INTRODUCTION
This article provides a case study of the sustainability journey of the Bond University Mirvac School of Sustainable Development (MSSD) building, with a particular focus on the use of the Green Building Council of Australia Green Star Education PILOT tool. The building was awarded a 6 Star rating under this tool, the highest rating possible and representing “World Leadership” in sustainable development.

The article does not aim to outline the entire process of the building, program, design, and construction; however, it focuses on the sustainability aspects of the design, the sustainability process, the sustainability features, and initiatives and the relevant lessons learned.

Bond University’s Mirvac School of Sustainable Development is one where planning, property, project management, construction management, and quantity surveying are integrated in a school of the urban environment in the context of sustainable development. The School is the first designated institute to fully integrate environmental, urban planning, property development, quantity surveying, construction management, and facilities management disciplines with the practical issues of managing economic and social viability with societal expectations. Unlike most other property planning schools around Australia that have evolved over the last 50 or so years, this School started with a blank canvas. Its philosophy is to look at where we see the built environment—the urban development—being in the future rather than where it was in the past.

The goal was to blend together the three aspects: ecological sustainability—indoor environment quality, transport, water, materials, emissions, land use and ecology—closely linked to economic and social sustainability. There was a desire from Bond University and Mirvac for a world class sustainable building as the home of the Mirvac School of Sustainable Development. This article will talk through the process using sustainable building features that were incorporated to deliver on this objective.

INTRODUCTION TO THE BUILDING
Bond University’s Mirvac School of Sustainable Development building embraces the world’s best practice sustainable processes, and includes an interactive “Living Laboratory” for sustainable education. The building is the first in Australia to achieve a 6 Star Green Star-Education PILOT Certified Rating for design by the Green Building Council of Australia.

Designed by Mirvac Design and partly funded by Mirvac as an element of the Mirvac and Bond University School of Sustainable Development partnership, the building’s optimum orientation maximises solar gain and the capture of prevailing breezes. The three-storey building with central corridors on office floors has light wells and natural ventilation. The orientation of the building is on a long axis east–west. This is the optimum orientation to maximise natural daylight and capture prevailing breezes. The construction is a lightweight façade. The building spaces consist of three studios, one CAD/GIS room,
two research rooms, 32 offices, four meeting rooms, one “Living Laboratory,” covered outdoor teaching, and recreation spaces.

The Living Laboratory concept supports sustainable education not only for Bond students, but also for the wider community. The Living Laboratory centre and Self-Guided Tours offer a unique learning experience for students, school groups, industry, and guests. The building minimises energy consumption through an innovative design that makes maximum use of natural light and mixed mode ventilation. Water tanks and a grey water recycling system means less reliance on the local water supply, and the building achieves a significant reduction in carbon emissions. The design also made extensive use of recycled materials, including recycled timber and loose furniture, as well as low-emission paints and environmentally friendly carpet. By going green the building not only reduces its environmental impact, it also reduces long-term operating costs, and provides students and teachers with healthy and safe surroundings that maximise their learning potential. The partnership between Bond University and Mirvac reflects a long-term investment in the next generation of students who will develop an invaluable understanding of the growing importance of sustainability.

**The Building at a Glance**
- 1400m² building double loaded 3 storey building, with a separate Living Laboratory building.
- AUD$11 million construction cost, 5–7 year payback on sustainability features expected.
- First in Australia to achieve a 6 Star Green Star–Education PILOT Certified Rating for design by the Green Building Council of Australia.
- Interactive “Living Laboratory” where students and the community can learn more about the future of development and book a Self-Guided tour.
- Energy consumption is minimised through the use of natural light and mixed mode ventilation.
- Water tanks and a grey water recycling system means less reliance on the local water supply.
- Extensive use of recycled materials, including recycled timber and loose furniture, as well as low-emission paints and environmentally friendly carpet.

**GENERAL BACKGROUND**

**About Bond University**

Bond University was the first private university established in Australia.[2] Bond also differs from other Australian universities as it schedules three semesters each year, commencing in January, May and September, allowing a six-semester degree to be completed in two years, instead of three, without increasing semester workloads. In August 2007, Bond University received top marks in 10 categories of the Good Universities Guide 2008, more than any university in Australia. The university has approximately 3500 students including both postgraduate and undergraduate students.

On May 15, 1989, Bond University welcomed its first cohort of 322 students at its brand new, state-of-the-art campus on Queensland’s Gold Coast.

Modelled on the traditions of the world’s most elite educational institutions, the vision for Australia’s first private, not-for-profit university was to provide an exclusive educational experience of the highest international standards, under the tutelage of the country’s leading academics.

When those foundation students graduated as Class of ’91, they were quickly recruited by some of Australia’s largest corporations, and their subsequent achievements in the workplace firmly established the Bond reputation for excellence.

