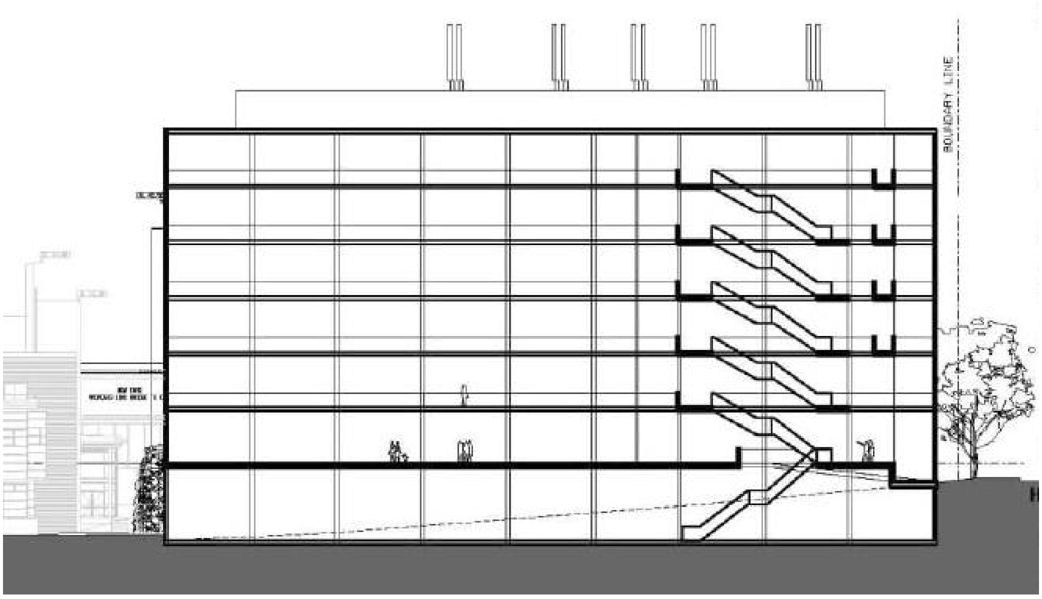

ECOLOGICALLY SUSTAINABLE DEVELOPMENT REPORT

ISSUE

WESTMEAD MILLENNIUM INSTITUTE AND WESTMEAD RESEARCH HUB

15 JULY 2010

ARUP

Revision	Date	Filename	0001_ESD_Part_3A_draft_WMI_arup_240510.pub		
Draft 1	24/05/2010	Description	First draft		
			Prepared by	Checked by	Approved by
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Revision	Date	Filename	0002_ESD_Part_3A_issue_WMI_arup_150710.pub		
Issue	15/07/2010	Description	Issue		
			Prepared by	Checked by	Approved by
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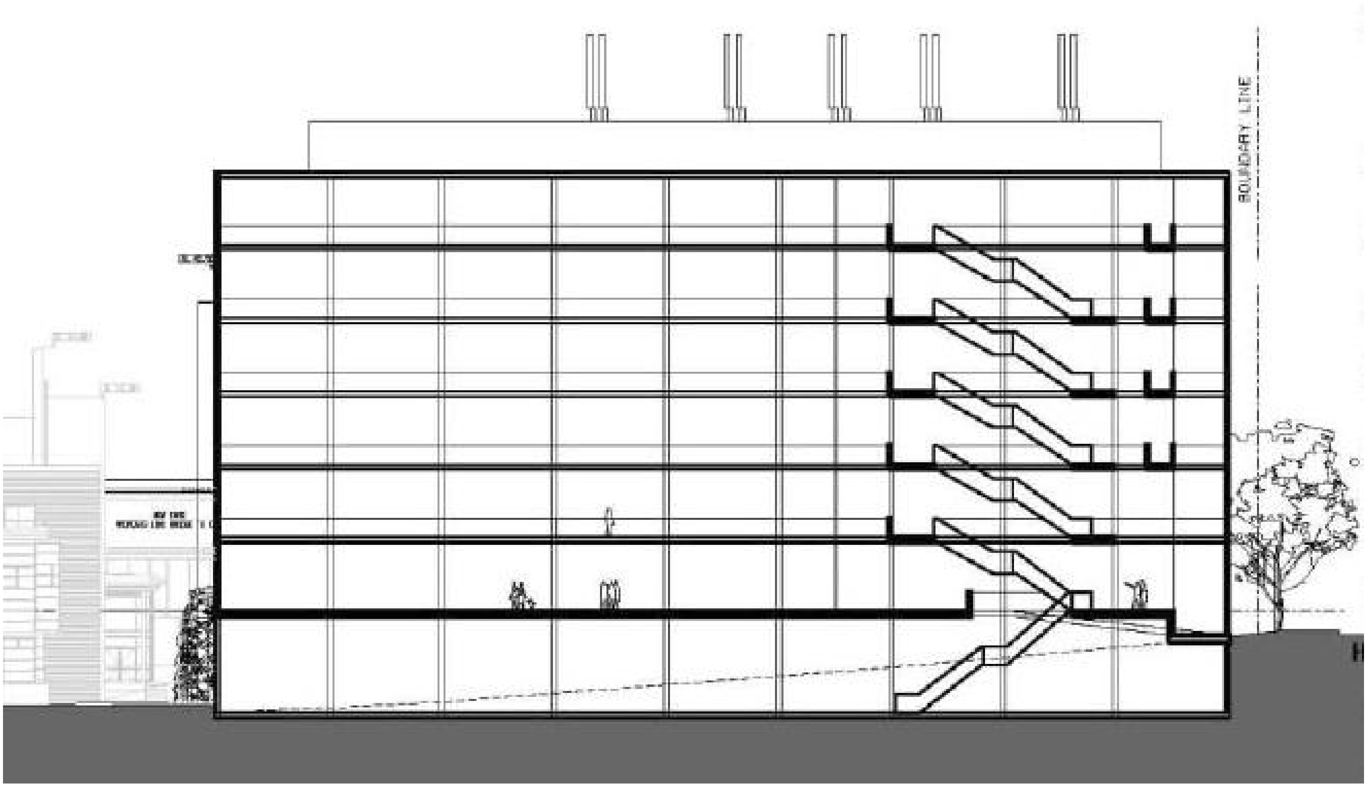
1.0 EXECUTIVE SUMMARY



North-South Section (IMAGE: Courtesy BVN Architects)

The Westmead Millennium Institute and Westmead Research Hub's proposed new laboratory building on the Westmead campus will consist of a first phase of approximately 15,000m² of laboratory, office and support space. The building will be designed with best practice sustainable design strategies that balance energy efficiency, water conservation, good indoor air quality, and operational and maintenance cost-effectiveness.

INTRODUCTION

This report has been prepared by Arup to provide input for the Part 3A planning application submission for the Westmead Millennium Institute and Westmead Research Hub research laboratory proposed for the Westmead Hospital campus on Hawkesbury Road in Westmead.

The report addresses Ecologically Sustainable Development (ESD), with input on mechanical and electrical building services. The report summarises initiatives under consideration by the design team to reduce environmental impacts caused by the design, construction and operation of the proposed development, aiming at high levels of environmental performance. It also benchmarks the building against international case studies of similar laboratory buildings, resulting in clear and meaningful energy targets the team is committed to achieving.

The design will focus on creating a highly energy efficient precinct that takes maximum advantage of the Sydney region's climatic conditions for creating efficient, comfortable public spaces and buildings within the site. The development is based on the construction of a new contemporary laboratory facility and associated support facilities, with one level of underground parking. It is proposed to include a combination of environmental strategies, including an internally daylit atrium, a rainwater collection and reuse system, alternative transport amenities and parking, and the creation of significant new public spaces for the Westmead campus.

The design of the Westmead laboratory will aim to achieve the following:

►A minimum 4 Star Green Star Design rating based on the Green Star Education v1 rating tool as customised for laboratory design in coordination with the Green Building Council of Australia;

►Generation of at least 20% of the building's energy demand through alternative means, including solar photovoltaics, wind, gas or bio-fuel; and

►A target 20% reduction in annual energy consumption when compared to the average energy consumption of similar laboratory buildings throughout the world.

