# SIX STARS IN THE TROPICS…IT CAN BE DONE

## CASE STUDY:

## WILLIAM McCORMACK PLACE STAGE 2, CAIRNS

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## ABOUT THE AUTHORS

**Graeme Standfield** is a Director of MGF Consultants, Nth Queensland P/L.

He has been a building services mechanical consulting engineer since 1973.

He was introduced to the field of mechanical building services under the watchful and experienced eye of Doug Elms (a session moderator at this conference) in 1970 and has resided in Cairns for the last 26 years, gaining extensive experience with air conditioning in the tropics.

He is passionate about energy savings associated within the air conditioning industry and has been directly involved in the design of numerous installations incorporating air to air rotary heat exchange systems and chilled water thermal energy storage systems.

He is a Fellow of the Institution of Engineers Australia and Member of ASHRAE and AIRAH.

**Carl Gray** is a specialist lighting designer in the employ of MGF Consultants, Nth Queensland P/L.

His interest in things mechanical rapidly developed over the duration of the design and construction phases of the William McCormack Place Stage 2 (WMP2) project and in addition to his introduction of the unique single blade ceiling fan into MGF’s Cairns office and its subsequent adoption into WMP2, he has enthusiastically led the charge to the ultimate achievement of the first 6 star Green Star building in the tropics.

## 1 ABSTRACT

In 2007 the Queensland Government chose 3 office accommodation building projects throughout the state aimed particularly at achieving a Green Star Office Design v2 rating of at least 5 with a preference for 6 if possible.

The William McCormack Place Stage 2 facilities, located in Cairns (FNQ), was one of the three and the only one located in the tropics. It is a government tenanted office building comprising 9 levels and 9638 $m^2$ net lettable area (NLA).

The final submission to the Green Building Council of Australia assessors resulted in the project being awarded a 6 Star Green Star Office Design v2 rating.

This is the first office building in an Australian tropical environment to achieve a 6 star rating, much of which was due to a mix of low water and energy consumption, air change effectiveness and lighting/daylighting systems. The project is completed and fully tenanted.

A major component of the rating was the achievement of maximum points in the energy and water categories.

The implementation of stratified chilled water thermal energy storage (TES) allowed the use of air cooled chilled water plant at night-time. The relatively low night time ambient temperatures resulted in energy efficiency ratios similar to that of water cooled chillers operating in a conventional daytime mode.

The project's engineering team – civil, structural, fire safety (Arup), mechanical, electrical, lighting, acoustic (MGF Consultants NQ) and hydraulic (Gilboy Hydraulic Solutions) – was entirely local to Cairns. In addition to a wealth of local knowledge and experience, the team brought to the table proven expertise in sustainable engineering.

***Keywords:*** Air cooled chiller, maximum demand, Thermal Energy Storage, ceiling fans, lighting.

## 2 INTRODUCTION

The Stage 2 building of William McCormack Place, Cairns has been awarded a 6 star Green Star Office Design v2 rating by the Green Building Council of Australia and was officially opened on 5 November 2010.

The client is the Qld. Department of Public Works, Accommodation Office. Design commenced in 2007 through a managed contract process and was commissioned in July 2010.

The 9 storey office building compliments and shares some of its services with its companion building, William McCormack Place Stage 1. The Stage 1 building was the first commercial building in Australia to achieve a measured 5 Star ABGR (now NABERS) in 2003.

The 9638 $m^2$ NLA stage 2 building is nominally twice the floor area of Stage 1 and accommodates Qld State departments and agencies.

The building was fully tenanted as of October 2010.

Features of the building responsible for the achievement of the rating include:

- Length to width ratio of 3:1 with long sides facing Nth Sth.
- West end has minimal windows.
- East and West ends incorporate external stairs, thus eliminating the need for stairwell pressurization and providing a solid façade to limit solar penetration.
- All facades have external shading systems designed to provide a total of 96% shading in accordance with the Green Star assessment method.
- Office windows are double glazed, mainly for acoustic control, but also reduce cooling loads.
- Combination of air conditioning and ceiling fans allowed a higher air conditioning temperature set point to provide an effective comfort condition in open plan spaces.
- 410 $m^2$ of roof mounted photovoltaic panels providing 64 kW of power.
- Whole of building envelope pressure tested to 50 Pa with an allowable maximum leakage loss of 1.4 $L/s/m^2$ of external envelope area. The tested leakage rate was 1.35 $L/s/m^2$.
- High comfort suspended direct/indirect lighting, with a novel daylight harvesting system which measures ceiling exitance as a proxy for workplane illuminance.
- Decoupled pre conditioning outside air (PCOA) system employing total enthalpy rotary heat recovery exchanger, dehumidification cooling coil and electrostatic spill air filters.
- Dedicated meeting rooms supply air system served directly from the PCOA.
- Ventilation rates at 150% of statutory requirements.
- Increased ventilation rates when high $CO_2$ levels are measured on a particular floor.
- Variable speed drives to all air handling fans and secondary chilled water pumps.
- 1.5 ML stratified chilled water thermal energy storage (TES) tank, sized to meet the requirements of Stage 1 and Stage 2 buildings.
- 1100 kW air cooled turbine chilled water generator which in combination with the TES tank provides sufficient capacity to serve a total maximum instantaneous buildings cooling load of 1550 kW.
- Integration of the chilled water system with the Stage 1 building to provide a redundancy facility for the single chiller installed within the Stage 2 building.
- Specially developed flow control solutions for water fixtures which exceeded water efficiency labelling schemes.
- Use of air cooled chiller system allowed minimal water usage and achievement of maximum Green Star points under the water category.
- Capture and re-use of the condensate from the PCOA unit. Estimated at 170 kL/y.
- Natural ventilation to the entire covered car parking areas.

This paper outlines the key features of the mechanical services installation but also touches on some of the other disciplines associated with the Green Star process.

## 3 HVAC SYSTEMS and MODUS OPERANDI

The following describes the main elements of the mechanical services and there operation.

### 3.1 Central Chilled Water System and Stratified Chilled Water Thermal Energy Storage (TES):

**3.1.1 The Central chilled water system** comprises an air cooled turbine chiller of 1100 kW capacity, primary and secondary chilled water pumps, backpressure control valve to service chilled water plant above the static head of the TES tank, distribution piping and controls valves etc and automatic refrigerant recovery system.

Maximum Green Star points are targeted through the adoption of a central chilled water system employing air cooled chillers thus eliminating water usage of cooling towers and maximum demand reduction through the use of a stratified chilled water thermal energy storage (TES) tank.

The chiller operates only at night time, typically 9:30 pm to 6:30 am, to service the chilled water TES tank. The chiller start time is determined from an algorithm based on the amount of time required to fully charge the TES tank by 6:30 am the next day.