Over 20 years of challenges and changes, Bond has adapted to the needs of the workplace, liaising with key employers in all fields to develop programs that reflect the current technological, theoretical and psychological practicalities of the corporate environment.

Bond University’s vision is “To produce uniquely identifiable graduates who are leaders and thinkers, imbued with initiative, the spirit of free enterprise, and a continuing quest for intellectual inquiry, challenge, and opportunity.”
About Mirvac

Mirvac Group ("Mirvac" or the "Group") is a leading integrated real estate group, listed on the Australian Securities Exchange ("ASX") with activities across the investment and development spectrum.

Established in 1972, Mirvac has more than 37 years of experience in the real estate industry with a reputation for delivering quality products and services across all of its businesses.

Mirvac is committed to the continual delivery of high quality products and services across all of its operating divisions.

Investment

As at 30 June 2009, Mirvac’s Investment Division had a diverse portfolio of 58 investment grade assets valued at more than $3.7 billion.

The portfolio includes a mix of commercial offices, retail centres, industrial properties and a hotel, leased to quality tenants, including leading Australian and international companies.

Mirvac’s integrated business approach includes a specialised in-house asset management team responsible for all asset leasing and management across the portfolio and in-house design, development and construction expertise to improve and expand existing assets and evaluate new asset acquisitions.

Development

Mirvac is one of the leading brands in the Australian development and construction industry and has a proven track record of delivering innovative and quality products that exceed customers’ expectations and lead the market.

Mirvac’s Development Division has also been responsible for some of Australia’s most awarded masterplanned communities, including The Peninsula in Burswood, WA; Newington in Sydney, NSW; Waverley Park in Melbourne, VIC; and Waterline at Bulimba in Brisbane, QLD.

Mirvac’s integrated approach to delivering projects means the Group applies in-house expertise from planning to after sales service in pursuit of project excellence. The Group’s team ensures absolute quality control over the entire development process through the implementation of a thorough planning, design, construction and marketing process, from concept to completion.

Mirvac’s vision for the building has been clearly articulated by Nick Collishaw, Managing Director, Mirvac Group.

“Our partnering with Bond University to establish the Mirvac School of Sustainable Development is an Australian first. It reflects a long-term investment in the next generation of students who will develop an invaluable understanding of the growing importance of sustainability and will bring that knowledge into the business world.

The students who graduate from this School will be industry leaders in implementing responsible and practical sustainability management initiatives and will help build a national focus on this very important topic.”

General Information about the Site

The building is located at Bond University on the Gold Coast, Queensland. Bond University is set on a 49.86 hectare campus at Robina on Queensland’s Gold Coast.

The original Master Plan and design of the University was developed by Daryl Jackson and Robyn Dyke, Architects and Planners, who designed a number of the University buildings on site, including the Faculty of Business and Law buildings, and the Student and Recreation Centre.

However, in keeping with the international focus of the University, the University Advisory Council appointed Arata Isozaki, a Japanese architect of international repute, who designed the Arch building, which houses the Library and the Faculty of Humanities and Social Sciences in two wings. The West and East Wings are linked by a two storey arch, housing the School of Information Technology and administration offices. The building looks out onto Lake Orr, a man-made lake.

The major axis of all the original buildings is east-west. This is not the preferred orientation for a sustainable approach to design. The design team for the MSSD building had the opportunity to determine the exact site and orientation for the new building within a pre-defined area. So the new MSSD had to re-orientate the axis of the new building to north–south, a much more sustainable approach.
At the time the project commenced in early 2006, South East Queensland was in the middle of a very bad drought, and water supply and security was an issue. As such water conservation and reuse became a critical feature of the building.

On the climatic side of the campus, the climate is subtropical, with a mean maximum temperature of 25.0°C (77°F), a mean minimum temperature of 15.3°C (60°F), and average annual rainfall of 1,428.6 mm (56.2 in).

One of the key figures that Bond University provided early in the design process was that 80% of their spaces are empty 80% of the time. This was a key driving force for a number of elements of the design of the building, particularly how to sense that spaces were unoccupied, and how to shut them down so that unnecessary resource consumption was minimised.

SUSTAINABILITY PROCESS
The process and program for the design, construction and achievement of Green Star Rating took over two and half years (30 months) and the major stages are shown in Table 1.

From day one Bond University embraced sustainable development with a triple bottom-line focus: a main platform of ecological sustainability combined with social and economic sustainability.

The process had a number of key steps. These included:
1. Prework and workshop and site tour
2. Action plan
3. Design analysis
4. GBCA process
5. Documentation
6. Construction
7. Operation

These processes are not based around the typical design and construction phases of concept design, schematic design, detailed design, and construction documentation. The processes are based around the sustainability elements.