The design targets include high levels of indoor environmental quality, environmentally low-impact materials, and efficient water and waste management. These targets are directed at reducing environmental impacts for the whole life cycle of the laboratory.

2.0 MANDATORY CODES AND STANDARDS

The sustainable design strategy for the Westmead laboratory will comply with all applicable codes and standards as outlined below.

MANDATORY CODES AND STANDARDS

TS-11

The NSW Government and NSW Health developed the *Engineering Services and Sustainable Development Guidelines Technical Series TS11* (Version 2.0, December 2007) to address the design and construction process of public health care facilities in NSW. These guidelines address a full range of services, including mechanical, electrical, hydraulics, and communications, as well as including an overview of good sustainable design practice. These guidelines refer to other documents, as well, such as the Environmental Performance Guide for Buildings (EPGB).

The key objectives of TS11 are to design a building that results in the following:

- ►Achieve a minimum 4 Star Green Star rating, using either the Green Star Health Care rating tool or the most appropriate Green Star tool;
- ►Generate at least 20% of the total building's electricity demand from alternative energy sources, such as bio-fuels, solar photovoltaics, wind, or gas;
- ►Create a comfortable and healthy indoor environment (in terms of thermal comfort, visual comfort and indoor air quality);
- ►Minimise non-renewable resource consumption (e.g. energy, water) and environmental impacts (e.g. greenhouse, other air and water emissions, solid waste);
- ►Provide a building that is cost-effective over its whole life cycle.

These objectives will inform the sustainable design of the laboratory. One of the key requirements of TS11 is to establish early on and consistently report the sustainability objectives throughout the design process.

BUILDING CODE OF AUSTRALIA—SECTION J

Section J of the BCA 2010 outlines basic energy efficiency standards that many buildings in Australia must meet. The Westmead laboratory will include a mix of Class 5, Class 7a, and Class 8 spaces, all of which would be designed to comply with the requirements of Section J. The design of the development will not only meet Section J's requirements for energy efficiency, but will also target to exceed these requirements.

3.0 VOLUNTARY RATING TOOLS AND GUIDELINES

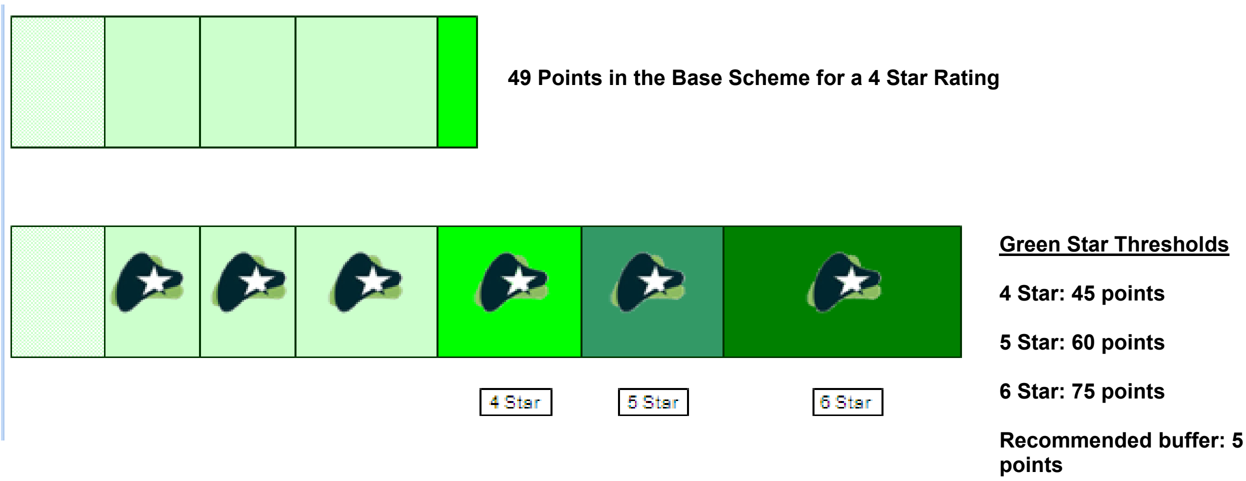


FIGURE 3.0 This graph shows the current base scheme's Green Star target of 4 Stars, or 49 points. This would comply with the recommendations of NSW Health's TS11 guidelines. The project may consider pursuing a 5 Star rating or higher given other considerations during the detailed design phase.

