1.	Mandatory
	Car parking does not exceed minimum planning scheme requirements by more than 10%.	Mandatory
	There are spaces dedicated for motorbikes and/or mopeds, with the number of spaces being at least equal to 10% of the available car parking spaces.	Mandatory

... Continued over page

APPENDIX 1 - SUSTAINABLE DESIGN CHECKLIST

	There is a continuous, fully accessible and well-lit path connecting the building to the nearest bus stop/ route (only applies to sites within 800m of a bus route).	Optional
	Secure, under cover and well-lit bicycle storage is provided for regular building occupants and visitors, and surpasses the minimum bicycle parking provision rates recommended by Austroads (see Table 2) by 5%.	Mandatory
	Showers, change rooms and lockers are provided for staff at the rate of 1 locker per staff bike parking space and 1 shower per 10 lockers.	Mandatory
Water and wastewater	Toilets have dual-flush cisterns with maximum 4 litre full flush (when calculated in accordance with Australian/New Zealand Standard AS/NZS 6400:2003)	Mandatory
	All taps are minimum 5 star rated (WELS rating system)	Mandatory
	Shower roses are a minimum 4 star (WELS rating system)	Mandatory
	Urinals are minimum 5 star (WELS rating system)	Mandatory
	Rainwater tanks are installed and connected to the roof drainage system, with a capacity exceeding the minimum stipulated in the QDC by 20%. The tank is connected to the external irrigation system and/or the toilets for flushing.	Mandatory
	The building is plumbed with dual water supply to allow future use of recycled water for non-potable uses.	*Optional*
	Black and grey water pipes are plumbed separately and pipes are easily accessible to facilitate future on-site treatment and reuse of greywater and blackwater.	Mandatory
	Only recycled or tank water will be used for landscape irrigation OR a xeriscape (minimal water requiring) garden has been installed.	Mandatory
	The development does not increase peak stormwater flows for rainfall events of up to a 1-in-2 year storm; AND All stormwater leaving the site, at any time up to a 1-in-20 year storm event, is treated or filtered in accordance with either: Urban Stormwater Best Practice Environmental Management Guidelines (CSIRO 1999) OR Australia and New Zealand Environment Conservation Council (ANZECC)'s Guidelines for Urban Stormwater Management	Mandatory
Indoor environment quality	At least 60% of floor area used for permanent work spaces (excluding meeting rooms) is within 8m of an external window that provides an unobstructed view.	Mandatory
	95% of all paints, clear finishes, adhesives, sealants and carpets used inside the building are low VOC in accordance with the guidelines set out in Table 3.	Mandatory
	All composite timber products used in the building are low formaldehyde (EO or E1 in accordance with the values from Good Environmental Choice Australia Standard No:GECA 04-2007; 41-2007 & GECA Guidance Note October 2007 – Formaldehyde Testing v0.1 Table 1)	Mandatory
	Provision is made for indoor plants (minimum one plant per 5 workspaces)	Mandatory
Waste and materials	A Waste Minimisation Plan is developed for all building projects and: - For new works at least 40% of construction waste (by weight) is reused or recycled - For retrofits and renovation at least 60% of construction waste (by weight) is reused or recycled	Mandatory
	Bins and adequate space provided for general recycling, paper recycling and general waste storage according to guidelines set out in Table 4.	Mandatory
	Public place recycling bins are installed outside the building in areas of high public use	Mandatory
	Composting is encouraged by providing outdoor space for worm farms or other composting systems	*Optional*
	The total value of materials with recycled content is at least 10% of the cost of materials used in the project. (This includes materials with partial recycled content).	Mandatory
	The total value of materials extracted, harvested or manufactured locally (within an 800km radius of the project site) is at least 10% of total project cost.	*Optional*