Workshop
A two-day workshop was held as the official commencement of the design elements of the project. This workshop was attended by all members of the design team as outlined below.

Client: Bond University
Project Manager: Lattison Pty Ltd
Architect: Mirvac Design
Builder: ADCO Constructions Pty Limited
Sustainability Consultant: Arup
Structural Engineer: Qantec McWilliam Consulting Engineers
Services Engineer: Bassett Consulting Engineers
Hydraulics Consultant: Steve Paul and Partners
Landscape Architect: Aspect Studios Pty Ltd

A key focus for this workshop was defining the sustainability objectives for the project, and then exploring ways of achieving these objectives. Prior to this workshop, a significant amount of background work was done and each attendee was provided with a workshop folder. This folder included 16 case studies of best practice education facilities from around the world, documents on rating tools, articles on sustainable education buildings, and reference materials. These case studies provided a number of benchmarks that guided the design team in the absence of a suitable Green Star rating tool at the time.

| TABLE 1. The Process and Program. |
|-------------------------------|----------------|
| Activity                      | Time Period   |
| Research + Consultant Briefing| Feb 2006      |
| Sustainability and Concept Workshops| March 2006  |
| Design Development complete   | Oct 2006      |
| Construction Documentation commenced| Nov 2006   |
| Site works commenced          | Jan 2007      |
| Green Star Education PILOT released | May 2007  |
| Activity                      | Time Period   |
| Construction commenced        | June 2007     |
| Green Star Round 1 submission | Oct 2007      |
| Green Star Round 2 submission | May 2008      |
| Construction complete         | June 2008     |
| Green Star Education PILOT 6 Star | June 2008  |
| Handover and Occupation       | July 2008     |

Journal of Green Building
The key objective for the building, from day one, was for “a world’s best practice sustainable education facility.” This became the guiding sustainability vision for the whole project. It was critical to define what this meant, how it could be achieved, and how it could be demonstrated to students, prospective students, and the public.

The workshop included a number of design activities; however, the architect refrained from establishing a form for the building for as long as possible. From a sustainability perspective, team members were encouraged to think outside the square, and then get pulled back by practicality, cost, and approvals, rather than to think of BAU and tinker at the edges. One example of this is the water systems, which started as blackwater treatment systems; however, regulations dictated that these be changed to greywater treatment only. Not for want of trying, with numerous workshops held with the local government and state approvals bodies in the effort to have the blackwater treatment system installed. As an aside, even though all water and reduced flow to sewer points in the Green Star system were achieved, Bond’s objective was to push the boundaries.

A site tour was also undertaken to view a number of facilities in Sydney.

Rating Tools
Rating tools were one obvious method of demonstrating and measuring this objective. Five rating tools were investigated in detail:

- Green Star
- LEED
- BREEAM
- TEFMA
- SPeAR®

Each tool had strengths and weaknesses. The most relevant tool was the Green Building Council of Australia’s Green Star rating tool; however, this tool did not address education buildings at the time. This was a key barrier for the project, which will be discussed in detail later in this case study.

Each of these tools was used to provide targets, benchmarks, initiatives, and ideas. A gap analysis of the tools identified that all issues were covered.

Action Plan
A Sustainability Action Plan was developed based on the initiatives identified from the rating tool gap analysis, and ideas from the design team generated at the workshop. This action plan was used to track targets, initiatives, responsibilities, and status of actions. The action plan was utilised and circulated to the design team at weekly design meetings.

Design Analysis
There were a number of steps for analysis of the design from a sustainability perspective. This included a number of workshops, with the entire design team or with specific members such as the architect and services engineers. Formal services reviews were also undertaken at each key project stage.

ADOPTING A BUILDING RATING PROCESS
There was a desire from Bond University to utilise a recognised building rating process to achieve a certified, market recognised system. Green Star is the primary rating tool utilised in Australia.

About Green Star
Green Star is a voluntary environmental rating system for buildings in Australia. It was launched in 2003 by the Green Building Council of Australia. Launched in 2002, the GBCA is a national, not-for-profit organisation that is committed to developing a sustainable property industry for Australia by encouraging the adoption of green building practices. It is uniquely supported by both industry and governments across the country.

The Green Star system considers a broad range of practices for reducing the environmental impact of buildings and to showcase innovation in sustainable building practices, while also considering occupant health and productivity and cost savings.

Nine categories are assessed with the Green Star tools: [1]

- Management
- Indoor Environment Quality
- Energy
- Transport
- Water
- Materials
- Land Use & Ecology
• Emissions
• Innovation

These categories are divided into credits, each of which addresses an initiative that improves or has the potential to improve environmental performance. Points are awarded in each credit for actions that demonstrate that the project has met the overall objectives of Green Star.

