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PROJECT

NORTH BYRON BEACH RESORT

ESD DA REPORT

CLIENT

NORTH BYRON BEACH RESORT

CONSULTING ENGINEERS

EMF GRIFFITHS

ISSUE 0

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1.0 INTRODUCTION

EMF Griffiths have been engaged to report on the principles of Environmentally Sustainable Development (ESD) that may be applied to the proposed development at North Byron Bay.
The development presents a fantastic opportunity to create a sustainable development which sits lightly in the landscape.

The North Byron Beach Resort Ecologically Sustainable Design philosophy uses passive design principles and eco-friendly technologies to provide a natural and open experience. The development:-

- Minimises energy and water use,
- Enhances site ecology, and
- Provides a sustainable service to the community.

Through the Passive Design Ethos natural and passive design principles minimise ecological impacts as follows:-

- Selective orientation of the buildings and a light footprint scheme to enhance the connection to the site habitat.
- Use of insulated lightweight construction to minimise embodied energy in the building fabric.
- Revegetation areas with native plant species.
- Site infrastructure configuration with integrated water sensitive design principles and to minimise ground disturbance.
- Natural ventilation during favourable climatic conditions, shading devices and comprehensive roof insulation minimise the electrical consumption due to operation of air conditioning.

The project provides a high quality eco-resort experience with:-

- Informative and educational features explaining the ecological design,
- Enhanced landscaping in a sub-tropical design setting,
- Sensitive selection of materials finishes for the building using recognised 3rd party eco-certification,
- Low noise building services and design for acoustic privacy,
- Selection of finishes with low solvent content to improve indoor air quality and
- Daylighting and vision corridors to the site flora for maintaining a continuous connection with the subtropical environment.

The Ecological Performance is to be maintained throughout the operational phase of the project by:-

- Ongoing management of energy, water and waste use during the operational phase,
- Minimising resource use through integration of robust and efficient building services into the design and
- Establishment and maturity of site landscaping.

2.0 AIM

To make the development:-

- As self sufficient as possible, working as an integrated system,
- As environmentally responsible as possible without adversely effecting amenity for the occupants,
- As cost effective as possible to build and operate, and
- Comfortable and enjoyable for the people who live and work there.

3.0 STRATEGY

- To use any natural resources available on site,
- To work with, rather than against, the local climate and prevailing weather conditions,
- To reduce long term effect on the site to a minimum: 'touch the earth lightly',
- To integrate systems so they operate in unison for maximum efficiency,
- To become a focal point for the local community,
- To minimise energy usage and generate as much on site as practical, and
- To minimise water usage and recycle water used on site.

The assessment process has used a scorecard scheme for the categories of technologies, design and materials to evaluate the concept sustainable initiatives. These scorecards and their elements are detailed in the following section.

4.0 TECHNOLOGIES SCORECARD

	Principles	Design	Operations	Ethos	Resources	Experience	Verdict
Photovoltaic power generation	Recognisable ESD principle for reduction in energy use.	Energy efficiency technology.	Reduction in Energy and emissions.	Integrated and responsible low energy solution.	Reduction of resources associated with grid energy generation	Recognisable ESD principle – symbol of 'green design'	Inclusion of PV energy generation = energy efficiency. Recommended
Solar organic Rankine cycle combined electricity and domestic hot water generation	Sustainable energy/hot water generation.	Efficient energy and hot water production.	Uses local climatic conditions.	Integrated and environmental design.	Reduction of energy resources and use of local site conditions.	Pushing green building boundaries	Not recommended
Solar hot water	Proven technology to decrease energy costs associated with water heating.	Energy efficient design.	Reduces energy, emission and cost of water heating.	Low impact design using available energy on site.	Reduce the need for energy resources	Natural, expected technology in sub-tropical design.	Solar hot water systems = energy efficiency
Geothermal air-conditioning	Decreases air conditioning energy use	Energy efficient system	Decrease emissions and energy.	Low impact solution	Using local climate resources	Pushing green building boundaries	Feasible determine cost implications
LED lighting	Low maintenance and reliable lighting	Energy efficient lighting	Minimises lighting energy use, and GHG emissions.	Low impact, simple, responsible and efficient design.	Low energy use minimises resource depletion.	Quality of design	LED lighting = smart design. Recommended
Energy monitoring and management strategies	Proven and reliable way to monitor use and discover faults.	Using technology to increase energy efficiency.	Assist in maintenance and management of the building	Integrated design solution	Using technology to minimise energy resources	High quality, luxury design.	Energy monitoring = smart design. Recommended
Greywater treatment	Proven sustainable technology	Water efficiency by reuse on site	Minimise water use and discharge	Low impact, water conservation.	Recycling and reuse of water.	Eco friendly solution.	Explore feasibility/ cost implications
Blackwater treatment	Proven sustainable technology	Water efficiency by reuse on site	Minimise water use and minimise sewerage waste	Integrated design. Low impact, water conservation.	Minimisation of water resources and discharge.	Eco friendly solution.	Not recommended
Biomass gasification	Sustainable solution to energy generation.	Onsite energy generation.	Reduction of waste and decreasing in energy use from the grid.	Pushing 'green building' boundaries.	Minimising waste and resources.	Pushing green building boundaries	Not recommended

5.0 PHOTOVOLTAIC POWER GENERATION

Description

Solar Photovoltaic Technology converts light energy into electrical energy. This electrical energy can be used on the site to reduce the energy require from the public grid. There 3 basic solar systems types;

- Grid Connected Solar System without battery: this system must have an incoming grid connect;
- Stand Alone System: this system requires batteries to store energy to be released at a later time. This system does not require a grid connect; and
- Hybrid Solar System: this system is a combination of batteries and grid connection.

The simplest to implement and most cost effective system is Grid Connected Solar. This type of system is quick to implement and involves no maintenance or knowledge to operate, this type of system is what you see on most homes.

This system can be designed as an open field system (solar farm) or installed on individual buildings. Grid- connect solar system will simply put energy into the grid supply up to the limit of the grid. When the solar grid system is operating it will displace any electrical load up and equal the value that the solar PV is producing any excess energy produced will be sent to the grid network. Some energy providers will pay for this excess energy, currently Origin Energy is paying $0.06 to $0.08 per kWh. The ideal system design would only produce enough Solar PV energy to match the customers load.