Wet season (Nov to April) night time ambient dry bulb temperature are usually around 24 $^{0}$C or lower after about 9 pm. This allows the air cooled chiller to operate at EER's comparable with water cooled chillers operating at typical daytime dry bulb temperatures of 30 -33$^{0}$C and 27$^{0}$C wet bulb temperature. At 24$^{0}$C the input power(kWe) to output cooling (kWt) ratio of the turbine chiller has an advertised rating of 0.22 at 100% load including the condenser fans. An additional advantage is that there is no condenser water pump and its associated parasitic load. It should be noted that when used on a TES system the chiller operates at full load unless it is deliberately load limited from within its controls features. The WMP2 chiller has nominally 10% redundancy capacity, accordingly it is load limited to 90%, and thus the effective EER will be better than noted above. Observations to date show it is closer to 0.205 and will be closely monitored over the summer wet season months.

**3.1.2 The TES tank** is designed to service the entire 24 hr cooling requirements of the new stage 2 building **and** the existing stage 1 building. The TES tank water volume is 1,500,000 litres having an effective capacity of 1,350,000 litres which equates to a daily cooling capacity of nominally 15,700 kWh.(thermal) at a temperature differential of 10 $^{0}$C. The modeled maximum was 13,500 kWh. TES effectiveness takes into account the loss of water volume taken by the upper and lower diffusers coverage and thermocline depth. The thermocline is the depth of water between the chilled ($6^0C$) and warm ($16^0C$) water conditions. A properly designed diffuser system will achieve a thermocline of 450 - 600 mm. It is unusable in terms of thermal storage capacity.

The adoption of a TES allows the air cooled chillers to operate at nighttime when ambient dry bulb temperatures are lowest (typically a maximum of $24^0C$), thus providing chiller energy efficiency ratios (EER) approaching that of daytime use water cooled (cooling towers) chillers. A secondary benefit of nighttime chiller operation is that the standby generator need only be sized for the worst electrical loading of either the daytime building load or nighttime chiller load. The daytime load is the worst condition and results in an emergency generator size of approximately 60% of that required for a conventional mechanical services design.

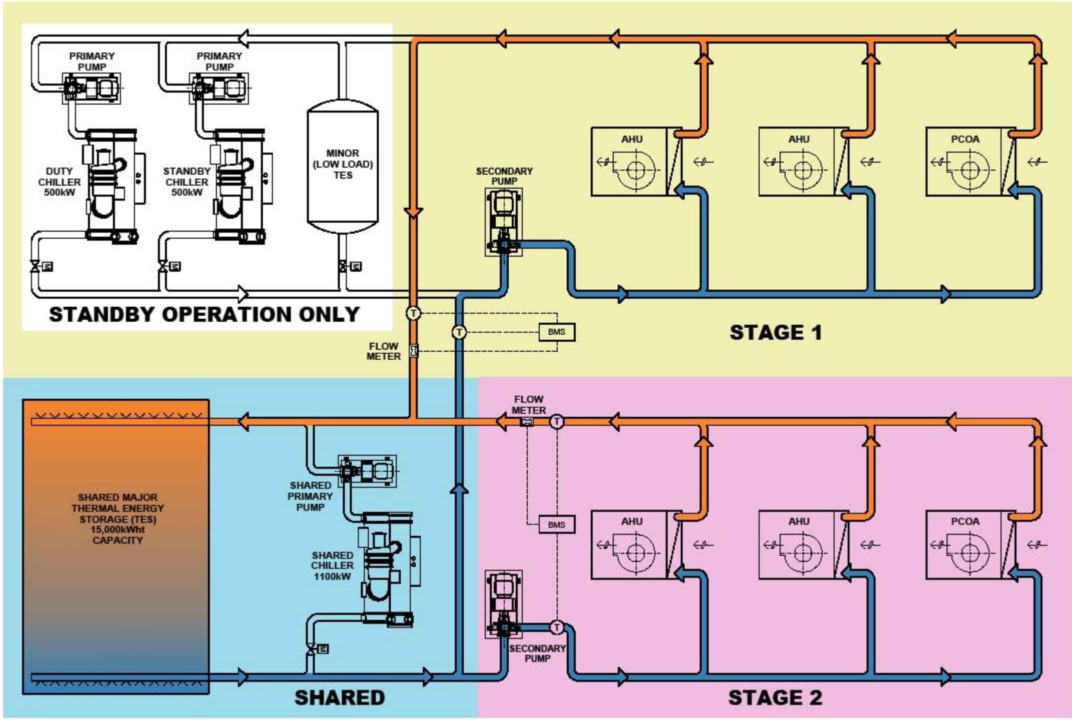


**Fig 1: Chilled Water Schematic**

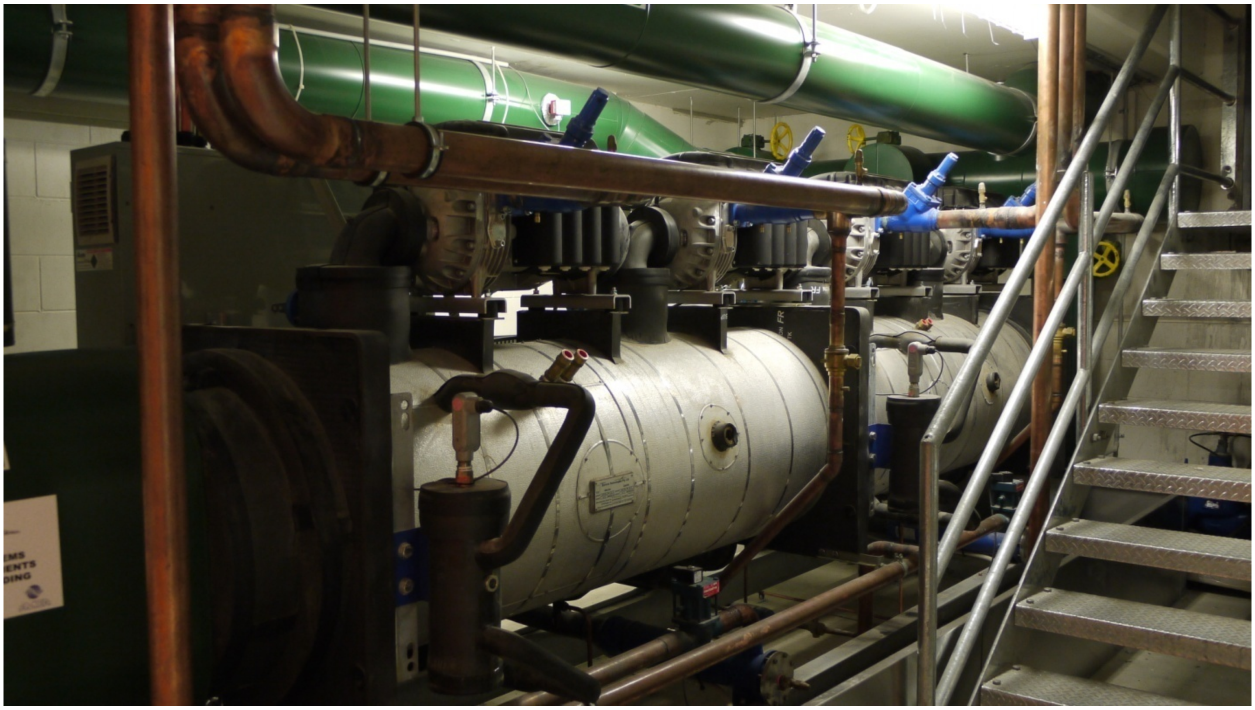

**Fig 2: Turbine Chiller**

The TES is sized to benefit both the stage 1 and stage 2 buildings through the use of a joined system. Pipe work reconfiguration was straightforward and relatively inexpensive. The existing water cooled chiller system serving stage 1 is retained for standby/redundancy capacity in the event of a failure of the new air cooled system. The existing water cooled system is operated on a regular timed cycle (fortnightly) for a period of 1.5 hours to keep the cooling towers chemical dosing system in optimum condition.  Electrical energy consumed through its operation is metered and accounted for in the total chilled water system power consumption.