There are several voluntary green building rating tools and guidelines that have been developed to address laboratory design, each of which are discussed in the following section. The approach to benchmarking for this project is to identify the most relevant rating tools to healthcare and laboratory spaces and apply the concepts where applicable, with the overall objective being the achievement of a formal Green Star rating for the building.

GREEN STAR

It is proposed that the design of the Westmead laboratory will aim to achieve the following:

►A minimum 4 Star Green Star Design Education v1 rating provided by the Green Building Council of Australia.

The Green Star rating schemes are voluntary holistic sustainable design rating tools which have been set up and are managed by the Green Building Council of Australia. These tools are used to guide the design process, and address a wide spectrum of environmental performance measures dealing with social, economic, and environmental issues. Green Star tools target performance levels in the general areas of water, waste, IEQ, management, energy, emission and transport and with specific targets for medical equipment and trade waste pollution.

A preliminary Green Star matrix can be found in the Appendix of this report.

The *Engineering Services and Sustainable Development Guidelines TS11* recommends that all NSW Health projects costing over $10 million achieve a minimum 4 Star Green Star Health Care rating. While the Health Care rating tool is applicable to buildings that include patient care and typical hospital functions, it is not applicable to research laboratories. The Green Buidling Council of Australia, which administers Green Star, has recommended adopting the Education rating tool instead. This is explained in the following section:

3.0 VOLUNTARY RATING TOOLS AND GUIDELINES

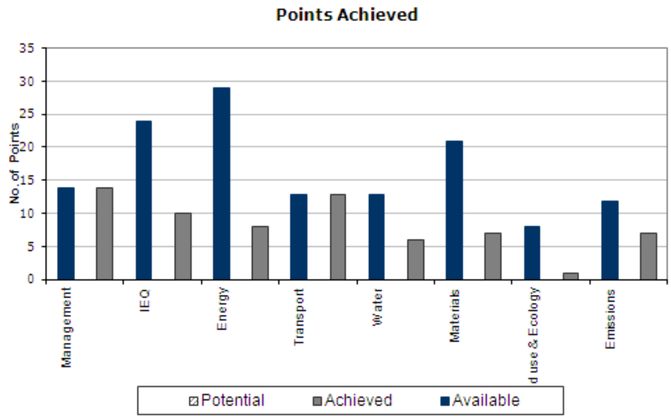


FIGURE 3.1 This chart summarises the points targeted for each category based on the spreadsheets on pages 8 and 9, using Green Star Education v1.

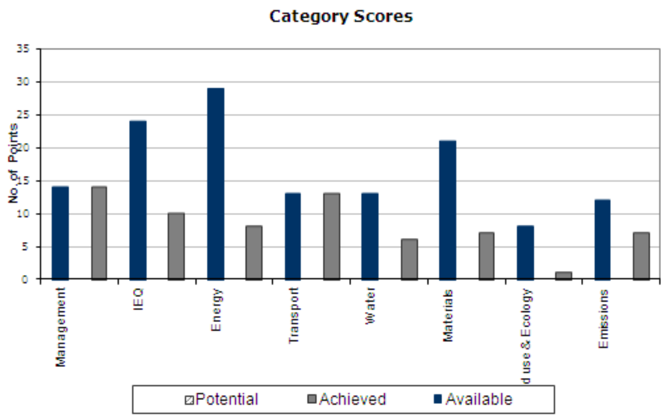


FIGURE 3.2 This chart summarises the category scores based on the spreadsheets on pages 8 and 9, using Green Star Education v1.