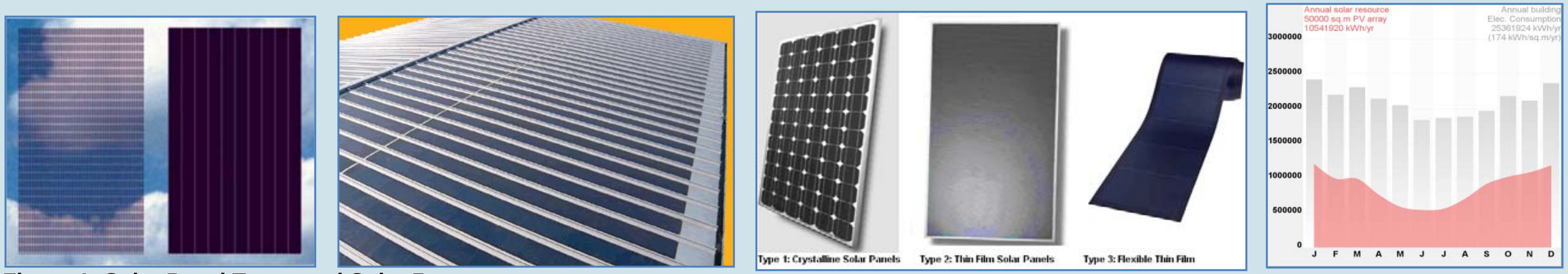


Figure 1: Solar Panel Types and Solar Resource

Properties	Crystalline solar	Thin film solar	Flexible thin film
Wattage per m²	140Watts to 175Watts per m²	60Watts to 90Watts per m²	60Watts per m²
Effect of heat on output	High	Low	Low
Cost per Watt Budget	$4.15 to $5.40	$3.25 to $4.00	$6
Cloudy day output	Low	High	High
Installation cost	$40 per m²	$56 to $80 per m²	Nil
Warranty	25 years to 80% of rated output	20 years to 80% of rated output	20 years to 80% of rated output

Table 1: Comparison of properties of different types of solar panel

Panels can be roof mounted or ground mounted. The advantage of mounting solar panels on the roof are as follows:-

- Reduced site labour; all solar panels and associated equipment can be preinstalled in the factory as pre-fabricated accommodation units using a twin rail and clamp system.
- No extra land required.
- Very simple to add extra power to site when more accommodation units are required.
- Connection to the grid very simple

The disadvantages of mounting solar panels on roof are:-

- Solar panels cannot be installed all facing North and at the correct angle.
- The cost of inverters is more expensive as much smaller inverters are used.

Ground Mounted; Ground mount systems do not use concrete to secure the posts into the ground but use a pile driven system. The depth the post is driven is dependent on the soil composition. Depth of post can vary from 1500mm to 6000mm into the ground.

Alternatively, solar panels can be integrated into a dual purpose structure such as a shading structure for car parking.

Figure 3: Solar Panels as Car park shading, ground and roof mounted.

Site Application

- The electrical load at North Byron Beach Resort can be broken up as follows:-
- Living Accommodation (A/C, lighting, fridges, Kitchens, A/V) – estimated maximum demand 2kVA and 20kWh/day per accommodation unit.
- Central facilities (A/C, Lighting, kitchen equipment, conference, laundry); General lighting for walkways and car parks; and various (water reticulation pumps, swimming pool filtration/circulation) – estimated maximum demand 120kVA with 1100KWh/day

6.0 CENTRAL FACILITY PV SYSTEM

Using shade structures over 40 parking bays would give 770m^2 of panels which would accommodate and an array of 480 off x 250W panels with peak wattage of around 100KW. (excluding structure, sub-main cabling and metering)
The annual electricity generation for a grid connected array would be around 130MWh per year with an estimated simple payback of 10 years approximately and supply around 13% of the development's annual electricity requirement.

Unit PV Solar System

Figure 4: PV Inverter

All accommodation unit inverters would be IP65 rated and can be mounted on the exterior next to the switchboard on each unit. One DC isolator will be required next to the inverter and the AC isolator can also act the circuit breaker which will be located in the unit sub-board. All equipment can be installed in the factory and transported to site creating a modular and scalable system. Alternatively, the individual inverter capacity can be increased to cover multiple unit PV systems and save around 15-20% on inverter costs along with reduced maintenance requirements. Note however that this system is inherently less modular than an inverter allocated per unit and installed as below. In addition, smaller inverter units can be fan-less reducing maintenance complexity.
Typical domestic solar system 1.5kW /12m^2 array for each unit and combined generations of 2.1MWh/year, or around 30% of the accommodation unit demand with around a 7 year payback on installation.

Summary:

Integration of PV within the development is recommended.

System	Environmental Benefit	Operational Considerations
Crystalline PV Array: Integrated with Car Parking Shading Structure Or Ground Mounted Array to 770m^2 i.e. over 40 parking bays. With 12m^2 unit system on 50% of the 75 accommodation units.	250Tn CO_2–e saved annually	25 year panel life. Inverter replacement after 10 years Annual panel maintenance.

7.0 SOLAR ORGANIC RANKINE CYCLE COMBINED ELECTRICITY AND DOMESTIC HOT WATER GENERATION

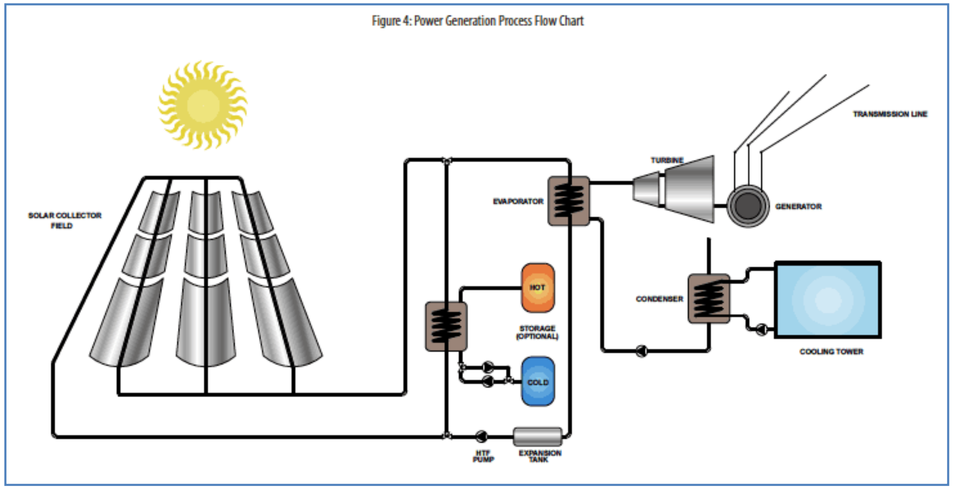


Figure 5: System Schematic

Description

The working principle of the solar organic Rankine cycle is the same as that of the Rankine cycle: the working fluid is pumped to a boiler where it is evaporated by heat generated by solar collectors, and then passed through a turbine (to generate electricity) where it is finally re-condensed. The solar energy collected is also used to provide hot water to the development

Site Application

Suitable for central facility. Sizing to be based on electrical/ hot water demand.
High risk from an operation viewpoint as maintenance could per problematic due to limited adoption of technology, corrosive coastal environment reducing efficiency of collectors.

Summary

Not recommended due potential lack of maintenance support.

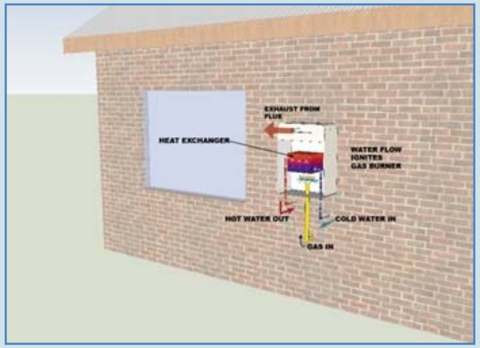
8.0 HOT WATER

Description

Roof Mounted Solar collectors can be used to provide hot water demand – can also be integrated with swimming pool heating if required. A gas or electric boost is required for periods of high demand. Heat pumps and gas condensing boilers are also efficient methods of generating hot water.