	At least 60% of PVC (by cost) is from recycled sources or is produced according to Green Building Council of Australia best practice guidelines (refer to guidelines by following the link in the more information section).	*Optional*
	No uncertified rainforest timber is used and 80% of all timber used is either recycled, certified plantation timber or, failing that, certified sustainably logged timber (see Table 5).	Mandatory
	Cement use is reduced by substituting it with industrial waste products or oversized aggregate as follows: 30% for insitu concrete, 20% for pre-cast concrete and 15% for stressed concrete.	*Optional*
	60% of all steel (by weight) has greater than 50% recycled content or is salvaged.	Mandatory
Environment	No remnant vegetation will be cleared to construct the building.	Mandatory
	The site is not prime agricultural land.	*Optional*
	Native vegetation clearance is avoided. Where vegetation is cleared, vegetation offsets will be planted and maintained according to Council policy.	Mandatory
	Topsoil remains on site and is protected from degradation and erosion. Topsoil is kept separate from fill and construction waste, and is re-used in landscaping works on completion.	*Optional*
	For sites abutting protected areas, remnant eco-systems, wetlands or waterways, a revegetation buffer is created at boundaries adjoining the land with natural values. The area of the buffer has a minimum width of 5m along those boundary(ies) or 10% of the site, whichever is greater.	Mandatory
	At least 80% of plants species (and at least 80% of total number of plants) selected for landscaping are local native species (excluding projects focusing on food gardens or community gardens)	Mandatory
	A green roof, vertical garden/green wall, community garden or food garden is included in the design.	*Optional*

APPENDIX 2 - Legislative Context

QUEENSLAND DEVELOPMENT CODE

Background

Schedule 1 of the Building Act 1975 details the parts of the Queensland Development Code (QDC) that have legislative effect. All other parts of the Queensland Development Code are advisory standards only.

Relationship with the Building Code of Australia

The Building Code of Australia also provides a nationally uniform set of technical building standards. However, it currently contains numerous additional provisions specific to Queensland. As the number of these provisions increases, it is not practical to include them in the national code. For example, new mandatory standards for Queensland, such as 'Fire safety in budget accommodation', are included in the Queensland Development Code rather than the Building Code of Australia.

Some of the Queensland variations to the Building Code of Australia are inserted into the Queensland Development Code. The application of these standards is mandatory and is enforceable by building certifiers.

If there is an inconsistency between the Building Code of Australia and the Queensland Development Code, the Queensland Development Code prevails.

Mandatory sections of the QDC

Queensland Development Code Part 4.1 – Sustainable Buildings.

Queensland Development Code Part 4.2 – Water Saving Targets.

Queensland Development Code Part 4.3 – Alternative Water Sources – Commercial Buildings.

Guideline Queensland Development Code Mandatory Part 4.1 – Sustainable buildings, 2009.

Water saving targets for councils, plumbers, builders and developers: A guide to the Queensland Development Code part MP 4.2, Effective August 2008.

Alternative water sources – commercial buildings
For councils, plumbers, builders and developers: A guide to understanding the Queensland Development Code part MP 4.3, Effective August 2008.

Building Code of Australia

A set of national requirements for the use in the design, construction, alteration or demolition of buildings, setting out procedures, acceptable methods or material and minimum or maximum values. Each state has its own variations to the national document.