**Fig 3: TES Tank**

**Fig 4: TES and Stage 2 Building (Stage 1 Building at background left)**

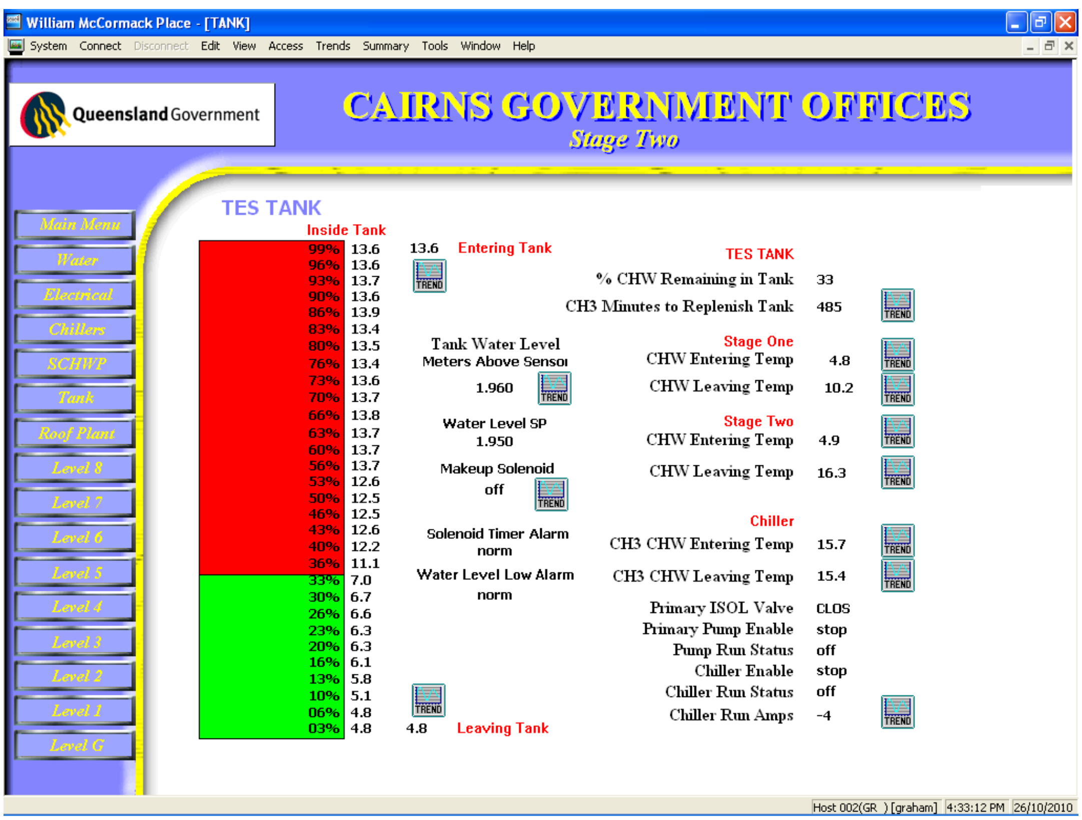


**Fig 5: TES Tank BMS Screen Dump at 4:33 pm, 26 October 2010.**

### 3.1.3 TES Operation

The basic operation of the TES system is as follows:

The construction of the tank comprises a bolted steel panel external structure, internal sprayed polyurethane insulation and 1.5 mm thick EPDM (ethylene propylene diene monomer rubber) waterproof liner material. Near the base of the tank and just below the top water level are two diffuser systems designed to provide laminar flow conditions to eliminate mixing of the tank contents. Chilled water at $6^0$C from the chiller is introduced into the bottom diffuser and slowly displaces warm water at $16^0$C at the top of the tank. The warm top water is drawn back to the chiller via the top diffuser system where it is cooled and reintroduced back into the bottom TES tank. This process continues throughout the night until the tank is fully charged with $6^0$C water.

The chiller then switches off.

During the course of the next day (7am – 6 pm) chilled water is pumped from the bottom of the tank, via the diffusers, in the reverse direction to the charging flow. This is known as the "discharge mode". The chilled water is circulated throughout the building air handling units.

It is important that the cooling coils are selected to suit the design conditions of the TES and that 2 way valves are used throughout all air handling units. The warm water returns to the top of the tank and is gently diffused on top of the $6^0$C water. The chilled and warm water stay separated in a zone approximately 450 -600 mm thick called a "thermocline". The thermal capacity of the TES is designed to cater for the maximum cooling day of the year.

Because the top water level of the TES tank is below the level of some of the air conditioning plants in the Stage 2 building (the Architects couldn't cope with the tank being higher than the building) , it is necessary to provide a pressure sustaining system to those parts of the chilled water system located above the tank. This is done to ensure that a siphoning effect of the lower tank water level does not create a situation where air can be sucked into the piping above it through control valve stems and the like when the secondary chilled water pump systems shut down or operate at low flow at night.