Figure 6: Roof Mounted Solar Hot Water System

Heat Pump Hot Water System



Instantaneous Gas Hot Water System

Air Sourced Heat Pumps are efficient at heating water and around three times more efficient than electric water heaters.
Gas heating of domestic hot water generates around a quarter of the CO_2 emissions generated by an equivalent electric water heater. The most efficient gas systems are instantaneous condensing boilers which are typically around 10% more efficient than conventional boilers. The additional efficiency is achieved by extracting heat from the water vapour generated during the combustion process.

Site Application

Five options have been considered:-

- Solar Hot water with an electric boost (accommodation units and central facilities.) For the central facilities a forced circulation split system would be appropriate. For the accommodation units a standard domestic closed coupled thermosiphon system.
- Solar Hot water with gas boost (central facilities) and with electric boost (accommodation units) and
- Heat Pumps (accommodation units and central facilities.)
- Gas Heating: Instantaneous gas boilers for accommodation and flow/return for central facilities – all with localized gas cylinders.
- Gas Heating: Instantaneous gas boilers for accommodation and flow/return for central facilities – all with reticulated gas from central LPG tank.

Individual units: Solar units mounted on accommodation roofs (2.5m2 approx) with integrated 160l roof mounted storage tanks
Central Facilities: 100m^2 solar collector area on roof with 10kL remote storage tank

Summary

Solar Hot water gas boost (central facilities) and Solar Hot water electric boost (accommodation) recommended as a proven and robust ESD Enhancement.

System	Environmental Benefit	Operational Consideration
Solar Hot water electric boost (all)	340 Tn CO2-e saved per year	Easiest maintenance
Solar Hot water gas boost (central facilities) Solar Hot water electric boost (accommodation)	More efficient than above. 360 Tn CO2-e saved per year	Most efficient.
Heat Pumps	Higher efficiency than electric –around 30% of CO_2-e compared to electric heating 350 Tn CO2-e saved per year	Additional fan noise Additional storage capacity can reduce boost requirement during periods of high demand
Localised Gas Heating with condensing boilers	25% of CO2-e compared to electric heating 320 Tn CO2-e saved per year	More maintenance. Less centralised infrastructure.
Reticulated Gas Heating	25% of CO2-e compared to electric heating 280 Tn CO2-e saved per year	Higher infrastructure initial cost. Lower operational maintenance than localised systems

9.0 GEOTHERMAL AIR-CONDITIONING

Description

This technology uses the constant ground temperature to act as a heat sink to allow for improved heat rejection for cooling systems. A ground source heat pump (GSHP) is a heating and cooling system that transfers heat to or from the ground, using the ground as a heat sink in the summer and heat source in the winter. This technology utilises the refrigerant cycle in combination with the constant ground temperature for heat rejection/capture.

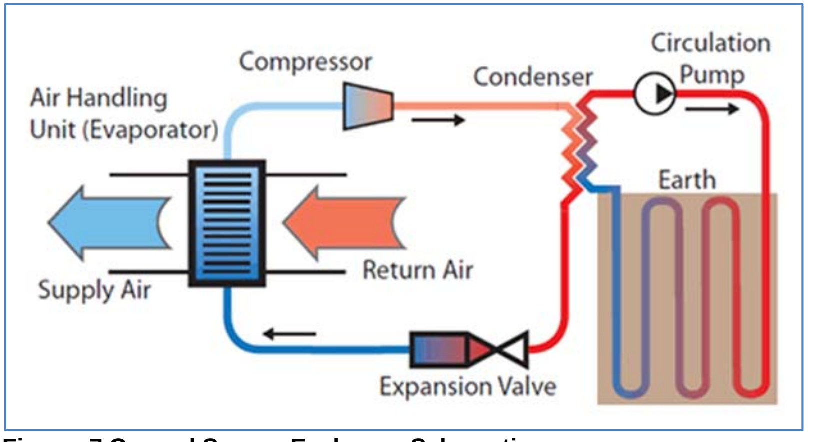


Figure 7 Ground Source Exchange Schematic

It can also operate as a heat pump to provide efficient cooling. The system relies on drilling multiple bores of 100-150m deep. In cooling mode, water is pumped in a closed loop arrangement a heat exchanger where heat is transferred from the A/C system. The water circulates through the bores and the heat gained is rejected to the lower temperature sub-surface.

Site Application

The site is relatively open and has a large area surface area and there is good access for pipe installation. Refrigerant and Water Ground source loops are both possible though water source loops are more cost effective and have reduced risk of refrigerant loss as key elements of the circuit are localised.
A temperature survey of soil at depth is recommended to determine heat rejection capacity. Heat rejection bores to 30m depth for 3.5kW heat pumps to the accommodation A/C fan coil units and 25 off bores at 60m for 260kW heat pumps for the central facilities A/C fan coil units

Summary

Geothermal heat pump systems should be considered for the development

System	Environmental Benefit	Operational Considerations
Ground Source Water loop for Space Heating and Cooling	More efficient than available split units	Lower risk of refrigerant leak Quieter than standard split/ air cooled units (no external fan unit required. Impact of acid sulphate soils/high salinity on pipe installation/
Ground Source Refrigerant Loop for Space Heating and Cooling	More efficient than available split units. More efficient than water source heat system	Higher risk of refrigerant leak. Quieter than standard split unit/ air cooled units (no external fan unit required. Impact of acid sulphate soils/high salinity on pipe installation/

10.0 LED LIGHTING

Description

Highly efficient and directional lighting system. LED (light emitting diode) lighting is a relatively new and very energy efficient technology which is developing all the time. LED lighting is equal to or greater than the efficiency of fluorescent lighting and has the added benefit of close to unity power factor and very long life. LED lighting comes in many shapes and forms and will work over a wide variety of voltages including AC and DC.

Figure 8: LED Lighting Schemes

Site Application

Architectural lighting, internal lighting and way finding lighting

Summary

LED Lighting is recommended.

System	Environmental Benefit	Operational Considerations
Exterior & Interior Lighting	Directional Light More efficient than non-LED fittings.	Low maintenance. Higher capital but lower operational cost compared to non-LED fittings.

11.0 ENERGY MONITORING AND MANAGEMENT STRATEGIES

Description

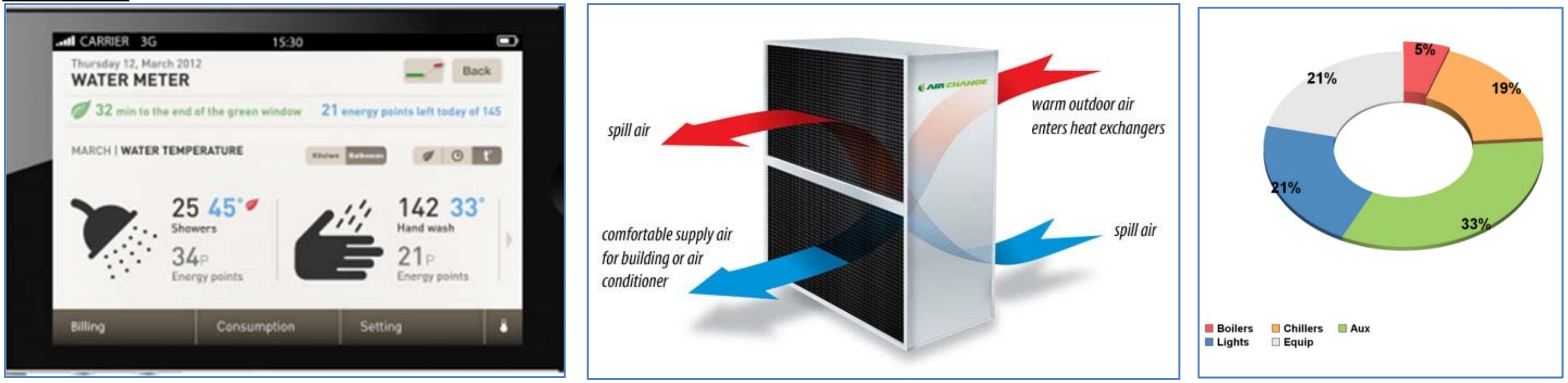


Figure 9 Water/Energy Monitoring Console and Heat recovery Scheme

Automated monitoring and control of development energy uses. Sub-metering and monitoring of key energy and water uses. Heat recovery and efficient chilled water air conditioning system.