Using Green Star Education v1 in lieu of Green Star Health Care

Currently the Westmead laboratory will be comprised of Class 5, 7a and 8 spaces according to the BCA 2010. While there are individual Green Star tools which rate these BCA classifications, they all have required area proportions which are not met by the project. In this case, the GBCA has advised projects such as Westmead to pursue a formal certification by using the Green Star Education tool, which can be modified through Credit Interpretation Requests (CIRs) to account for laboratory-specific design requirements. This will be a hybrid approach, where the project may use the Green Star Education tool for most of its credits, but propose an alternative compliance path for credits that don't apply, such as the Energy (Ene-1) credit for annual energy consumption. The GBCA is developing a so-called custom tool for rating buildings that don't directly comply with specific rating tools, but this is currently not available. It may be that the project will use the custom tool if it is released prior to detailed design.

LABS 21

The most comprehensive lab benchmarking program underway—Laboratories for the 21st Century (www.labs21century.gov)—is in the United States, although many international projects have relied on the program. A joint venture between the U.S. Government's Department of Energy and the Environmental Protection Agency and recently expanded to the U.K., the Labs21 program has collected information on hundreds of new laboratory buildings in public, private, and institutional sectors to cre-

3.0 VOLUNTARY RATING TOOLS AND GUIDELINES

ate a benchmarking database for a variety of metrics. The energy metrics are based on the American Society of Heating, Refrigerating, and Air Conditioning Engineer's Standard 90.1-2004 Energy Efficiency in Buildings (ASHRAE 90.1).

The approach to lab design contained within Labs21 will allow the design team to set realistic energy benchmarks to an agreed set of perimeters, providing a design target that can be measured against throughout the design phase. It has been determined that the Westmead project cannot participate as a Labs21 pilot, since it's a foreign project, but the Labs21 program can still be used as a guideline for design.

LEED HEALTH CARE

The United States Green Building Council produces a suite of tools called LEED, which is a third-party certification program and an internationally accepted benchmark for the design, construction and operation of high-performance green buildings similar to Green Star. The LEED program includes a specific health care system that mostly addresses acute care hospital design, however there are many worthwhile credits and benchmarks included in the program. For the Westmead project, however, LEED is considered within the context of two other relevant tools—the Green Guide to Health Care (listed below) and LABS 21 (explained above).

GREEN GUIDE TO HEALTH CARE

The Green Guide to Health Care is a voluntary, self-certifying metric toolkit of best practices used to guide and evaluate progress towards high-performance healing environments.

The tool was developed in collaboration with LEED by health care design and industry experts. Many of the concepts outlined in this tool translate well to the Westmead project. The goal of providing superior indoor air quality, a fundamental requirement for health care facilities, by eliminating most carcinogenic indoor emissions is one that is particularly appropriate for a world-class research laboratory. Strategies from the Green Guide will be used to inform the design of the Westmead laboratory.

NABERS ENERGY

The NABERS Energy program, formerly known as the Australian Building Greenhouse Rating (ABGR), is widely recognised for energy emissions rating. It was born from the perceived need to encourage existing buildings to reduce their energy-related impact on the environment. The scheme rates a building's Green House Gas (GHG) emissions, which lead to global warming compared to other buildings.

Currently NABERs provides rating schemes for commercial, residential, retail buildings and hotels and is developing a tool for health care. However, achieving a NABERs rating for the project will not be a key goal. The design team will track the progress of the NABERS health care tool as it is developed and otherwise strive to incorporate the program's key goal of reducing operation energy consumption as a fundamental design target if possible.