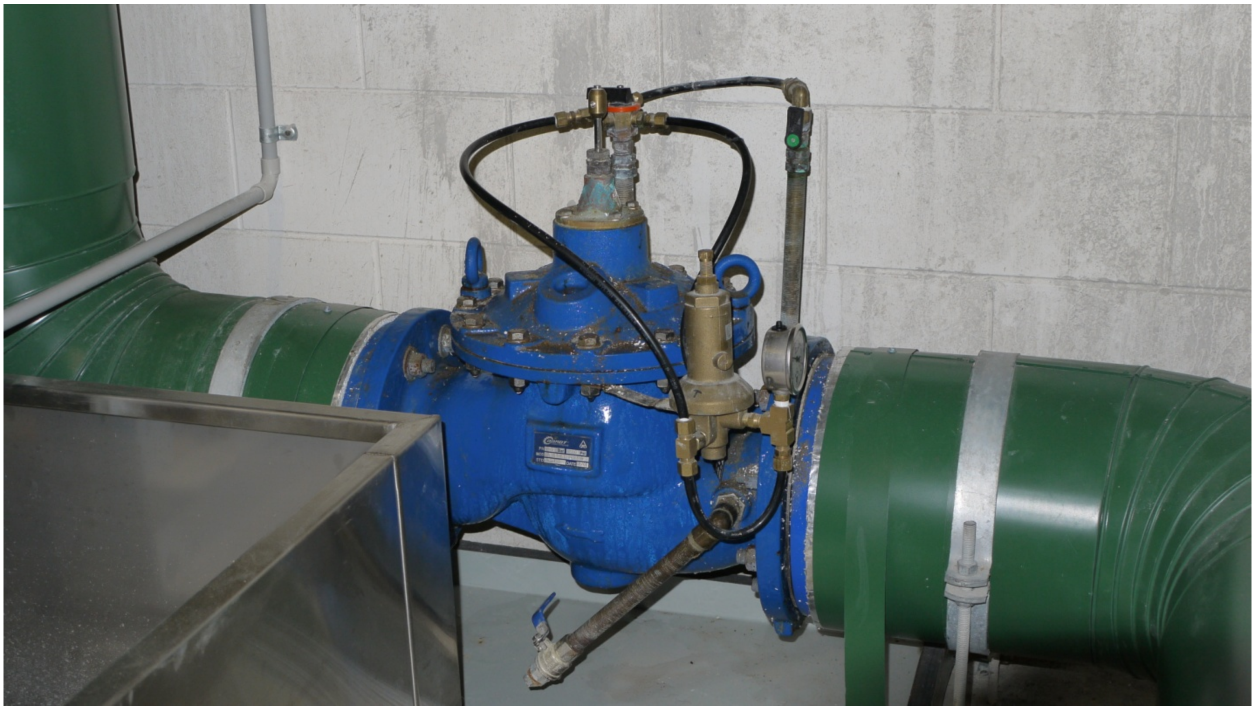

**Fig 6: Back Pressure Sustaining Valve**

**3.1.4 A refrigerant recovery system** was added at a late stage when it become apparent that a 6 star Green Star rating was possible and was one of the features necessary to secure the rating.

**Fig 7: Refrigerant Recovery Plant – 1200 kg Capacity**

## 3.2 Pre Conditioning Outside Air (PCOA) Unit.

The **PCOA unit** comprises supply and spill air fans, particulate air filters, electrostatic air filters, rotary sorption (hygroscopic) type enthalpy heat exchanger and cooling coil. The supply and spill sections are fire segregated to allow it to also function as a stairwell lobby relief and zone pressurization system. A separate small roof mounted smoke spill fan is provided in series with the main spill air fan to control lobby relief air in fire mode. Spill (return) air is drawn directly from toilets and tenant photocopier rooms via segregated duct systems to the exhaust side of the PCOA. The spill air is filtered upstream of the heat exchanger with an electrostatic and fabric filter to ensure maximum containment of even sub - micron particles which may be emitted by some printers/photocopiers. Supply and spill fans are arranged to eliminate the risk of cross passage of the exhaust and supply air streams via the rotary heat exchanger face seals.

The outside air pre-conditioning unit fulfils six (6) roles.

1. Provides energy recovery utilizing the “spill” air from the otherwise wasted ventilation air via a hygroscopic (sorption) rotary heat wheel. Efficacy at the maximum design ventilation airflow rate of 13,650 l/s is nominally 74% for both sensible and latent heat. At a diversified air flow rate of nominally 10,000 l/s, the efficacy rises to 77% for sensible and 81% for latent heat.

2. Dehumidifies the high moisture content of tropical ambient air by cooling the pre-conditioned outside air stream with a chilled water coil to the same absolute humidity condition as the room design condition. That is, an apparatus dew point (ADP) of nominally $13.5^0$C.

3. Provides 100% outside air at a supply temperature of approximately $14^0$C to all meeting rooms.

4. Provides statutory toilet and Green Star tenant (photocopier) exhaust in normal mode.

5. Acts as a zone pressurization system in a fire mode.

6. Provides smoke spill and lobby relief in a fire mode.

The construction of the PCOA is arranged to ensure no cross contamination can occur between the toilet and photocopier exhaust air streams with the outside ventilation make up air via the rotary heat exchanger. The outside air supply fan and spill air exhaust fan locations ensure that any air leakage across the heat exchanger is always in the direction of clean to dirty air. The extract quantities of toilet and tenant exhausts are high enough to dilute potential odours from toilets and photocopiers to un-objectionable levels.

In order to act as a fire smoke management system to AS1668.1-1998, the PCOA is fire compartmented with 2 hr fire resistance separation between the supply/heat exchanger section and the spill/exhaust section. On receipt of fire alarm, combination smoke and fire dampers on both sides of the heat wheel are activated to fail safe condition to isolate it from the exhaust air path.  The common riser shaft throughout the height of the building is fire separated between the supply and exhaust duct systems.

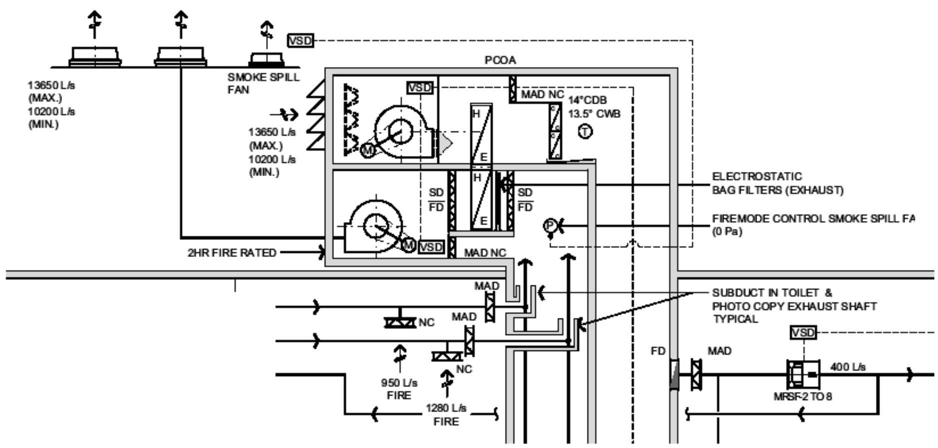


**Fig 8: Pre Conditioned Outside Air Unit Schematic**

### 3.3 Floor Air Handling Units and Duct Systems. – General Office Spaces

Each of floors L2 to L8 inclusive are provided with two (2) built up type cold room panel air handling units and serve the general office areas. The AHU plants are located mid length of the floor plate and serve the East and West ends respectively. Centre and perimeter zoning is achieved via a typical variable air volume design. Meeting rooms are provided with a separate system as described later.

Ventilation air flow rates from the PCOA are maintained at the statutory/Green Star levels at all times irrespective of the turn down of the respective air handler. This is accomplished through the use of a Constant Volume (CV) terminal unit delivering the ventilation air directly into the plant room plenum. A CV unit is simply a commercial VAV having its maximum and minimum flow rate settings set at the same value.