Site Application

Energy/Water consoles monitoring energy/water use can be integrated with accommodation fitout works. Metering for all individual accommodation units to allow for private ownership. Central facility Use: visual display to clients of energy and water use as part of informing clients of resort sustainability. Display to show energy generated, water saved in easy to understand format. Meter output to Facility Manager console to assist in maintaining efficiency.

Summary
Energy monitoring and management strategies are recommended

System	Environmental Benefit	Operational Considerations
Unit Consoles showing energy and water use. Central facility sub-metering of water and energy use to trend and optimise energy use of spa, cafe, conference facility, pool, office. Chilled water and Heat recovery.	Reduced energy and water consumption due to improved maintenance. Educational technology for clients. Reduced A/C noise and energy consumption.	Improved preventative maintenance as inefficient equipment performance is detected early. Additional meters required. Recommend simple wireless metering technology adopted to allow for automated tracking and alarms

12.0 GREY WATER SYSTEMS

Description

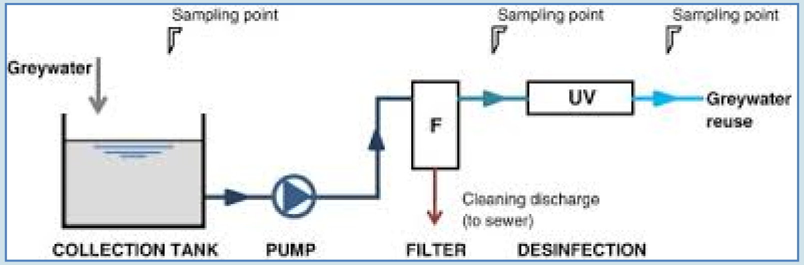


Figure 10 Grey water schematic and example of system

Grey water harvesting and reuse of grey water is a straight forward approval process through local government.

Site Application

Recover grey water from central facilities, pool backwash and use for toilet flushing – possibly treat and use for irrigation. Dispersed nature of development means not readily applicable to accommodation units as significant infrastructure cost. Individual unit grey water systems can be installed to capture shower / dishwasher/ basin for irrigation reuse.

Summary

Not recommended due to high maintenance cost and remote technical support.

System	Environmental Benefit	Operational Considerations
Grey water recovered from swimming pool, showers, on site laundry, basins, and dishwashing. Water used for irrigation and toiler flushing.	Reduced water consumption.	On-going maintenance.

13.0 BLACK WATER SYSTEMS/ SEWER MINING

Description

Blackwater is classified as water containing organic contaminants, particularly sewage. Black water requires chemical purification before re- use. The result (required by law in all states) is 100% pure potable water suitable for drinking, even if the water is not intended for that use. The by-product of blackwater treatment would be an organic sludge that could be used as fertiliser.

Site Application

Difficult to maintain and obtain council approval
Blackwater on- site treatment of property sewer is not allowed however sewer mining and treatment is. A recycled water management plan must be implemented if the treated water is to be used in the building however if it were to be used for non potable onsite water this would not be required.

There is further potential to sewer mine and on-sell to surrounding areas

Maintenance: Maintenance plan required

Summary

Not recommended due to high maintenance cost, remote technical support and available sewerage instruction

System	Environmental Benefit	Operational Considerations
Blackwater	Reduced water consumption and flows to sewer	On-going maintenance. Variable flows/

14.0 BIOMASS GASIFICATION

Description

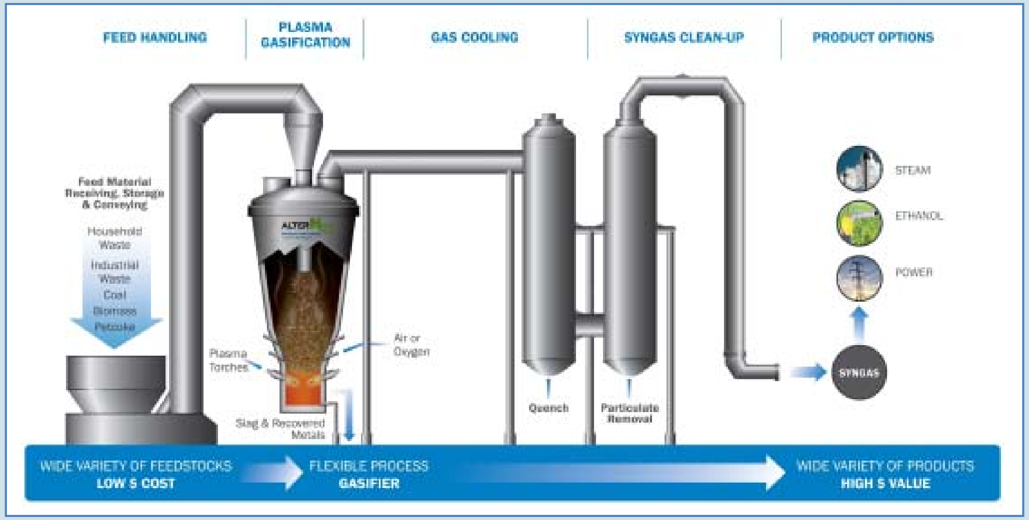


Figure 11 Biomass Gasification Schematic

Organic material, including biomass (e.g. from landscaping, food wastes, and plastic waste) is gasified to syngas and burnt for power production Regardless of the final fuel form, gasification itself and subsequent processing neither directly emits nor traps greenhouse gases such as carbon dioxide. Power consumption in the gasification and syngas conversion processes may be significant.

Site Application

Bespoke system required highly industrial, maintenance concerns.

Summary

Not recommended due to high maintenance cost and remote technical support, additional environmental approvals, industrial nature of plant not appropriate for site configuration.

15.0 ELECTRO CHROMIC WINDOWS

Description

Electro chromic windows in sections of the facades or on the roof can be used to control solar loads and privacy.

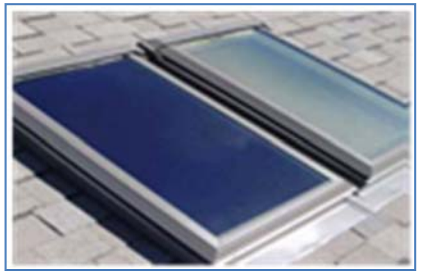


Figure 12 Electro- chromic Skylights

Site Application

Electro chromic windows in a section of the facades on function rooms or on the roof.