Once all claimed credits in each category are assessed, a percentage score is calculated and Green Star environmental weighting factors are then applied. These environmental weighting factors vary across states and territories to reflect diverse environmental concerns across Australia.

The following Green Star Certified Ratings are available:

• 4 Star Green Star Certified Rating (score 45–59) signifies Best Practice in environmentally sustainable design and/or construction.
• 5 Star Green Star Certified Rating (score 60–74) signifies Australian Excellence in environmentally sustainable design and/or construction.
• 6 Star Green Star Certified Rating (score 75–100) signifies World Leadership in environmentally sustainable design and/or construction.

Uncertainty for this Project
When design started, there was no Green Star education tool and as such no certified rating could be achieved. There was an office tool, and guidance was available from this tool on the likely credits that would be included in an education tool. The GBCA advised that an education tool was in development and would be released in the near future. In fact, the PILOT education tool was not released until May 2008, 15 months after design commenced. Before the tool was released a number of key questions were unanswered for the design team as the contents of the Green Star tools is confidential until the PILOT is launched. These included:

• Would there be any new credits in the tool?
• What would the weightings be for new credits?
• What would the key water, energy and flow to sewer benchmarks be?
• When will the tool be released?
• Will we be selected as a PILOT project, as only six are selected nationally?

Without this information, it was impossible to assess the performance of the building, and therefore any additional cost necessary to achieve the necessary “world’s best practice” rating. This also meant that construction would not begin in earnest, as any items constructed either could not be changed, or could only be changed with cost and program implications.

However, Bond University was absolutely committed to achieving a certified rating as a world’s best practice building, and this leadership and vision was fundamental to achieving this target. Even when numerous risks were identified, Bond University remained committed.

BUILDING DESIGN
Design Philosophy
Before pen was put to paper a couple of very intensive workshops with the architects and engineers ventured that the process should not start with creating shapes but with the vision of what was wanted out of the building and where on campus it could be best located—to use cutting edge design and technologies. The shape of other recent additions to campus was known almost from the very start. Indeed, the process from design to construction and handover was fairly linear and expected.

After two months of design work on the MSSD the building’s shape was still unknown. For other buildings, in that time frame the University Council would have had the shape of the building, a budget, and it would have been signed off. It has been a process of working through those kinds of things. It is an expensive building, and the process has been particularly difficult because of the moving six-star green target.

Part of that education tool is that all the offices are the same size. Everybody through assistant professor, associate professor, professor, and tutor to a Ph.D. student all get the same size office; it doesn’t make any accommodation difference when the make-up of the staff changes.

And it is not a large room. That was done first to save space, but the real reason was to provide a comfortable enough space so that occupants could work on their computers or to do what else they needed to do, but not be so comfortable that they did not go...
out of the room and get that interactivity with others. The rooms need to be large enough to be comfortable but, if staff are to engage with other people or with students, they have to go outside into the outdoor-indoor space.

The School is the first designated institute to fully integrate environmental, urban planning, and architectural disciplines with the practical issues of managing financial viability and societal expectations.

The building's optimum orientation maximises solar gain and the capture of prevailing breezes. All offices have operable internal and external windows to promote cross-ventilation, and ceiling fans reduce the demand for air conditioning, a major consumer of energy. When outdoor conditions are optimum the Mirvac School of Sustainable Development utilises a natural ventilation mode; the building's management system senses favourable outdoor conditions and ceases operation of the air conditioning plant, and building occupants open their windows to control air temperature and movement to achieve thermal comfort.

**Summary of Building**

- Double loaded 3 storey building with central corridors on office floors with light wells and natural ventilation, linked “Living Laboratory” learning facility.
- Orientation: Long axis east–west : Optimum orientation to maximise natural daylight and capture prevailing breezes.
- Construction: Lightweight façade.
- Building spaces: 3 studios, 1 CAD/GIS room, 2 research rooms, 32 offices, 4 meeting rooms, 1 living laboratory, covered outdoor teaching and recreation spaces.
Building Systems and Environmental Initiatives