### 3.4 Floor Constant Volume (CV) – Meeting Rooms.

Each of levels L2 –L8 is provided with two or more small meeting rooms at each of the east and west wings.

L1 is provided with one small meeting room and LG (ground) is entirely devoted to meeting rooms.

Under Green Star and AS1668.2 code requirements, meeting rooms require special consideration in respect of the quantity of ventilation air, being nominally 10 times the rate per $m^2$ of floor area to a general office area.

The design approach adopted comprises a 100% outside air introduction from the PCOA unit delivered directly to the respective meeting room through a dedicated supply duct facility emanating at each floor plant room. The air is fan assisted and speed controlled by a duct static pressure sensor at each level to ensure positive delivery to a CV unit serving each meeting room.

The CV units provide a fixed air flow rate depending on the design occupancy. They are activated following a 5 minute occupancy confirmation period (infrared occupancy sensor) in each meeting room and close again if occupancy is not sensed for a similar period. Due to the flow rate being higher than that needed to satisfy the room sensible cooling load, meeting rooms would be overcooled. Accordingly, electric reheat is fitted as part of the CV unit at each terminal to control the space temperature to the set points. The amount of reheat imposes a diversified electrical load of only 2.3 watts/$m^2$. This compares with 10.4 watts/$m^2$ for a current generation PC with 24" LCD monitor rated at 130 w per PC.

### 3.5 Operation in Fire Mode

On activation of a fire alarm the following sequences occur.

- Stairwell pressurization fan is activated and controlled to operate at an average stairwell pressure of 50 Pa maximum. VSD's have been shown to be the most reliable method of control and are adopted for this project. As the building height is relatively modest and the stair served is of the open handrail configuration, it is not necessary to provide a dedicated fire rated masonry riser shaft adjoining the stairwell. In this instance it is introduced only at the top of the stair. A stainless steel pressure sensing tube with sampling openings at each level is provided within the full height of the stair to obtain an average pressure profile for control of the VSD.
- The PCOA unit supply fan starts (if not already operating) and heat wheel bypass dampers open to fail safe condition. The PCOA supply fan is ramped to maximum speed to afford maximum zone pressures to non-fire floors.
- The combination smoke/fire dampers on the upstream and downstream side of the PCOA heat wheel fail safe to close as the heat wheel must be fire isolated from the zone pressurization system and lobby relief exhaust.
- The PCOA unit spill fan is shutdown as its capacity far exceeds the lobby relief air quantity of the fire floor, nominally 2000 L/s, which equates to the amount of air spilling through an opened stairwell door.

- The roof mounted lobby relief fan is speed controlled via a pressure sensor located in the spill air riser duct to a preset negative pressure. This is to ensure that influence of its exhaust capacity does not cause the door opening force of 110N at stairwell entry doors to be exceeded. The pressure set point was field adjusted during commissioning trials.
- All toilet and tenant riser duct smoke/fire dampers on non-fire floors power to close position to provide a non relief air position to achieve floor pressurization.
- All PCOA outside air smoke /fire dampers and CV units on non-fire floors at the riser shaft power to full open position to provide zone pressurization.
- The smoke/fire dampers on the fire affected floor at the connection to the exhaust riser fail safe to open and the duct mounted dampers within the plant room adjacent to the smoke/fire dampers also fail safe open to provide additional exhaust flow rate to that afforded by the ducting connected to the toilets and photocopier rooms. This facility also acts to provide lobby relief whenever stairwell doors on the fire affected floor are opened by exiting staff. This is to ensure there is no impediment to maintenance of the statutory air velocity of 1 m/s through the stairwell fire door into the fire floor when opened.

### 3.6 Standby Power Generation

Both Stage 1 and Stage 2 buildings are provided with 100 % capacity (including full air conditioning) standby diesel powered emergency generator sets. They are fully synchronized with the local electricity provider (Ergon) for parallel co-generation, allowing regular generator testing using the chillers as a load bank.

Apart from their obvious use as an emergency power supply during mains failures, a reasonably common occurrence during the summer storm season, they are used to provide power to the chiller groups for regular scheduled testing and also to serve the chillers if the need arises to operate the chillers during daytime periods. This avoids the potential of destroying the maximum load imposed on the power providers metering and subsequent penalties under the tariff structure.

**Fig 9: Stage 2 Standby Power Diesel Engine Generator – 1100 kWe**

### 3.7 Chilled Water Generation Plant Failures

The integration of the Stage 1 and Stage 2 chilled water systems and respective 100 % capacity diesel generator sets (500 kW –stage 1 and 1100 kW – stage 2) provides a facility whereby the Stage 1 chillers, comprising 2 x 550 kW Duty/Standby screw chillers, can act as a emergency chiller back up to serve the TES tank should the turbine chiller should fail for any reason.

Scenarios available through the BMS include:

- Stage 2 Turbine chiller fault- transfer to Stage 1 chillers to serve the TES tank.
- TES tank less than 90% charge any time between 7 am and 3 pm – Revert Stage 1 building back to its own system to remove demand from the TES.
- TES tank less than 20% charged anytime between 7 am and 3 pm **<u>and</u>** all plant available – Initiate diesel generators and operate chillers to serve their respective buildings. This is to avoid maximum demand penalties from the power provider.
- TES tank less than 20% charged anytime between 7 am and 3 pm and Stage 2 turbine chiller unavailable – Initiate diesel generators and operate the two Stage 1 chillers to serve both buildings. This will mean partial loss of conditions and is considered a highly irregular event.
- Mains power failure to the Stage 2 turbine chiller during a night charge mode – Initiate the Stage 2 diesel generator.

- Scheduled fortnightly run for the Stage 1 chillers and cooling towers to keep cooling towers chemical treatment in optimum condition. The Stage 1 diesel generator is initiated to prevent excess maximum demand penalties from the power provider.

All consumed diesel fuel is logged as an energy source for the assessment of NABERS ratings.

### 3.8 Daily Power Consumption Profile

The single most important advantage of the TES system is the ability to "load shift" the power consumption for the production of chilled water from the typical daytime instantaneous cooling demands of the buildings to nighttime.

The obvious outcome of this action significantly reduces the maximum electrical demand registered by the power provider by about 40%, being the typical power load of the chiller group(s) contribution to a normal daytime building power profile.

As can be seen from the BMS data (Fig 10) taken on 26 -27 October 2010, the power profile is relatively flat for the entire 24 hr period. This data was taken during a period of virtually zero occupancy in the Stage 1 building whilst it is undergoing complete fit-out refurbishment, but includes the operation of the air conditioning for the comfort of fit-out contractors. It is expected that the inclusion of normal tenant occupancies will fill in the power profile dip between 7 am and 5 pm to result in a virtual constant 24 hr demand of nominally 300 kW.

The profile shown below translates into a maximum power demand of nominally 21 $W/m^2$ of NLA.