Summary

Consider where facades are exposed or where flexible visual privacy is required.

System	Environmental Benefit	Operational Considerations
Electro chromic windows in sections of the facades or on the roof	Improved privacy and solar load control. Adaptable Space Use. Allows for dematerialisation of interior and facade.	Established technology

16.0 DESIGN SCORECARD

	Principles	Design	Operations	Ethos	Resources	Experience	Verdict
Orientation	Cost effective and proven strategy.	Using natural and passive techniques to maximise the energy efficiency	Low maintenance. Helps with achieving certification.	Integrated, low impact simple.	Using local climate to maximise efficiency.	Quality of design and experience of the space.	Building orientation = good design. Recommended.
Passive thermal design	Good design practice	Passive, efficient and integrated to the natural environment.	Low maintenance. Helps achieve certification.	Simple, smart design	Passive strategies for energy efficiency	Quality of design and experience of the space.	Passive thermal = good design. Recommended.
Daylight access	Proven and reliable maintenance free ESD strategy.	Natural lighting is a passive can decrease energy used for artificial lighting.	Decreased costs for artificial lighting, decreased emissions and energy use.	Simple, natural and integrated lighting solution. Promotes connection to outside.	Natural, reduction of energy resources.	Natural and open experience – connection to the outside. Natural lighting increases	Daylight access = good design. Recommended.
Shading	Proven and cost effective, low maintenance.	Passive technology uses building form to reduce energy	Energy efficient design. Helps achieve certification.	Natural and comfortable solution.	Promotes connection to natural environment	Open facades	Shading = good design. Recommended.
Rainwater harvesting	Proven reliable design	Water efficiency	Costs savings due to decreased potable water use.	Standard response for a 'green' building'	Reduce water use	Eco –friendly design.	Rainwater systems = standard systems. Recommended.
Connection to environment	Sustainable design solution.	Passive design	Regenerative and efficient.	Environmentally integrated, simple design.	Using local and resources on site.	Natural experience.	Connection to the environment = good design. Recommended.
Use of recycled materials	Sustainable use of materials can be cost effective.	Passive and efficient use of resources.	Minimise waste and embodied energy. Regenerate.	Low impact	Recycle and reuse. Decreasing new resources.	natural materials, eco friendly	Recycled materials = eco materials selection. Recommended.

17.0 ORIENTATION

Description

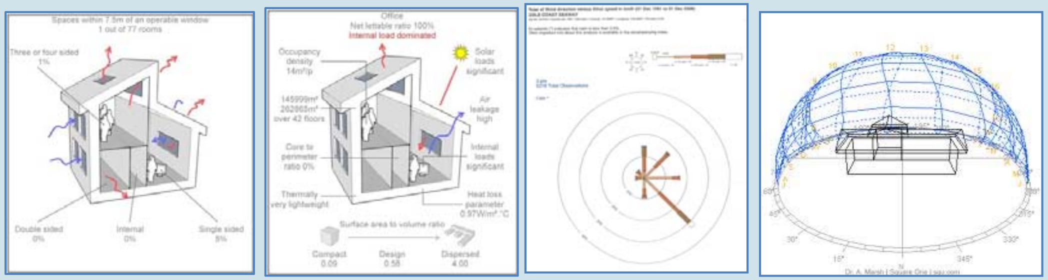


Figure 13 Orientation Diagrams

If buildings are correctly positioned on the site at the beginning of the design process, many other factors will fall into place. The correct positioning of buildings and features relative to the land and to each other can directly affect heating, cooling and lighting costs and have a dramatic effect on the amenity of the site for the users. For example, east/ west orientation will minimise the exposure of buildings to the sun when it is low in the sky in Summer, early in the morning and in the late afternoon. As part of the detailed design development process, suncast modelling and thermal modelling can be applied to deliver an outcome that addresses these factors. Using natural and passive techniques to maximise the energy efficiency :-

- Shading to maximise daylight penetration, minimise glare and solar load.
- Orientation of roofs to allow for maximum efficiency of solar hot water units.
- Natural ventilation studies to utilise sea breezes and cross flow through buildings.
- Respond to local climate and weather patterns: temperature, humidity and wind direction and speed.
- Integrate with natural features such as waterways and vegetation
- Orientation of buildings and transparent building elements to maintain connection with external site.

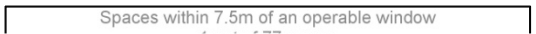
Site Application

Shading studies to maximise daylight penetration, minimise glare and solar load. Efficiency assessment for orientation of roofs to allow for maximum efficiency of solar hot water units. Natural ventilation studies to establish configuration of openings to utilise sea breezes and cross flow through buildings. Views study to orientate buildings and transparent building elements to maintain connection with external site.

Summary

Recommend orientation studies are completed to

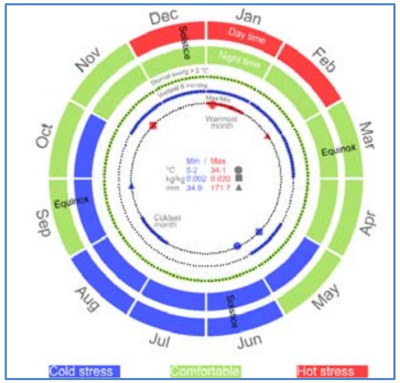
System	Environmental Benefit	Operational Considerations
Orientation of Shading Orientation of roofs to allow for maximum efficiency of solar hot water units. Orientation of natural ventilation elements Orientation of buildings and transparent building elements to maintain connection	Reduced Energy. Improved Quality of Indoor Environment.	Passive Design means inherent in building configuration and limited operational impact.

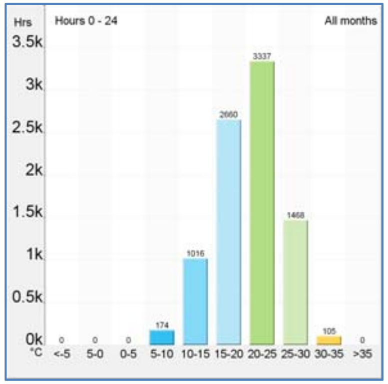


18.0 PASSIVE THERMAL DESIGN

18.1 ROOF INSULATION & ROOF REFLECTIVTY/COLOUR

Technology Description





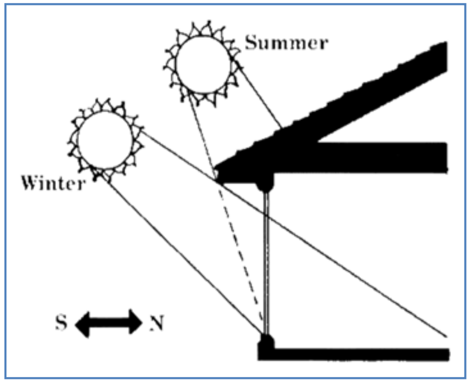


Figure 14 Thermal Parameters and Solar Access Diagrams

High levels of insulation in the roofs to reduce the cooling load required to maintain a comfortable indoor environment and also lower energy costs. The roof colour is a sensitive selection to reduce contrast between roofs and surrounding site. Highly reflective roofs can significantly reduce solar load and insulation requirements but can be visually obtrusive. Deep eaves to walls to minimise thermal load. Natural ventilation studies to utilise sea breezes and cross flow through buildings.