- Multi-split VRV air cooled air conditioning systems to take 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.
- Occupancy and daylight controlled high efficiency lighting (T5) with task lighting in offices.
- Regenerative lift technology that 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.
- Inclusion of 18.375kW PV Cells and 1kW Wind Turbine.
- 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.
- Water efficient equipment, fixtures, and fittings are used throughout the building.
- All systems integrated onto the MSSD BMS, which is connected to the campus wide BMS.
- Provision of an advanced “Living Laboratory” facility where static and active touch panel displays, along with cut-away wall sections will explain how the building works and what the current and historic performance of the building has been. This facility will be used internally by Bond University to complement the curriculum and is expected to attract significant attention from others in the construction industry and broader community with an interest in sustainable buildings.
- 90% of construction waste by weight was reused or recycled.
- Refrigerants with zero ozone depleting potential and minimal global warming impact.
- 30% of cement in concrete was substituted with fly-ash in all concrete to reduce embodied energy.
- Low volatile organic compound paints, carpets, and furniture to improve the indoor environment.
- Office spaces have been designed to standard sizes to minimise waste and over 95% of loose furniture is recycled.
- Extensive cyclist facilities for staff and students.
- The quantity of flows to the Council sewer system have been reduced by 52% compared to a benchmark building.
• Green Star Accredited Professionals provided sustainability advice throughout the design and delivery period.
• Comprehensive pre-commissioning, commissioning, and quality monitoring was performed by the appropriate contractors and subcontractors.
• The design team and the contractor provided information and documentation to the building owner regarding design intent, as-installed details, commissioning reporting and training of building management staff.
• The building will undergo a 12-month commissioning / building tuning period.
• An independent commissioning agent was appointed.
• A Building Users’ Guide is provided.
• Site specific Environmental Management Plan (EMP) for the works in accordance with Section 4 of the NSW Environmental Management System guidelines (1998).
• 90% of construction waste by weight was reused or recycled.
• The building’s environmental attributes are displayed in a manner that can be readily understood by building users.
• A facilities management representative was included on the design team.

TABLE 2.

<table>
<thead>
<tr>
<th>Management</th>
<th>Indoor Air Quality</th>
<th>Energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>• The building was designed for 60% of the UFA to have a 2.5% daylight factor.</td>
<td>• Clare was reduced across the UFA by using shading devices.</td>
<td>• 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 was modelled to produce 19,800 kg CO₂/yr, compared to a benchmark of 113,252 kg CO₂/yr, which is an 82% reduction. 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%. This has been achieved by on-site generation. Highly visible, internal stairs with good daylighting are provided as an alternative to using the lift. Services to each space automatically shut down when not in use. All spaces have individual light switches. Switching is clearly labelled and easily accessible by building occupants. An automated lighting control, including occupant detection and daylight adjustment, is provided.</td>
</tr>
<tr>
<td>• Comprehensive pre-commissioning, commissioning, and quality monitoring was performed by the appropriate contractors and subcontractors.</td>
<td>• High frequency ballasts were installed in fluorescent luminaries over a minimum of 95% of the UFA.</td>
<td>• The facility lighting design provides a maintenance luminaire of no more than 25% above those recommended in AS1680.2.3 for 95% of the UFA.</td>
</tr>
<tr>
<td>• The design team and the contractor provided information and documentation to the building owner regarding design intent, as-installed details, commissioning reporting and training of building management staff.</td>
<td>• The facility lighting design provides a maintenance luminaire of no more than 25% above those recommended in AS1680.2.3 for 95% of the UFA.</td>
<td>• All of the UFA has a direct line of sight to the external environment.</td>
</tr>
<tr>
<td>• The building will undergo a 12-month commissioning / building tuning period.</td>
<td>• Thermal comfort levels for the as-built design of the UFA have been assessed and used to evaluate appropriate servicing options.</td>
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</tr>
<tr>
<td>• An independent commissioning agent was appointed.</td>
<td>• A Predicted Mean Vote (PMV) level of between −1 and +1, calculated in accordance with ISO7730 (or equivalent using Draft ASHRAE Comfort Standard 55 and “Developing an Adaptive Model of Thermal Comfort and Preference—Final Report on ASHRAE RP884”) has been achieved during Standard Hours of Occupancy and using standard clothing, metabolic rate, and air velocity values for 98% of the year.</td>
<td>• A Predicted Mean Vote (PMV) level of between −1 and +1, calculated in accordance with ISO7730 (or equivalent using Draft ASHRAE Comfort Standard 55 and “Developing an Adaptive Model of Thermal Comfort and Preference—Final Report on ASHRAE RP884”) has been achieved during Standard Hours of Occupancy and using standard clothing, metabolic rate, and air velocity values for 98% of the year.</td>
</tr>
<tr>
<td>• A Building Users’ Guide is provided.</td>
<td>• Every enclosed office is provided with individual control of its air supply rates and air temperature.</td>
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</tr>
<tr>
<td>• Site specific Environmental Management Plan (EMP) for the works in accordance with Section 4 of the NSW Environmental Management System guidelines (1998).</td>
<td>• Every enclosed office has openable windows.</td>
<td>• Every enclosed office has openable windows.</td>
</tr>
<tr>
<td>• 90% of construction waste by weight was reused or recycled.</td>
<td>• The building services noise level meets the recommended design sound levels provided in Table 1 of AS/NZS 2107-2000.</td>
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</tr>
<tr>
<td>• The building’s environmental attributes are displayed in a manner that can be readily understood by building users.</td>
<td>• 95% of all paint, adhesives, sealants, carpets, and other floor finishes, are low-VOC emitting.</td>
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</tr>
<tr>
<td>• A facilities management representative was included on the design team.</td>
<td>• 95% of all tables, chairs, and desks are recycled.</td>
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<tr>
<td>• •</td>
<td>• No composite wood products were used in the project.</td>
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(continued on next page)
### Transport
- The number of car parking spaces provided on the site was significantly reduced.
- All parking spaces are designed and labelled for small cars.
- The parking space is dedicated solely for use by carpool participants, hybrid or other alternative fuel vehicles.
- Secure, undercover storage is provided for 10 student bicycles.
- Lockable, undercover storage is provided for 5 staff bicycles.
- Showers, changing facilities, and lockers are provided for cyclists.
- A dedicated, well lit, and signposted pedestrian route, linking the site to public transport nodes and other nearby amenities is provided.