The onset of peak summer weather conditions (November to April) will not add to the maximum demand, but it will add to the consumed electrical energy (kW.hrs) by virtue that the chiller will operate for a longer nighttime period to restore the TES tank charge.

For comparison, the maximum electrical demand of the same site using typical water cooled, instantaneous demand chillers serving each respective building (pre Stage 2 scenario) and assuming a Kwe/kWt ratio of 0.205 for the chiller group, the maximum power demand is estimated to be in the order of 600 kW. That is, nominally double the TES design.

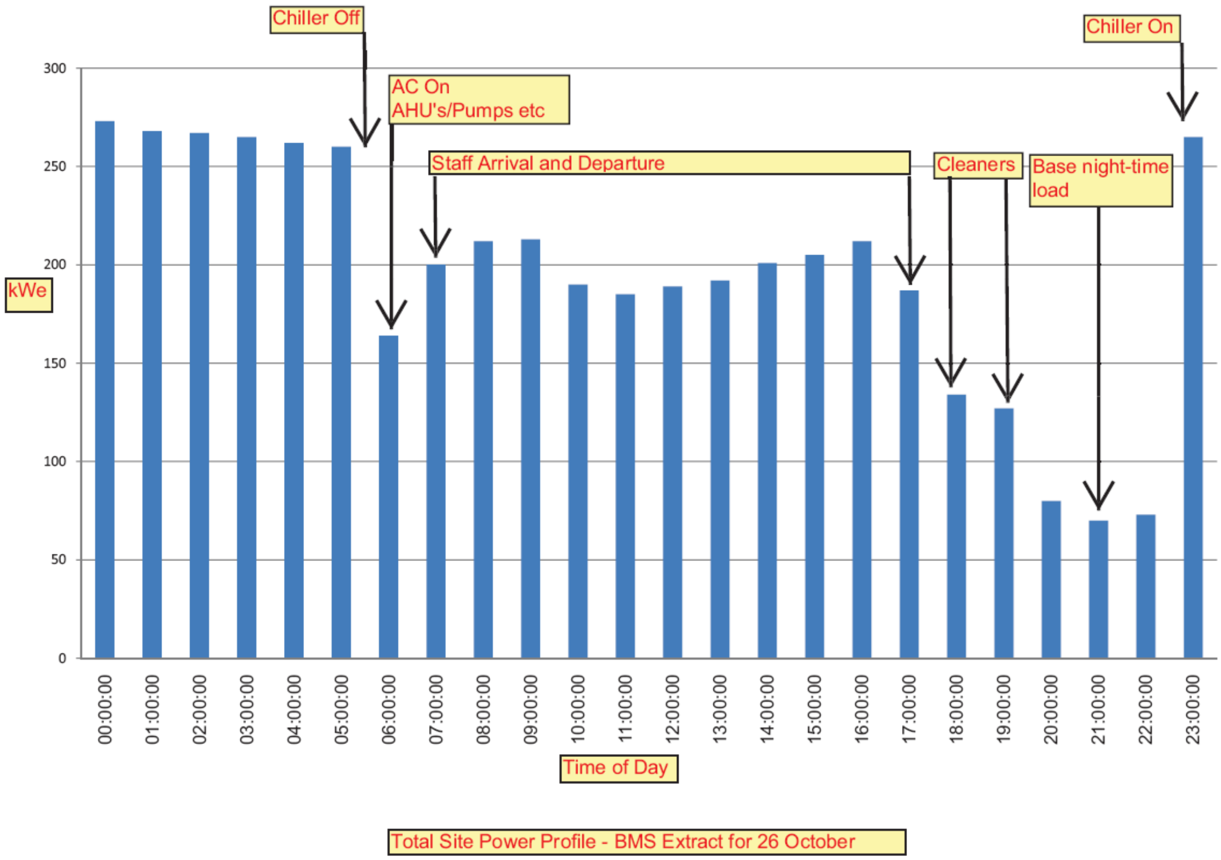


**Fig 10: Total Site Power Profile – 26 October 2010**
**Stage 1 Building not tenanted.**

# 4 LIGHTING and CEILING FANS

## 4.1 Lighting Overview

The lighting system within the building has several energy efficient benefits that ensure appropriate lighting is always available for working, whilst minimizing energy consumption. The main features are:

- The use of energy efficient, high output light fittings containing high frequency ballasts,
- Efficient placement of light fittings to ensure sufficient lighting levels is maintained whilst minimizing energy consumption.
- The breakdown of the office floors and levels into strategic lighting zones and the allowance of independent control by daylight sensors.
- Direct communication between the lighting control system and the Building Management System that provides better on line management of the system.

## 4.2 Tenancy Lighting and Controls

Electric lighting is provided to all tenancies as part of an integrated fit out.

In the open-plan zones, suspended direct/indirect fluorescent lighting is arranged to coordinate with ceiling fans and, as no walls are to be constructed in these zones, there is never any need to modify this lighting installation.

Lighting is controlled on a DALI addressable lighting control system, with open plan lighting grouped into zones of nine (9) fittings in a zone of approximately 8m x 8m. A daylight harvesting sensor is provided in the centre of each zone and the lighting dimmed in response to this sensor. The daylight harvesting sensor is located on top of the centre light in each zone and measures ceiling exitance as a proxy for work plane illuminance for improved stability. Dimming offsets for perimeter versus core open plan lighting was found to be unnecessary.

In the central spine built zones, surface mounted fluorescent lighting is located in a grid arrangement to suit modular room designs. Lighting is controlled on a DALI addressable lighting system. A switch panel is provided in each room for manual ON and auto/manual OFF operation. Occupancy sensing was not provided as research shows manual operation to be more effective for small offices.

An overall lighting and ceiling fans control system is provided. This system connects multiple DALI buses into a single system and handles all monitoring / logging of lighting operation, daylight harvesting performance, and equipment failures. Equipment failures are reported to the building manager.

Lighting to all open-plan zones is switched on throughout business hours and utilizes daylight harvesting to reduce energy use. Lighting to built-zone offices is 'enabled' throughout business hours but does not switch on until initiated at the room's switch panel.

A touch screen is provided in the lift lobby on each floor for after-hours control of lighting, ceiling fans, and air conditioning. Each zone is presented graphically to encourage ease of use.

The lighting control system is connected to the BMS for scheduling of business hours / after-hours operation. This accounts for public and other holidays, as well as weekends and daily working hours. After hours, lighting will initially set back to a lower level (50% dimming) and then to a security mode (approx 5% via switching and dimming). When a user requests after hours lighting, full lighting is provided in the requested zone plus selected transit and utility areas; with security lighting to the remainder of the tenancy.

## 4.3 Ceiling Fans

High efficiency, low noise single-bladed aerofoil ceiling fans (Fig 11) are provided throughout high-ceiling / open-plan zones of each tenancy from Levels 1 to 8. The ceiling fans provide improved air mixing which allowed the elimination of separately ducted perimeter and core supply air zones and reduced the amount of ductwork needed on each floor.