Site Application

Passive heating may be required and would be effective during the coldest part of the year in July and May, but is a much lesser issue than cooling from October to April. The roof colour is to be a sensitive selection to reduce contrast between roofs and surrounding site. Thermal properties of roof construction to be enhanced with additional insulation.

18.2 SOLAR TUBES

Description

Solar tubes can be used to introduce daylight into central spaces to improve daylight levels in core areas.

Fenestration product	Visible Transmission (Vt)	Solar Heat Gain (SHGC)	Daylighting Energy Performance Ratio (Vt/SHGC)
Triple Glazed Low-e Window Clear glass, suspended low-e Heat mirror film	22%	0.16	1.38
Triple Glazed Window Clear glass, suspended low-e Heat mirror film, clear glass	63%	0.36	1.75
Double glazed Window Clear glass, low-e glass)	71%	0.49	1.45
Double Glazed Prismatic Skylight Clear outside, prism inside	71%	0.51	1.39
Solatube® 750 DS Daylighting System	60%†	0.20†	3.00

Source: NFRC Spectral Weighting Function Research Project, Draft 2.0, March 2007

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Figure 15 Solar Tube Installation and Thermal/Visual Properties

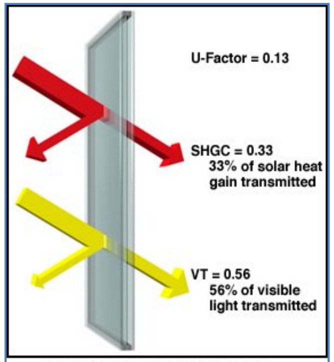
Site Application

Areas where there is limited daylight access from transparent facade elements

18.3 SPECTRALLY SELECTIVE GLAZING

Description

Spectrally-selective glazing transmits a high proportion of the visible solar radiation (sunlight), but screen out up to 80% of the infra-red radiation. This results in a low transmission of radiant heat from the sun, and reduces the need to cool building interiors.



Credit: Efficient Windows Collaborative

Figure 16 Spectrally Selective Glazing Diagram

Site Application

Suppliers: various, Cost: Approx 6% increase on standard glazing. Generally deep eaves and shading in the project will reduce potential impact of spectral glazing. Consider higher performance glazing selection for exposed glazed facade elements.

Summary

System	Environmental Benefit	Operational Considerations
Highly insulated roofs	Reduced Energy Consumption	None
Solar Tube on internal areas.	Improved quality of indoor environment. Reduced lighting energy consumption.	Limited to maintenance of integrity roof penetrations.
Spectrally-selective glazing on exposed facades.	Reduced glare and energy consumption	None – Tints can be inherent glass property and performance glazing films are ideally an internal element of a laminated construction.

19.0 DAYLIGHT ACCESS

Description

Daylighting is a function of exposure to the sky. Daylight levels and contrast levels to be optimized for occupant comfort balancing external and internal shading devices with glazing area and light transmittance.
In general daylight will extend into a space for a distance of about twice the head height of the opening admitting the daylight. Buildings with a shallow footprint and high ceilings are therefore perfectly suited to daylighting. The desired outcome is always that no electric lighting be required during daylight hours. As this can be difficult to achieve, less occupied spaces can be positioned towards the inside of the footprint to ensure that the most often occupied spaces receive the majority of the daylight.

Sunlight delivers heat as well as light, mostly unwanted heat in these climatic conditions. In Summer in particular, sunlight allowed into internal spaces becomes additional unnecessary load on the cooling system. Ideally daylight is harvested completely independently of sunlight. As the sun is in the northern half of the sky for most of the year, south facing high level windows provide good exposure to the sky for daylighting without the radiant heat gain from sunlight.
Eaves, shade structures, verandahs, louvres and slats can shield north facing spaces from sunlight and still admit daylight. Planting can reduce glare and reflected heat into internal spaces from the surrounding paving and exposed ground

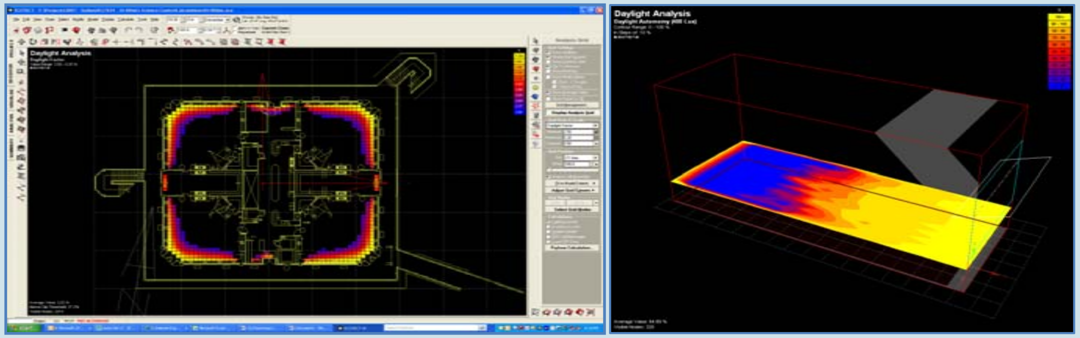


Figure 17 Daylight Analysis Diagrams

Site Application

The dispersed configuration both of the central facilities and accommodation buildings is ideally suited to high levels of daylight penetration.

Summary

System	Environmental Benefit	Operational Considerations
Configuration for daylighting	Connection with external climate. Reduced lighting energy consumption	Must be balanced with increased solar load

20.0 SHADING

Description

Maximise Eave Depth and optimize vertical shading elements orientation to minimize contrast and solar load. Maximise plant shading elements (Green Walls, Trellis framework, etc) for softening light by absorbing high energy solar wavelengths.

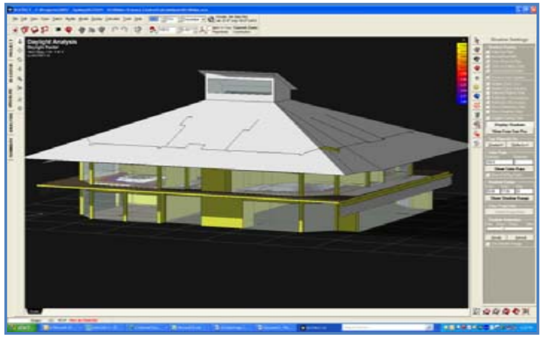



Figure 18 Shading with Eaves and Green Walls

Site Application

Provision of deep eaves and optimised vertical shading elements to minimise glare and solar load. Green Walls can be considered

Summary

Recommend shading elements are optimised to minimise glare and solar load.

System	Environmental Benefit	Operational Considerations
External and Internal Shading Elements	Minimize contrast and solar load.	None for external elements. internal shading can be achieved with blinds which will require cleaning and repair
External Green Walls	Reduced contrast	Irrigation and plant care.

