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Australia's First 6-Star Green Education Building: Construction and Services Technologies

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Abstract
Green Star is a voluntary environmental rating scheme that evaluates the environmental design and achievements of buildings. It was developed by and is administered by the "Green Building Council of Australia" (GBCA). Green Star covers a number of categories that assess the environmental impact that is a direct consequence of a projects site selection, design, construction and maintenance. The nine categories included within all Green Star rating tools are management, indoor environment quality, energy, transport, water, materials, land use/ecology, emissions and innovation

The new School of Sustainable Development completed in mid-2008 is the country's first 6-star rated green education and is a 'pilot' project for all similar education buildings in the future. This paper presents a summary of the important construction and building services systems in the building that contribute to its premier green rating. A distinct feature of the building is the monitoring of the various systems in the building continuously and some of the results of this monitoring will be presented and analysed.

Keywords
Sustainable design, Construction, Services, Environmental rating

1. Introduction

The Green Star Education PILOT rating tool is a voluntary points based green building rating tool for educational facilities developed by the Green Building Council of Australia. It assesses the design in areas such as Management, Energy, Indoor Environmental Quality, Transport, Water, Emissions, Materials, and Innovation. The minimum recognised Green Star rating is 4 Star.

A Green Star rating of 4 Stars represents 'Best Practice'. A Green Star rating of 5 Stars represents 'Australian Excellence'. A Green Star rating of 6 Stars represents 'World Leadership'. This building has been designed to achieve a GBCA (Green Building Council of Australia) Green Star Education PILOT rating and has achieved a rating of 6 stars under the Green Star Education PILOT rating tool. This is the first education project in Australia to be awarded a 6 star 'World Leadership' rating.

Important features of the building will be highlighted in this paper and include:

- Bio retention basin: capture and naturally treat stormwater in a 1 in 20 year event.
- Landscaping for natural habitat
- Living Laboratory: information and building tour
- Cyclist facilities: for staff and students. Staff have lockers and showers.
- Sun, glass and light: ventilation, orientation, day light, glazed windows, shading, glass type
- Ecological Finishes: acoustic screen, partitions, ceiling tile, volatile organic compounds minimised.
- Photovoltaic Cells: 18kW to generate 13,500kWh per year.
- Materials: recycled reinforcement, recycled concrete, timber, roof sheeting disassembly
- Services: generator, Building Monitoring Systems (BMS), main switch board, fire room, riser, weather station, plant rooms
- Regenerative Drive Lift: generates electricity on the descent
- Waste Storage: dedicated waste storage.
- Water demand: minimise demand, low flow fixtures and fittings
- Water supply: grey-water treatment, rainwater harvesting, subsurface irrigation,
- Wind turbine: for demonstration only.

2. Energy & Environmental Strategy

The building employs energy and environmental strategies through the following design and management initiatives:

- The building has been designed with a mixed-mode air conditioning system. This means that when climatic conditions are favourable, the air conditioning shuts down and the building operates in natural ventilation mode. When the climatic conditions are unfavourable, the building operates with air conditioning. This reduces energy consumption and provides for a healthy indoor environment.
- Commitment to commissioning building tuning. This requires minimum quarterly reviews within the first year of operation. This process ensures that the building maintains optimum energy efficiency and that all systems work to the intent of the design.
- The publication of a Building Users' Guide to all occupants. This guide ensures that all building users and occupants are aware of the environmental and energy strategies put in place by the design team and the optimum working conditions for these systems.
- This building has been designed to maximise views to the outdoors for occupants and building users with all occupants being within 8m of a clear window. This improves the indoor environment by reducing eyestrain and provides a visual connection with the external environment.
- Paints, carpets, adhesives and sealants used in this building have been selected carefully to minimise emissions typical of these materials to ensure occupant health.
- Electrical sub-metering has been incorporated into this building in order to provide information for building users about the distribution of energy use so that high electrical use areas can be identified and addressed accordingly to save both energy and money.
- Efficient lighting has been employed on all parts of the building in order to reduce lighting energy consumption. This lighting has been linked to the Building Management System (BMS) to ensure that it is turned off at night and in the case of teaching areas, when classes are not in progress.
- Water meters are installed in this building and linked to the Building Management System. This assists in the management of water consumption for the building and allows any leaks to be detected quickly to prevent the wastage of any water. Water efficient fittings have been used in the bathrooms and showers.
- A greywater recycling system has been incorporated in the building design to reduce potable water use for irrigation.