The ceiling fans also provide some cooling effect in lieu of air conditioning. As a result, the air conditioning temperature set-point is raised from the more usual 23.5°C to nominally 25.5°C whilst providing equivalent comfort conditions for occupants wearing climate-appropriate dress. The higher temperature set-point provides an energy benefit due to reduced conductive heat gains on the building fabric and reduced cooling demand.

The adoption of this initiative was based on the personal experiences of MGF staff at their Cairns office where such a system has been employed since 2007 and also from the personal support of Professor Richard Aynsley, Ph.D F.AIA, F. AIRAH. M.ASHRAE and Director, Big Ass Fans Australia Pty.,

Each ceiling fan is individually controllable (3 speeds and off) via the DALI addressable lighting control system. The three speeds are nominally 80rpm / 8.1W, 130rpm / 16W, and 150rpm / 24W. In accordance with the client's instructions, individual occupant control of ceiling fans is not provided.

Not all building occupants have 'permission' (via access cards) to request after-hours air conditioning, but all have permission to use ceiling fans. Therefore each ceiling fan operates at low speed whenever air conditioning is provided in the associated zone; and at medium speed whenever air conditioning is not provided (i.e. during after-hours occupancy). This is controlled via an interface between the BMS and the lighting control system, and allows for improved after-hours comfort conditions with minimal energy use.

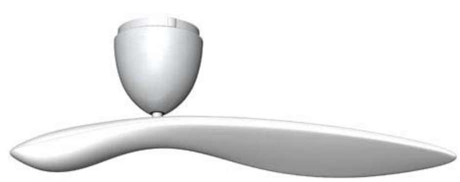

**Fig 11: Single Blade Ceiling Fan**

**Fig 12: General View of Open Plan Office Space with Built Zone (Meeting and Private Offices) on left**

# 5 GREEN STAR OUTCOMES

## 5.1 The Green Star Learning Curve

When MGF Consultants first became involved in the project in 2007, only limited knowledge of the Green Star processes were appreciated.

It soon became apparent through attendance at training courses that we were not on our own. The magnitude of knowledge and attention to presentation detail required to achieve a smooth assessment of the case, to say the least seemed overwhelming.

Despite the somewhat daunting task of continuing to drive forward to achieve the holy grail of 6 stars, it was in the end a very rewarding and worthwhile exercise. However it is not a process to be treated lightly and requires a team of devoted and singularly focused engineers, client and project manager. It is indeed a team effort.

The objectives of reducing our footprint on our planet's resources have been realized in this project.

Green Star Office As- Built v2 and Office Interiors v1.1 submissions are currently being prepared.

### 5.2 Green Star Category Scores and Credit Summary.

The following are extracts of the final Green Building Council of Australia category scores and credit summary for this project.