21.0 RAINWATER HARVESTING

Description

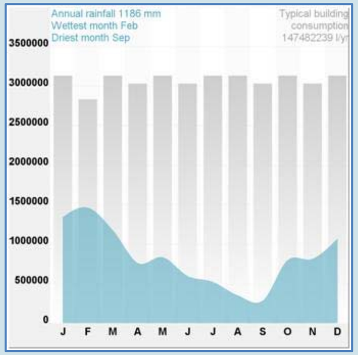


Figure 18 Rainwater Tank and Rain resource diagram

Rainwater collection is the backbone of any water efficiency strategy as rainwater has the rare characteristic of being a free commodity. Rainwater off all roofs could be collected, either centrally or individually in every building First flush systems would ensure that contaminants off the roof would be diverted rather than being stored: this water could be diverted straight to the grey water system for processing before (or instead of) being delivered direct to bathrooms.

Site application

Central Facilities. Water balance to match capture and use.

Summary

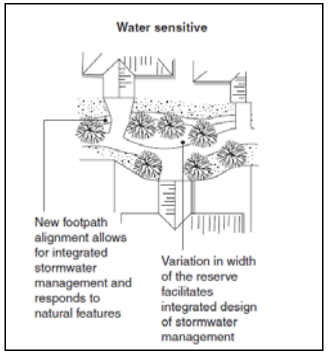
Recommend rainwater harvesting as part of water efficiency strategy

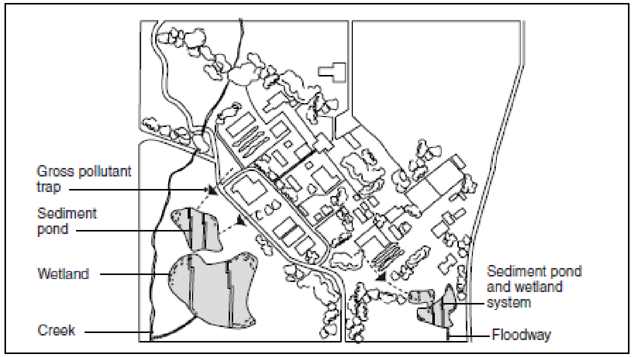
System	Environmental Benefit	Operational Considerations
50kl tank for W/C flushing in central amenities, pool top up and wash down.	Reduced water consumption	Ongoing maintenance of pump and filters.

22.0 CONNECTION TO ENVIRONMENT

Description:

Connection to the external site and surroundings can be achieved by maximizing builder user's access to external views to ffeature landscaping which highlight natural flora and sense of place. Outdoor space landscaping adjacent to the building should avoiding ponding, use selective planting and introduce screening to allow outdoor-indoor connectivity spaces to be with minimal presence of mosquitoes. Water Sensitive Urban Design (WSUD) features integrates native plant landscaping features into the stormwater management systems at the site.





Site application

- Vegetated swales to reduce stormwater runoff directly into waterways. Acting as drains these remove silt and pollution from surface runoff water and are designed to maximise time spent in the swale before passing into the waterways. This is a further method of water treatment
- Oil and sediment arresters can have different design and operating dynamics, ranging from plate separators, to vortex, swirl and dynamic separators. Oil and sediment separators are often sited in car parks;
- Sand filters, grassed swales and porous pavements, can be effective treatment techniques, especially in car parks. Permeable surfaces can also be designed with a turf cell reinforcement structure or open-celled pavers, and concrete or plastic grids with voids that are filled with topsoil, growing medium or aggregate to ensure that vehicle or foot traffic can still use the area securely whilst surfaces remain permeable;
- Roof runoff, which is predominantly clean, can be directly infiltrated into the soil near a building by connecting the downpipe to a subsoil drain system with an overflow for large events, providing that there is a 'first flush' diverter or catchment system to filter out the initial flow of roof runoff;
- Small check dams can be added to slow velocities and increase pollutant removal, but a sequence of swale sections with proper growing medium and planting is necessary to properly filter and confine pollutants;
- Constructed wetlands that resemble local natural wetlands and provide a balanced and productive ecosystem. When a constructed ecosystem is productive, it means that there is a significant biomass of plants and microscopic algae that take up nutrients, and provide habitat and food for animals. When an ecosystem is diverse it has a large range of animal, plant and microbial species that promote materials transfer and decomposition of organic material;
- Vegetated Filter Strips (VFS) can also be used to help remove pollutants from stormwater.

Summary

Recommend to maximize access to external views to feature landscaping and create view corridors We also recommend incorporating WSUD principles in Stormwater Management design.

System	Environmental Benefit	Operational Considerations
View corridors to maximise external views Feature landscaping Vegetated swales Oil and sediment arresters Oil and sediment separators are often sited in car parks; Sand filters, grassed swales and porous pavements, Direct infiltration of Roof runoff	Improved connectivity to external site. Improved stormwater quality.	Maintenance of WSUD elements.

23.0 MATERIALS SCORECARD

	Principles	Design	Operations	Ethos	Resources	Experience	Verdict
GECA	Products with proven sustainable credentials	Strategy for use of certified materials to allow for easy sustainable materials choice.	Helps with certification schemes such as green star.	Responsible environmental materials selection.	Focussed on best practise for environmentally friendly product use.	Eco friendly and informative selection of materials.	GECA certification= eco materials selection. Recommended.
VOCs	indoor air quality	Use of materials	Quality of indoor environment for building users.	Responsible design, simple and achievable.	Minimising harmful materials.	Quality of design	Low VOC= good design. Recommended.
Concrete	Minimising concrete use may be cost effective	Minimising Portland cement use is an efficient use of high embodied energy materials.	Can assist with certifications such as Green Star.	Minimisation of Portland cement is simple low impact design	Minimising resource depletion, recycling and use of low impact materials.	Quality sub tropical design minimises concrete use.	Reduction in Portland cement = eco materials selection. Recommended.
Steel	Using steel with environmentally responsible criteria.	Promote energy efficiency and lightweight construction.	Can help with certification such as Green Star.	Environmentally responsible sourcing of materials	Minimising resources	Quality material selection.	Environmentally responsible steel= eco materials selection. Recommended.
Pre-fabrication	Sustainable and cost effective construction practise	Lightweight and low impact - minimising site disturbance.	May decrease construction time and increase site regeneration.	Low impact, preservation of site.	Protection of site diversity.	Quality of design.	Prefabrication= eco materials selection. Recommended.
Use of recycled materials	Sustainable use of materials can be cost effective.	Passive and efficient use of resources.	Minimise waste and embodied energy. Regenerate.	Low impact	Recycle and reuse. Decreasing new resources.	Informative and natural.	Recycled materials = eco materials selection. Recommended.
Use of local material	sustainable solution	Connection to local community.	Decreases transport and maintenance distances.	Supports local/community culture.	Minimising transport resources.	Opportunity for connections to local business.	Local materials = eco materials selection. Recommended.

	Principles	Design	Operations	Ethos	Resources	Experience	Verdict
Low embodied energy	Sustainable materials strategy	Passive and efficient materials strategy.	Low emissions	Natural and low impact	Minimises resources	natural materials, eco friendly	Low embodied energy= eco materials selection. Recommended.
Low formaldehyde	Proven	Passive, healthy materials selection.	IEQ	Healthy, low impact responsible design.	Minimising harmful materials	Quality of indoor environment	Low formaldehyde = good design. Recommended.