- Photovoltaic cells and a wind turbine have been installed in the building to provide energy to the building and also provide an education element for building occupants, particularly students, and the community.
- Rain water is being harvested through roof catchment and stored in inground tanks. This water is treated and used within the building in toilets and urinals.
- Fire test water is also drained to the in-ground rain water tanks along with condensate from the air conditioning units.
- The required hot water to the building is generated through the use of solar and solar / gas systems.
- The plumbing system shave been split into black and grey water discharges to enable the wastes streams to be split for different treatment processes.

2.1 Overview of Potential Savings

Based on modelling during the design phase the building achieves an 82.5% reduction in CO2 emissions per year (19,800 kg CO2 compared to 113,252 kg CO2) compared to 'business as usual'. This equates to a financial saving on electricity bills of approximately $11,000 per annum. This is based on a total electricity demand of 101,851 kWh/year, with 84,508 kWh being provided by renewable energy systems.

3. Building Monitoring

The Building Management System (BMS) controls several functions that are critical in improving the environmental efficiency of this building including automatically turning off lights and adjusting or shutting down the air conditioning. Water and energy meters have been incorporated in the design of the building. These have been connected to the Bond University Site-Wide Building Management System (BMS) to facilitate easy monitoring of water and electricity consumption or electricity generation. The data collected by the BMS are displayed on the video displays within the *Living Laboratory*. This will facilitate simple review of operational performance against the building's targets.

Energy meters have been installed on a number of areas including the building as a whole, lift, lighting and power for each level, Photo-Voltaic cells, wind turbine, Biodiesel generator, Living Laboratory and water treatment plant. Water meters have been installed on a number of areas including the water treatment plant, the rainwater tanks, the potable water supply (mains), and hot water systems.

4. Water

This building has been designed to minimise water consumption during operation. It is expected to use significantly less water when compared to a standard university building of the same size. Potable mains water is only used in the building for showers, basins and taps. An annual benchmark for potable-water consumption has been set at 400kL/annum. This amount is to be revised once operational data is available.

5. Building Services

5.1 Ventilation, Heating and Cooling System

Fresh and clean air supply for indoor spaces should be maximised to promote a healthy indoor environment. The building utilises a mixed-mode ventilation system, meaning that when climatic conditions are appropriate, the building will operate with natural ventilation. During the mornings the air-conditioning operates in a traditional fashion with cooling provided by air conditioning plant. In the

afternoons, if the outdoor conditions become favourable, the building air conditioning plant moves into natural ventilation mode. During natural ventilation mode the air conditioning plant shuts down in order to save energy. This is a key energy saving feature of the building. During this mode users are requested to open windows and utilise ceiling fans to control comfort levels within the spaces.

When the building is operating in natural ventilation mode the "NATURAL VENTILATION" indicator panels provided at the entrances to the various building areas are illuminated. If the conditions are not favourable for natural ventilation then the air conditioning plant will continue to operate. To minimise the amount of cooling required, tenants on the eastern side of the building are requested to leave their blinds down at night. During the late afternoon, blinds on the western side are closed in response to the sun's movement. This reduces the amount of heat that enters the building and additionally, reduces the glare from the low sun in the mornings and late afternoons. The east is the most critical as this can lead to the building heating up and the air-conditioning starting on a summer morning before anyone even enters the building. Cooling has been provided to the operating spaces by zero ozone depleting refrigerant air conditioning systems and without the use of water in removing heat from the rooms. Figure 1 shows the simple system diagram and outlines the ventilation and heating and cooling system which is a key energy saving feature of the building.