4.0 HEALTHY PLANNING AND ENGAGEMENT

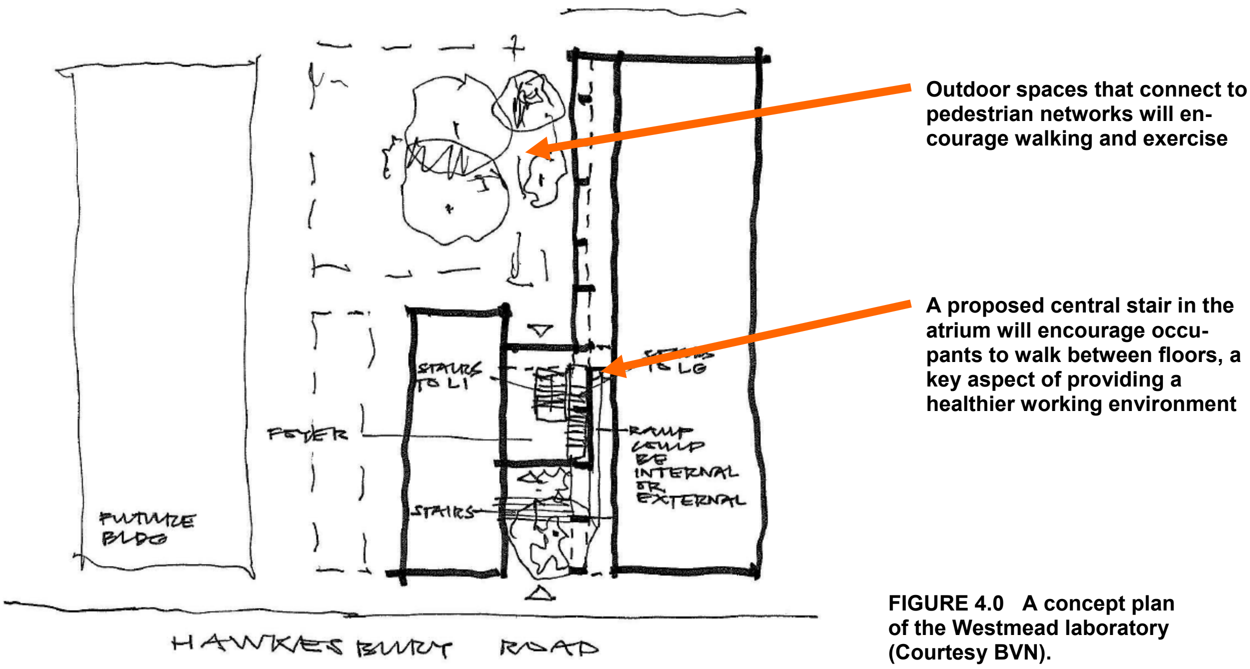


FIGURE 4.0 A concept plan of the Westmead laboratory (Courtesy BVN).

HEALTHY PLANNING

There are clear links between sustainability and health. By virtue of addressing the triple bottom line–social, environmental and economic–healthy and sustainable outcomes can be achieved. The sustainability strategy for the Westmead laboratory will seek to ensure that the design supports physical activity and does not contribute to 'urban obesity-promoting environments' both within the site and its precinct by incorporating the design principles espoused by the Department of Health and Ageing's *Healthy Spaces and Places* program and others deemed appropriate. Such approaches may include a wayfinding strategy from public transport nodes to the building which identifies the number of calories that have been burnt by walking from one point to another. The current proposed design for the laboratory also includes a central atrium with a stair that will encourage occupants to walk between floors.

COMMUNITY ENGAGEMENT AND BENEFIT

The development of the Westmead laboratory will consider stakeholder—both community and occupant—feedback. The project will be a highly visible building with linkages to the Westmead Children's Hospital and other hospital facilities on the campus. The design and consultant team will also consider how the building's design and performance can be shared with the wider community, either through reporting building performance data or sharing lessons learned with peer laboratories and universities.

The project design, consultant, client and maintenance team will be fully integrated so that all members can participate in the development of the project. The design process will formally recognise this integration and provide mechanisms to ensure it is consistently incorporated. An overall lifecycle cost evaluation will be made at the strategic and system level to gauge feasibility of a design response.