### Materials
- A dedicated storage yard is provided for the separation, collection and recycling of office consumables.
- The concrete used in the building construction has 30% of cement replaced with an industrial waste product.
- The total PVC content cost for major services elements was reduced by more than 60% (by cost) by replacing PVC with alternative materials.
- All timber products used in the building and construction works were sourced from either post-consumer reused timber or Forest Stewardship Council (FSC) certified Timber.
- The flooring used in the project has a reduced environmental impact.
- 95% of the joinery (by area) used in the project is new and has been designed to be modular and easily disassembled for future reuse.
- Loose furniture used in the project has a reduced environmental impact by being recycled from other parts of the University.
- In excess of 50% (by area) of the structural framing, roofing, and façade cladding systems are designed for disassembly.

### Emissions
- 95% of all HVAC refrigerants in use have an Ozone Depletion Potential (ODP) of zero and the specified thermal insulation does not use ozone depleting substances in both manufacture and composition.
- All stormwater leaving the site, at any time up to a 1-in-20 year storm event, is treated/filtered.
- The development does not increase peak stormwater flows for rainfall events of up to a 1-in-2 year storm.
- The outflows to the sewerage system due to building occupants' usage have been reduced through the use of an on site grey water treatment system. The annual flow to sewer from this building has been reduced by 52%.
- No light beam is directed beyond the site boundaries or upward without falling directly on a surface with the explicit purpose of illuminating that surface.
- There are no evaporative heat rejection systems in the project.

### Land Use and Ecology
- The development site is neither prime agricultural land nor land on or within 100m of a wetland.
- The ecological value of a development site was enhanced beyond its previously existing state primarily through the inclusion of an artificial wetland.
- Cut and fill were balanced on the campus and there was no exportation of topsoil from the immediate site.

### Water
- The potable water consumption in the building has been reduced by using water efficient fixtures/fittings, and by using rainwater and recycled water.
- Water meters have been installed for all major water uses. Meters are linked to the Building Management System to provide a leak detection system.
- All of the water requirement for landscape irrigation is sourced from rainwater and recycled water collected on site.
- No water-based heat rejection system is used.
- Temporary storage has been provided for fire protection system test water and maintenance drain-downs for reuse on-site.

### Innovation
- Innovation points awarded by the Green Building Council of Australia were:
  - For exceeding the benchmark PVC minimisation, with 96% achieved compared to a best practice benchmark of 60%.
  - For exceeding the benchmarking for learning resources, with the self-guided tour and living laboratory described below going above and beyond the Green Star requirements.
  - For the installation of a regenerative drive lift in a university building, with a multi-function meter linked to the living laboratory display and educational screens.
LEARNING ELEMENTS
The ability of the building to provide learning was a critical objective of the design. This is achieved in two key ways. The first is through the living laboratory, and the second is through the self-guided tour.

The Self-guided tour is a 13 station guide to the building that explains each of the sustainability aspects of the design and construction of the building. Additional features include the water treatment plant behind glass doors, which allows everyone access to view the plant and see the different components and how everything is working. This tour is all accessible at ground level at all times, for the community to be able to access it.

One of the stations on the tour is the Living Laboratory which is a major feature itself. This is a separate building available for use by the community and Bond classes to learn about sustainability. The key feature is two touch screen TVs linked into the BMS that feed live building information to users. This includes:

- Energy consumption, broken down per meter, which includes lighting and power separately for each level, lift energy, and greywater treatment energy.
- Energy generation by the wind turbine and PV cells.
The panel below is an example of one of the self guided tour stations. This outlines the water strategy for the building which includes rainwater capture and greywater treatment and reuse. © Bond University.