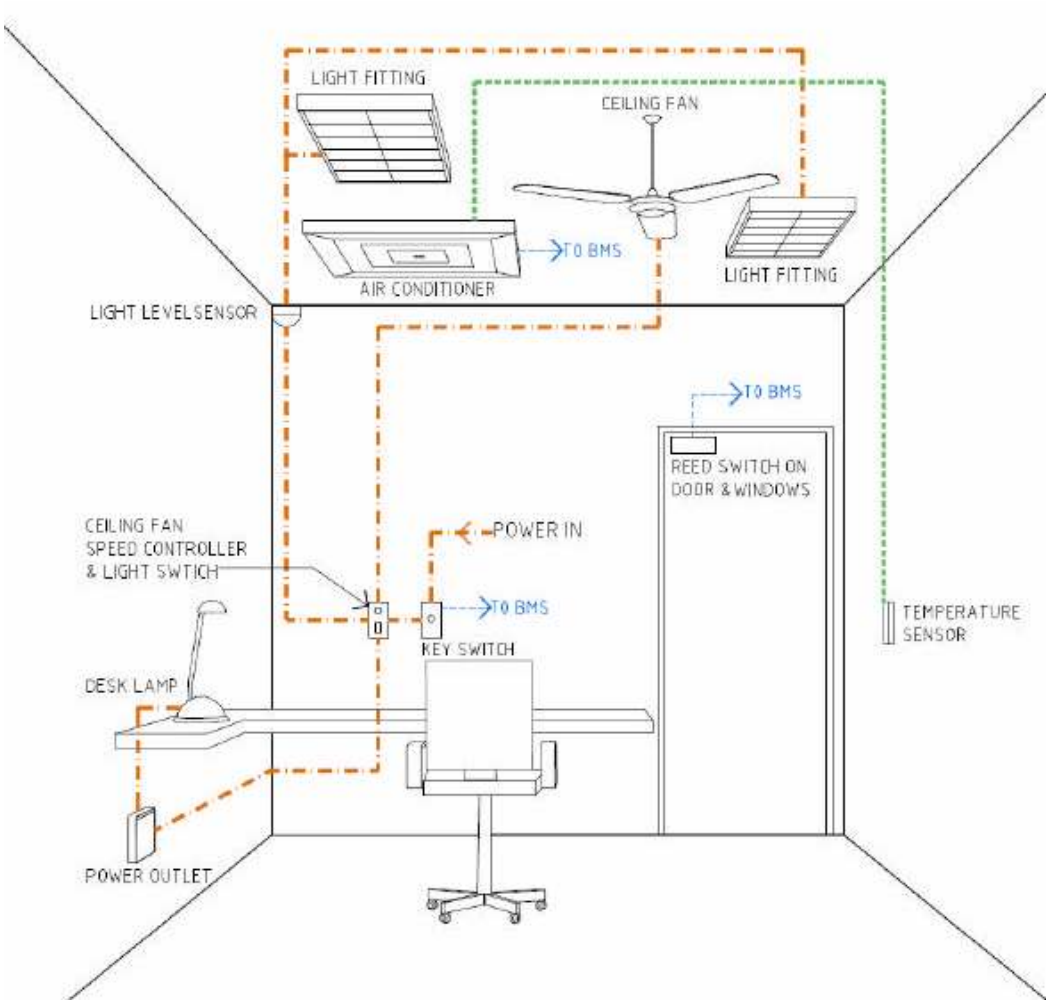

Figure 1: Ventilation and Heating and Cooling System (Arup Sustainability)

Within offices, lighting and air-conditioning is controlled by the key switch. To turn the air conditioning on, the office key must first be put into the key switch within the office. Then the ceiling fan and air conditioner will be enabled. Placing the key into the key switch will also enable the lights within the

office. When you leave the office, you can switch off all the lights and air conditioning separately or you could just remove the key switch. Removing the key switch will turn off all lighting and air conditioning to the office.

There are sensors on the office doors and windows to prevent air conditioning from operating when doors and windows are left open. If occupants want to leave their door and/or windows open, occupants will only be able to use the ceiling fan. Similarly, when the Building Management System detects that outdoor conditions are suitable, the building will automatically switch into Natural Ventilation Mode. At this time, your office air conditioner will switch off and you will need to open your windows and door and use your ceiling fan.

5.3 Lighting

The lighting system includes daylight sensors, motion detectors and task lighting. This should ensure that appropriate lighting is always available for working, whilst minimising energy consumption. Figure 2 shows how the building has been designed to maximize the amount of natural daylight thereby decreasing reliance on artificial lighting. This is a key energy saving feature of the building.