24.0 INDEPENDENT CERTIFICATION (GECA, FSC, ETC.)

Description

Independently recognised certification of environmentally friendly products: Carpets, Joinery, Wall Finishes, Plasterboard, Roofing materials.
For recycled timber, Forest Stewardship Council (FSC) certified provides a credible guarantee that the timber product comes from a well managed forest that has been independently certified for its timber resource sustainability, forest ecosystem maintenance and financial and socioeconomic viability.

Site Application

Selection of finishes and furniture for the project which have independent accreditation.

Summary

System	Environmental Benefit	Operational Considerations
Recognised low impact products: Carpets, Joinery, Wall Finishes, Plasterboard, Roofing materials, furniture.	Lower GHG emissions, lower toxicity, reduced embodied energy.	Limited – integrated into building fabric. Extended Warranties and Product Stewardship are often features of eco-certified products which reduce operation costs.

25.0 LOW VOC PAINTS AND FINISHES & FORMALDEHYDE.

Description

Off-gassing of building materials can dramatically affect indoor air quality, especially in air conditioned environments which are not properly ventilated. The volatile organic compounds given off by most paints, varnishes sealants and adhesives and formaldehyde given off by most medium density fibreboard (unless it has been properly sealed) are two of the worst contributors. MDF is also highly toxic in its manufacture.

Site Application

Selection of finishes with low VOC and low formaldehyde emission levels.

Summary

System	Environmental Benefit	Operational Considerations
Low VOC Paints, Finishes & Formaldehyde.	High quality internal environment	Water based coatings in some cases are not as durable as solvent based coatings

26.0 CONCRETE

Description

Concrete has a high embodied energy component. Reducing the associated energy can achieved with using significant recycled content. Alternately a proportion of the cement used in concrete on site can be replaced with industrial waste product such as aggregates or waste products.

Aggregates:

Recycled aggregate may affect the engineering properties of structural concrete, and this should be considered as it is not a desired environmental outcome that projects increase the amount of concrete used to counteract this. HB 155-2002 Guide to the use of recycled concrete and masonry materials presents an overview of material and processing requirements of recycled concrete and provides general guidelines for the specification and use of Class 1 and Class 2 recycled concrete aggregate products. Class 1 products can be used in structural concrete, Class 2 as fill or granular sub-base.

Industrial waste product:

The industrial waste product can be slag or fly ash but must not come from industrial facilities co-fired with hazardous waste. Kilns have been identified in the US EPA Dioxin Inventory as one of the top ten sources of dioxin to the environment (more than 22-fold increase over standard cement, per kilogram of cement fired). Slag (a waste product from steel manufacturing using a blast furnace), whether as an aggregate or cement replacement, is appropriate for meeting the Credit Criteria. The quality and properties of concrete can actually be improved by replacing a portion of the Portland cement with industrial by-products such as Fly Ash, Blast Furnace Slag and Silica Fume. Fly ash is commonly used to replace between 20-25% of Portland cement in ready mixed concrete in Australia, although higher ratios are possible and have been achieved on many projects overseas.

Site Application.

Concrete on site is limited.

Summary

System	Environmental Benefit	Operational Considerations
Concrete -pre cast, in- situ & reinforced with:- • 20% reduced Portland cement. • Recycled aggregate	Reduced embodied energy	Recycled aggregate may affect the engineering properties of structural concrete. Fly ash replacement can affect the curing time of concretes.

27.0 STEEL

Description

Steel a high embodied energy component. Reducing the associated energy can achieved with using significant recycled content, using High Strength Grades, minimising waste using off site fabrication, marking to enable reuse and using design-for-disassembly construction techniques.

Site Application

There is significant scope for incorporating best practice steel use due to the lightweight design concept and capacity for off- site fabrication.

Summary

System	Environmental Benefit	Operational Considerations
Steel (structural and reinforcing) with significant recycled content, High Strength Grades, Off site fabrication, Marking to enable reuse Design-for-disassembly construction	Reduced embodied energy content. Ability to reuse materials	No operational impact.

28.0 PRE-FABRICATION

Description

Pre-fabricate building elements off-site and use modular construction techniques to minimize site disturbance and waste.

Site Application

Potential of short distances to manufacturers allows for accommodation unit pre –fabrication. Can be considered for elements of central facilities

Summary

System	Environmental Benefit	Operational Considerations
Unit Pre-fabrication	Reduced Waste Reduces site disturbance	None

29.0 USE OF RECYCLED MATERIALS.

Description

Recycled content of materials (used in the building fabric and site operation) can be verified through the 3rd party certification discussed earlier in this report. As part of a commitment to minimise the long term effect on the natural environment, a general waste strategy should be established to produce as little as possible, as coping with it consumes valuable resources. The ability to recycle, reinvent, reshape goods into something useful prevents it becoming waste. This is a consideration for everything acquired as part of the development and material processed as part of site waste handling

Site Application

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Along with the conventional separation of the waste stream into recyclables and non-recyclables the following waste processing and reuse initiatives can be considered:-

- Organic matter including paper can be composted and used on site as fertiliser. As previously discussed, collecting methane from the decomposition process is an option that would require further investigation.
- Unlike the collection of methane, the production of biodiesel is relatively straightforward and cost effective. Note the amount of biodiesel produced from cooking oil is unlikely to contribute significantly to fuel requirement. Management vehicles could be fuelled by biodiesel as a marketing exercise.

Summary

System	Environmental Benefit	Operational Considerations
Recycled Timber	Minimise resource use	None
Waste Steam Management		Ongoing management
Composting & Worm Farms		Ongoing management
Biodiesel		Sourcing

30.0 USE OF LOCAL MATERIAL

Sourcing local products to minimise transport impacts of materials, sustain local economy.

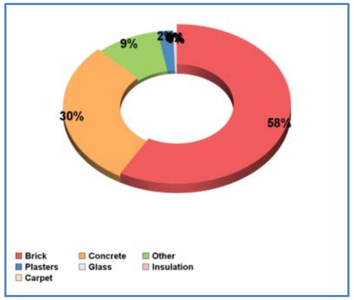
Summary

System	Environmental Benefit	Operational Considerations
Local material sourcing	Reduced GHG emissions associated with product use, contribution to maintaining local economy	None

31.0 LOW EMBODIED ENERGY

Description

Material Name	Material group	Total quantities	
		Vol(m^3)	Weight(t)
ASPHALT	Other	1000	1700
CAST CONCRETE	Concrete	5283	10565
CLEAR FLOAT 6MM	Glass	25	63



Use self-finished products, efficient design to minimise concrete and steel use and reuse materials were possible. Generally materials which are dense / heavy or materials that have been heavily processed and materials that have been transported long distances have high embodied energy Additionally some materials contain or are manufactured using substances which are toxic. PVC is an often quoted example. Alternative materials should be of lower embodied energy, or when limited choice / option is available high embodied materials should be used as efficiently as possible. Typically 10% of construction materials are wasted during the construction process Better design, on site waste management and on site recycling (typically this can reduce the waste to around 2%) could dramatically improve this with the following consequential benefits:

- Significant cost savings (material, labour, transport and disposal costs)
- Reduction of environmental impact
- Improved productivity and efficiencies on site
- Improved health and safety

Summary

System	Environmental Benefit	Operational Considerations
Low embodied energy	Reduced green house gas emissions and resource use.	None