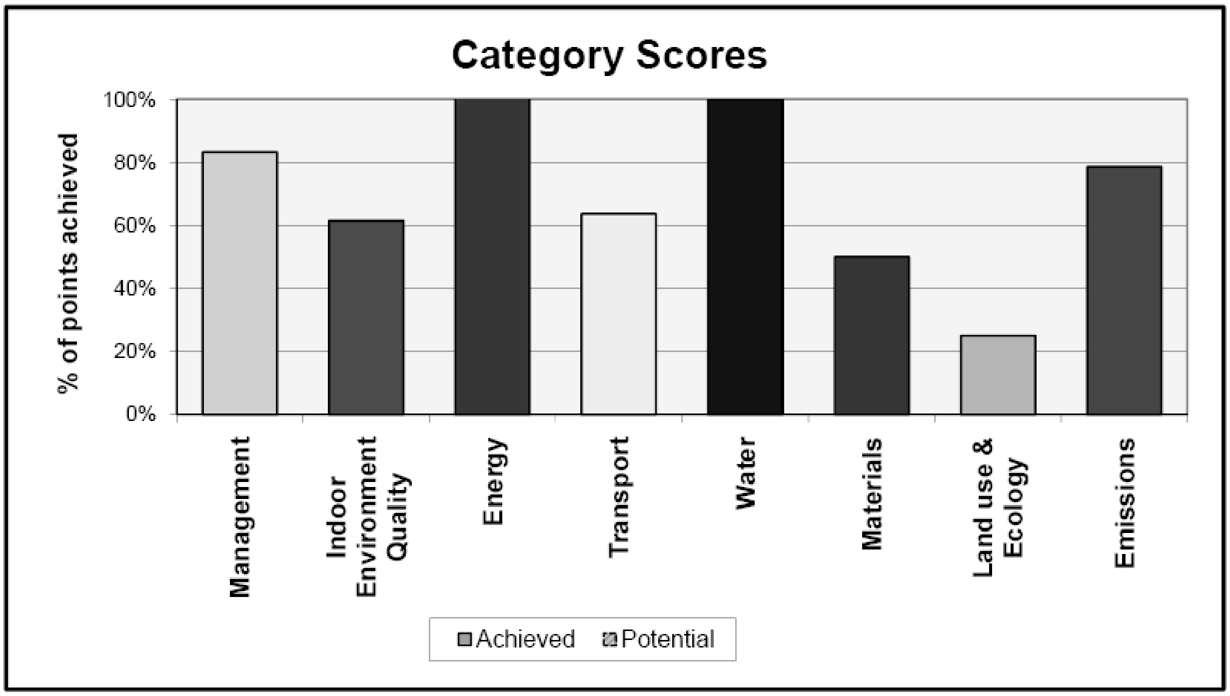


**Fig 13: Green Star Category Scores for WMP2**

| Category | Title | Credit No. | Points Available | Points Achieved |
|---|---|---|---|---|
| **Management** | | | | |
| | Green Star Accredited Professional | Man-1 | 2 | 2 |
| | Commissioning - Clauses | Man-2 | 2 | 2 |
| | Commissioning - Building Tuning | Man-3 | 1 | 1 |
| | Commissioning - Commissioning Agent | Man-4 | 1 | 1 |
| | Building Users Guide | Man-5 | 1 | 1 |
| | Environmental Management | Man-6 | 3 | 3 |
| | Waste Management | Man-7 | 2 | 0 |
| | | TOTAL | 12 | 10 |
| **Indoor Environment Quality** | | | | |
| | Ventilation Rates | IEQ-1 | 3 | 1 |
| | Air Change Effectiveness | IEQ-2 | 2 | 2 |
| | Carbon Dioxide Monitoring and Control | IEQ-3 | 1 | 1 |
| | Daylight | IEQ-4 | 3 | 1 |
| | Daylight Glare Control | IEQ-5 | 1 | 1 |
| | High Frequency Ballasts | IEQ-6 | 1 | 1 |
| | Electric Lighting Levels | IEQ-7 | 1 | 1 |
| | External Views | IEQ-8 | 2 | 1 |
| | Thermal Comfort | IEQ-9 | 2 | 2 |
| | Individual Comfort Control | IEQ-10 | 2 | 0 |
| | Asbestos | IEQ -11 | 0 | na |
| | Internal Noise Levels | IEQ-12 | 2 | 2 |
| | Volatile Organic Compounds | IEQ-13 | 3 | 2 |
| | Formaldehyde Minimisation | IEQ-14 | 1 | 1 |
| | Mould Prevention | IEQ-15 | 1 | 0 |
| | Tenant Exhaust Riser | IEQ-16 | 1 | 1 |
| | | TOTAL | 26 | 17 |
| **Energy** | | | | |
| | Energy | Ene-1 | Conditional Reqr | yes |
| | Energy Improvement | Ene-2 | 15 | 17 |
| | Electrical Sub-metering | Ene-3 | 1 | 1 |
| | Tenancy Sub-metering | Ene-4 | 1 | 1 |
| | Office Lighting Power Density | Ene-5 | 4 | 3 |
| | Office Lighting Zoning | Ene-6 | 1 | 1 |
| | Peak Energy Demand Reduction | Ene-7 | 2 | 2 |
| | | TOTAL | 24 | 25 |
| **Transport** | | | | |
| | Provision of Car Parking | Tra-1 | 2 | 2 |
| | Small Parking Spaces | Tra-2 | 1 | 1 |
| | Cyclist Facilities | Tra-3 | 3 | 3 |
| | Commuting Public Transport | Tra-4 | 5 | 1 |
| | | TOTAL | 11 | 7 |
| **Water** | | | | |
| | Occupant Amenity Potable Water Efficiency | Wat-1 | 5 | 5 |
| | Water Meters | Wat-2 | 2 | 2 |
| | Landscape Irrigation Water Efficiency | Wat-3 | 1 | 1 |
| | Cooling Tower Water Consumption | Wat-4 | 4 | 4 |
| | Fire System Water Consumption | Wat-5 | 1 | 1 |
| | | TOTAL | 13 | 13 |
| **Materials** | | | | |
| | Recycling Waste Storage | Mat-1 | 2 | 2 |
| | Re-use of Façade | Mat-2 | 0 | na |
| | Re-use of Structure | Mat-3 | 0 | na |
| | Shell and Core or Integrated Fitout | Mat-4 | 3 | 3 |
| | Recycled Content of Concrete | Mat-5 | 3 | 1 |
| | Recycled Content of Steel | Mat-6 | 2 | 1 |
| | PVC Minimisation | Mat-7 | 2 | 0 |
| | Sustainable Timber | Mat-8 | 2 | 0 |
| | | TOTAL | 14 | 7 |
| **Land Use & Ecology** | | | | |
| | Ecological Value of Site | Eco-1 | Conditional Reqr | yes |
| | Re-use of Land | Eco-2 | 1 | 1 |
| | Reclaimed Contaminated Land | Eco-3 | 2 | 0 |
| | Change of Ecological Value | Eco-4 | 4 | 1 |
| | Topsoil and Fill Removal from Site | Eco-5 | 1 | 0 |
| | | TOTAL | 8 | 2 |
| **Emissions** | | | | |
| | Refrigerant ODP | Emi-1 | 2 | 2 |
| | Refrigerant GWP | Emi-2 | 1 | 0 |
| | Refrigerant Leak Detection | Emi-3 | 1 | 1 |
| | Refrigerant Recovery | Emi-4 | 1 | 1 |
| | Watercourse Pollution | Emi-5 | 2 | 2 |
| | Reduced Flow to Sewer | Emi-6 | 4 | 2 |
| | Light Pollution | Emi-7 | 1 | 1 |
| | Legionella | Emi-8 | 1 | 1 |
| | Insulant ODP | Emi-9 | 1 | 1 |
| | | TOTAL | 14 | 11 |
| **TOTAL CREDITS** | | | 122 | 92 |
| **Innovation** | | | | |
| | Innovative Strategies and Technologies | Inn-1 | 5 points in total for Inn-1,2&3 | 4 |
| | Exceeding Green Star Benchmarks | Inn-2 | | 0 |
| | Environmental Design Initiatives | Inn-3 | | 0 |
| | | Total | 5 | 4 |
| **OVERALL WEIGHTED SCORE:** | | | | 79 |

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**Fig 14: Green Star Credits Summary for WMP2**

## 6 CONCLUSIONS

The engineering initiatives discussed in the paper have assisted in delivering the WMP Stage 2 project on budget and ahead of schedule.

The building's energy savings initiatives outlined is expected to deliver in the order of $450,000 per year in cost savings compared to a median (2.5 star) building. The design is also predicted to deliver an impressive suite of environmental outcomes as follows:

- 60% (1,000 tonnes/y) reduction in $CO_2$ emissions, compared to a median (2.5 Star) building; including
  - 110MWh/y generation from 64kW Solar PV;
  - 25% reduction in chilled water energy needs due to PCOA heat recovery exchanger;
  - 20% reduction in cooling requirements due to ceiling fans;
- 40% reduction in whole-building demand on the electricity grid;
  - 90% of the chiller work lies within the network off-peak period.
- 75% (17 ML/y) reduction in potable water use, compared to a median (2.5 Star) building; including:
  - 5ML/y saving due to the air-cooled chiller
  - 55% reduction in toilets potable water use (due to rainwater re-use)
- 25% (2 ML/y) reduction in flow to storm water system.
- 20% (1 ML/y) diversion of grey water to landscape instead of sewer.
- 600 lux annual average daylight in open-plan zones (with >200 lux for 99% of working hours);
  - 62% lighting energy reduction in open-plan zones.
- 70% reduction in reinforcing steel used.
- 30% reduction in air conditioning ductwork due to simplified single run distribution.
- 50% increase in fresh air to office areas;
  - with significant further reduction in indoor air pollution.
- 6 Star Green Star Office Design v2 rating;
  - With targeted 6 Star Green Star Office As-Built v2 rating; and
  - targeted 5 Star Green Star Office Interiors v1.1 rating.

- Anticipated 5 Star NABERS Energy ratings (whole building, base building, and tenancy);
- Anticipated 4 Star NABERS Water rating (whole building).

### 6.1 Community Benefits

The completion of William McCormack Place Stage 2 in July 2010 has raised the bar for office accommodation in Cairns. It has demonstrated that world leadership in sustainable design is possible in the Tropics and was due to a large part by the knowledge of local engineers experienced in the vagaries of the tropics. The engineering team brought intelligent and responsive design to the table and exceeded client expectations. The success of the project has placed Cairns on the sustainability map on a national and international level.

In the process of completing the design and construction, the local marketplace including builders, sub-contractors and suppliers have also learnt the benefits of sustainable design and in some cases raised their performance to help the project succeed.

The engineering team looks forward to future opportunities within Cairns and further afield to help clients capitalize on the real value of their commercial space by applying proven techniques to help achieve long term environmental performance and reduced life-cycle costs.

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Independent Commissioning Agent: Mr Frank Schulze

## 8 REFERENCES


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