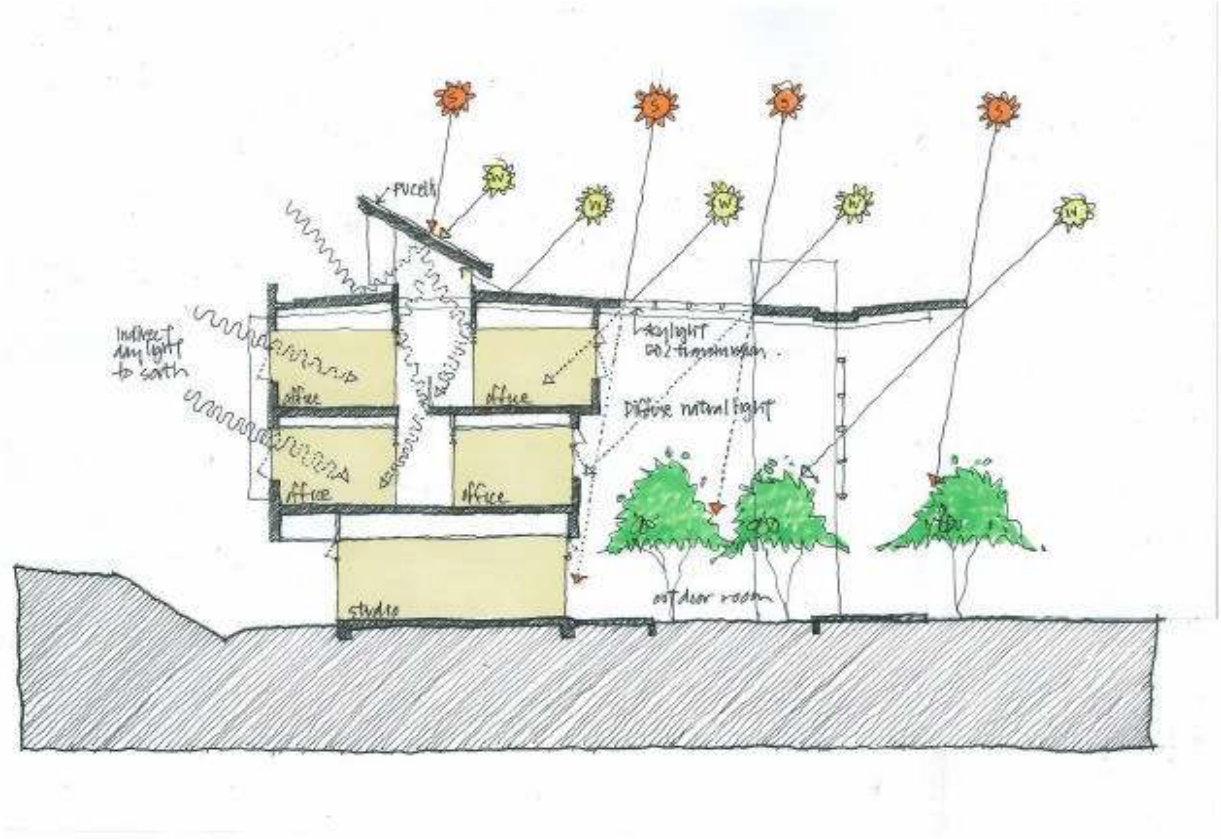

Figure 2: Daylighting to the Building (Mirvac Design)

Within offices, lighting and air-conditioning is controlled by the key switch. To turn the lights on, the office key must first be put into the key switch within the office. Then the light switch and power to the desk light will be enabled. Placing the key into the key switch will also enable the air conditioning unit and the ceiling fan. When you leave the office, you can switch off all the lights and air conditioning separately or you could just remove the key switch. Removing the key switch will turn off all lighting and air conditioning to the office. When the ceiling lights are switched on, a light level sensor automatically

adjusts the light level in the office. Any daylight into the office will reduce the need for electric lighting and so the light level sensor will dim the ceiling lights to suit.

5.4 Domestic Hot Water

The domestic hot water is efficiently provided by a gas boosted solar heating system as outlined in the simple system diagram below. This is a key energy saving feature of the building.

5.5 Water Recycling

A number of steps have been taken to minimise potable water use in the building. For example, rainwater is used to flush toilets and urinals, and greywater (water from bathroom sinks and basins) is treated and used for irrigation. All taps are clearly labelled as appropriate. Figure 3 is a diagram that outlines the water strategy implemented in the building.