12 Water Management

- Water consumption.
- Water storage in tanks.
- Water treatments.
- Data from the rooftop weather station.

KEY LESSONS LEARNED AND SUCCESSES

A number of key lessons were learned during the Bond University Mirvac School of Sustainable Development project. Bond University wants others to learn from the successes and mistakes of the building, realising that this is fundamental to sustainable design.

These are outlined below.

Sustainable design is integrated design

One of the most fundamental lessons that was reinforced during the building was that sustainable design is integrated design. Numerous workshops and weekly design meetings aided in team communication; however, there were still situations where communication could have been improved. A proactive client and project manager were critical to effective communication. Additionally, there is a need for all disciplines to allow for the additional design time and interaction required to achieve a world’s best practice building.

Whilst a site office was not established for this project, and is not the norm for building projects in Australia, there are potentially significant design, cost and clash benefits to be reaped by facilitating and forcing maximum interaction between disciplines.

Rating tools

The use of the Green Star tool to deliver a formal, third party certified rating of the building has provided Bond University with significant benefits. This includes the ability to clearly communicate with industry and the market. This was a relatively expensive exercise for a small building such as the Bond University MSSD, with the administration and documentation costs being similar for a project of this size and a $100M+ project where the economies of scale are significantly improved.

Arup have also been involved in a number of projects that use the Green Star tools as a framework,
without seeking formal certification. In addition to not being able to market this rating, in our experience the building does not achieve the same level of performance with a certified rating, as the detail and initiatives are not always implemented and assessed with the same level of thoroughness.

In saying this, whilst it was frustrating, and costly, to proceed before the tool was released, and to work through the PILOT tool, there were benefits to this process. This included the fact that design initiatives were not just included to chase points. As the team had 15 months of design before the tool was released, each feature had to be identified and thoroughly analysed to justify its inclusion in the building.

For any tool that looks to use a rating tool, it is possible to achieve the best of both worlds. The

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2. Living Lab: information and building tour.
3. Cyclist facilities: for staff and students. Staff have lockers and showers.
4. Sun, glass, and light: ventilation, orientation, day light, glazed windows, shading, glass type.
5. Ecological Finishes: acoustic screen, partitions, ceiling tile, VOCs.
6. Photovoltaic Cells: 18kW to generate 13,500kWh per year.
8. Services: generator, BMS, MSB, fire room, riser, weather station, plant rooms.
9. Regenerative Drive Lift: generates electricity on the descent.
ability to cross check against the desired tool early in design, as well as to “park” the tool and analyse options for actual practicality and outcomes, is a perfect situation.

Regulatory Approvals
Due to the international nature of this journal, this case study hasn’t dealt in detail with local details of approvals. It should be noted, however, that the process of seeking to change the playing field and set new benchmarks, particularly around water treatment, provided Bond University with a number of benefits. This included a leadership position on the issue within Australian education facilities, as well as within the Gold Coast region. It also provided the project with confidence that the default position of greywater treatment would be approved as opposed to the desired blackwater treatment.

The original water strategy for the building included blackwater treatment and reuse with the building drawing no mains water except during long droughts. Regulatory barriers prevented the implementation of this strategy. © Bond University.

The project team, and Bond University, would encourage other projects around the world to challenge the status quo. Don’t assume that things won’t be approved. Someone has to move first and ask the questions.

Engaging Students and the Community
A number of members of the design team have been involved in the building use and operation. Arup gave guest lectures on the building as part of the Sustainable Construction Course. A number of subjects taught in the building utilise it for assignments. Design team members have been contacted by students with initiative to provide input and information to master’s assignments. Bond University also uses the building for a number of Master and Ph.D. projects.

Additionally, tours of the building have been very popular, with a number of post-graduate students...
trained to give tours of the building. The demand has been so high that an online booking system has been established, and up to a school group a week is going through the building and teaching primary and secondary school students about sustainable design and development.

**Operational Performance**

Operationally, the building has had a number of teething issues. This is not surprising given it includes a number of new technologies and is a world’s best practice sustainable building. Throughout the operational issues, the building has still been fully operational.

**Mixed mode**

Staff and users are adapting to the requirements of a sustainable building. The staff are now becoming familiar with a building that is not passive and that needs "driving" to make it provide the necessary conditions for activities to take place. For instance, occupants have to turn on their office or teaching space to provide the necessary comfort and lighting conditions for those activities to take place. If the spaces are not keyed in, then the space remains inert and does not use wasteful energy. In fact, the building and the occupants now work as a team to minimise energy use whilst maximizing comfort conditions.

A number of complaints were made about the temperature of the building during the early phase. Whilst a building user’s guide was developed and distributed explaining the design intent of the building and how each system operated, there were still a number of people who were uncomfortable.