http://www.abcb.gov.au/

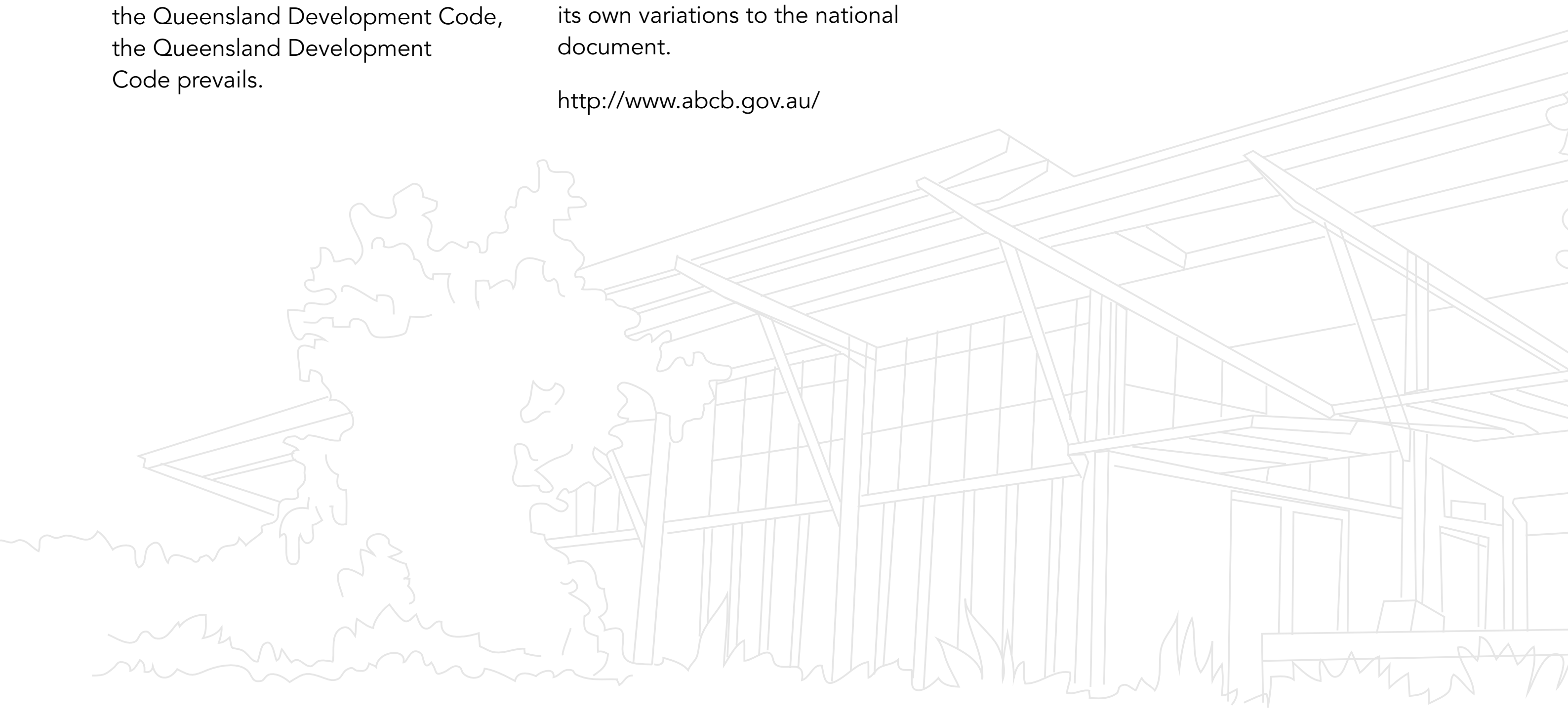


PHOTO CREDITS

Page 4 *Tyto Wetlands Cultural Centre*, Troppo Architects
Page 6 Troppo Architects
Page 7 *Tyto Wetlands*, Troppo Architects
Page 8 Port Douglas, Cairns Regional Council
Page 9 Cairns Regional Council
Page 11 Above right: *William McCormack Place, Cairns*, Arup
Below left: Troppo Architects
Page 12 Above left: Studio Mango Architects/Kym Joseph, Photography 4 Real Estate
Above right: Troppo Architects
Below: *Port Douglas Community Hall*, Cairns Regional Council
Page 13 Corrugated iron roof
Page 14 Top right: *James Cook University Cairns Campus*, Arup
Middle: *Tyto Wetlands Cultural Centre*, Troppo Architects
Bottom: *Port Douglas Community Hall*, Total Project Group Architects
Page 15 Above: *Council House 2*, City of Melbourne
Left: *Port Douglas Community Hall*, Total Project Group Architects
Right: Atrium
Page 17 *William McCormack Place, Cairns*, Arup
Page 18 *Chilled water storage tank at the William McCormack Place building in Cairns*, Arup
Page 20 *Rooftop wind turbines at the Council House 2 building in Melbourne*, City of Melbourne
Page 21 Rainwater tank
Page 23 *Green roof on the School of Art, Design and Media at Namyang University*, Singapore
Page 24 *Bioretention swales at the Tropical North Queensland Institute of TAFE in Cairns*, Arup
Page 25 *Council House 2*, City of Melbourne
Page 26 Above: Troppo Architects
Below: *Council House 2*, City of Melbourne.
Page 27 *Tropical North Queensland Institute of TAFE Health and Sustainability Precinct in Cairns*, Arup.
Page 29 *Council House 2*, City of Melbourne.
Page 31 Left and right: Studio Mango Architects/Kym Joseph, Photography 4 Real Estate
Page 34 Troppo Architects
Page 35 *Cattana Wetlands*, Cairns Regional Council
Page 36 *Northey Street Community Allotments*, Brisbane
Page 37 *William McCormack Place, Cairns*, Queensland Department of Public Works
Page 38 *Tropical North Queensland Institute of TAFE, Cairns*, WSP Group and Total Project Group Architects
Page 39 *Council House 2*, City of Melbourne
Page 42 *Clarke Quay*, Arup – Photographer Darren Soh
Page 45 *Solar panel installation at the Cairns Botanic Gardens Visitor Centre*, Cairns Regional Council

Design by Hot Croc Advertising 2011

Cairns Regional COUNCIL

Small steps can make a world of difference. Recycled paper.