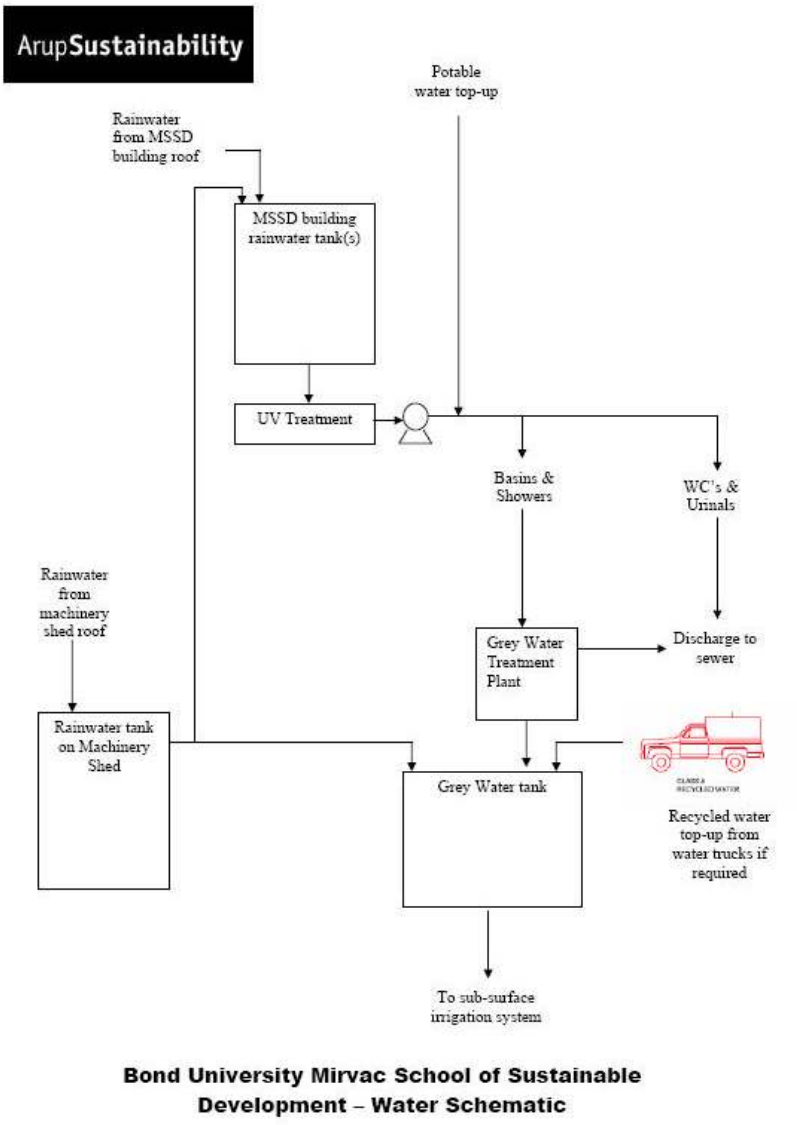

Figure 3: Water Strategy

6. Out of Hours Operation

There are several functions that have special out of hour's operation. The air-conditioning turns off at 6pm, except where a prior negotiation has been made. If there is a special event which requires air-conditioning, the Facilities Management Department of Bond University can override these times. Generally provision for natural ventilation only will be provided after hours. If there is a client event for more than 20 people or an external client function then air conditioning may be provided. Lighting sensors operate the lighting in common areas after 6pm. Within offices, lighting remains switched on as long as the key remains in the key switch.

7. Summary of Building Systems and Environmental Initiatives

The design reduces the energy consumption and greenhouse gas emissions of the base building compared to a conventional benchmark building as follows:

- Bond University School of Sustainable Development will produce 19,800 kg CO2/yr, compared to a benchmark of 113,252 kg CO2/yr which is an 82% reduction.
- Multi-split VRV air cooled air conditioning systems takes advantage of the wide load diversity within the building (estimated by Bond University as 80% of offices vacant 80% of the time);
- Mixed mode with ceiling fans to encourage natural ventilation and extend the comfort range without air conditioning;
- Naturally ventilated corridors and common areas;
- Sub-meters are provided to monitor both lighting and general power consumption. The sub-meters are connected to the BMS and continually demonstrate actual performance against energy benchmarks.
- Energy demand reduction systems are installed to reduce peak demand on electricity infrastructure by 40%.
- Regenerative lift technology which generates electricity as the lift descends. This technology is fully metered to allow for student and industry analysis of the effectiveness of this technology;
- Solar hot water with gas boost;
- Grey water collected from the building is treated to Class A standard and stored in a 45,000 litre irrigation tank. This grey water is combined with rainwater from the roof of the adjacent maintenance shed to supply 100% of landscaping irrigation water needed for the MSSD;
- Rainwater is collected from the roof of the MSSD building and treated before being used to flush urinals and toilets. Excess rainwater from this system is directed to the 100,000 litres of rainwater storage and used for irrigation;

8. Acknowledgements

This paper has been based on the work carried out by Arup Sustainability (Brisbane, Australia) in its *Building Users Guide* (May 2008), with the assistance of the architect (Mirvac Design), the services consultants (Bassett and Steve Paul and Partners), the builder (ADCO Constructions) and Bond University.