For example, in August 2008, a few months after the building had been opened; there were a particularly cold few days. During this time, the naturally ventilated corridor was cold, in the order of 12–13°C. A number of complaints were raised. These complaints were satisfied through providing the occupants with the average temperatures, which for that time of year is a daytime figure of 21°C. This information was sufficient to satisfy occupants that the design was not flawed, explaining that there would be a few days in summer when the corridors were particularly hot, and a few days in winter when they would be particularly cold.

There has also been good feedback. Discussions with one staff member identified who had used the air conditioning in his office only once during the year. This was during winter. During summer the conditions were comfortable enough with windows open and the ceiling fan operating. This is far above the modelled comfortable conditions for thermal comfort and demonstrates how variable personal thermal comfort is.

**Energy Performance**

The figures below identify the actual energy performance compared to the modelled performance of the lighting and HVAC systems. These figures demonstrate that the building modelling undertaken in line with the Green Building Council modelling protocols provided accurate figures, even for a complex mixed-mode building such as the MSSD. There are a number of broader studies underway in Australia on the actual performance of Green Star buildings, and these studies are likely to provide further guidance on the issue of building modelling and usage estimation.

<table>
<thead>
<tr>
<th></th>
<th>Modelled Annual Figure (kWh)</th>
<th>First 12 months of operation (kWh)</th>
<th>Difference (kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lighting</td>
<td>17,540</td>
<td>20,076</td>
<td>2,536</td>
</tr>
<tr>
<td>HVAC</td>
<td>31,613</td>
<td>32,088</td>
<td>475</td>
</tr>
</tbody>
</table>

**BENEFITS TO BOND UNIVERSITY**

Bond University has obtained a number of benefits from achieving a world’s best practice sustainable education facility.

These include:

- A calculated financial payback of nine years on the additional investment in the building above business as usual. This does not allow for expected increases in utility costs which will see the payback reduce to in the order of five years.
- Marketing to attract students nationally and internationally.
- Partnerships with overseas universities in the UK and the UAE.
- Partnership with the development of sustainable codes in the Middle East.
- Corporate change-driven engagement in the university and the establishment of a University Committee driving campus-wide sustainability.
• Retrofitting of the university using experiences gained in the development of the building.
• Learning facility, with numerous subjects including lectures, tours, or assignments on the building, which are in addition to the use of the facility for teaching purposes.
• A number of awards have been given to the building including:
  – Green Star Education PILOT 6 Star World’s Best Practice rating.
  – Winner of the prestigious 2009 Royal Institution of Chartered Surveyors (RICS) “Sustainability Awards.”
  – 2009 Queensland Environmental Protection Agency Sustainable Industries Award “Sustainability in the Built Environment Award.”
  – 2009 Queensland Regional Architecture Awards “Sustainable Architecture Award.”
  – 2009 Queensland State Architecture Awards “Sustainable Architecture Award.”
  – Gold Coast City Council–2009 Urban Design Awards, Award of Excellence in Urban Design and the People’s Choice Award.

CONCLUSIONS
The development of the Bond University Mirvac School of Sustainable Development building has achieved all of the original objectives which include:
• Providing first class accommodation for both staff and students.
• Providing a world class example of what can be achieved in designing and building a true triple bottom line sustainable building.
• Providing an opportunity for Bond University students at large to appreciate triple bottom line sustainability, while at the same time providing a platform for community engagement in sustainability by the use of the living laboratory. The building’s environmental attributes are displayed in a manner that can be readily understood by building users. These are presented in thirteen information stations located at key points around the building and are part of the building tour conducted by staff in the school. The building tour aims to educate students and visitors about the ecologically sustainable attributes incorporated into the design and construction of the Mirvac School of Sustainable Development.
A site tour map that outlines the viewing stations for each of the sustainability attributes is available from the living laboratory. The tour leads students through the site to strategically located viewing stations. Information boards are located at each viewing station enabling students to learn about the sustainability attributes and their effect on the surrounding environment.
• Providing a platform to launch the University Mirvac School of Sustainable Development on the world stage by conducting tours for international visitors and organisations pursuing sustainability, including a delegation from the Masdar project in Abu Dhabi.
• Providing a unique teaching environment for students of the school and allowing the development of a unique suite of subjects in sustainability due only to the way the building was designed and built (interactive data display in the living laboratory).
• Providing an opportunity for school students to engage on local, national, and international “real world” projects in sustainability due to the international recognition of the building and the school’s unique curriculum.

This article provides a case study of the sustainability journey of the Bond University Mirvac School of Sustainable Development (MSSD) building, with a particular focus on the use of the Green Building Council of Australia Green Star Education PILOT tool.

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• Bond uni living lab article
• Mirvac website