5.0 CLIMATE CHANGE

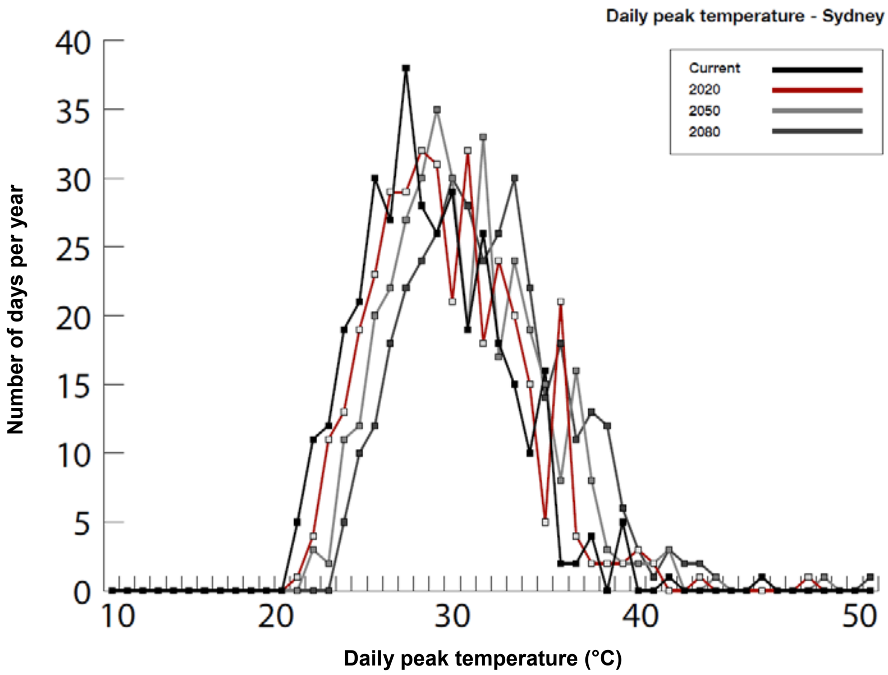


FIGURE 5.0 **Arup has morphed existing climate data for Sydney to gauge potential temperatures in the future based on climate change models recognised by the Intergovernmental Panel on Climate Change. The graph above indicates that Sydney will experience a significant increase in the number of hot days each year. By 2080, for example, there would be expected to be twice as many days where the temperatures reach above 40°C than occurs in 2050.**

CLIMATE CHANGE

The Westmead Millennium Institute and Westmead Research Hub recognise that the project must be flexible and adaptable so it can respond to changes in the Sydney climate expected in the next 30 to 100 years, based on the design life of the building. Daily peak temperatures in Sydney are expected to increase in both intensity and occurrence in the next 70 years as illustrated in the figure above.

The design will address how the building will contribute to the heat island effect of Westmead and Parramatta, respond to increased flood risk where appropriate, provide for comfortable pedestrian access to and through the site, and reasonably accommodate occupants in instances where mechanical ventilation systems may fail to deliver comfort conditions. Consideration will be given to microclimate conditions at the ground plane and the effect of the building on surrounding public spaces through the creation of sun and shade spaces, shelter (wind and rain), calm and active spaces, and spaces that avoid wind funnelling and turbulence.

6.0 BENCHMARKING

The Westmead Millennium Institute and Westmead Research Hub are committed to delivering a facility that achieves a reduced environmental impact and a high level of occupant satisfaction when viewed in the context of similar laboratory buildings both in Australia and internationally. The project will target a formal green building certification through the Green Building Council of Australia, but also recognises the need to address global best practice performance benchmarks for buildings of the same typology. As a result, a review of all available tools and case studies was undertaken to aid in defining baseline performance benchmarks the design team will seek to achieve for the laboratory.

REVIEW OF INTERNATIONAL CASE STUDIES

In the absence of a specific laboratory tool for environmentally rating buildings in Australia, a review of international case studies and rating tools has been undertaken in order to aid in the establishment of benchmarks for the project. This review included the USA-based Laboratories for the 21st Century program (Labs21), developed by the U.S. Department of Energy and the U.S. Environmental Protection Agency, to specifically benchmark and improve the energy and environmental performance of laboratory buildings. Labs21 is an internationally recognised program that provides designers with benchmarking data for annual energy consumption in the context of laboratory type, climate and ratios of lab to office space. Arup has based its benchmarking exercise on this data and combined it with other data compiled independently through experience and in publicly available media.

The Labs21 program also includes design strategies and targets based on the U.S. Green Building Council's LEED rating tool. Many of these same strategies—such as recycled content in materials, reduction in potable water use—have already been adopted into the proposed design of the Westmead laboratory.

The following sections outline the benchmarks established in the areas of energy, water, materials, waste, transport, and indoor environmental quality that the design team will seek to achieve for the project. In some instances, the design team would expect to exceed the performance requirements of these benchmarks, while the team also recognises that some benchmarks may not be met due to unforeseen issues that can only be addressed during the detailed design phase.

6.0 BENCHMARKING

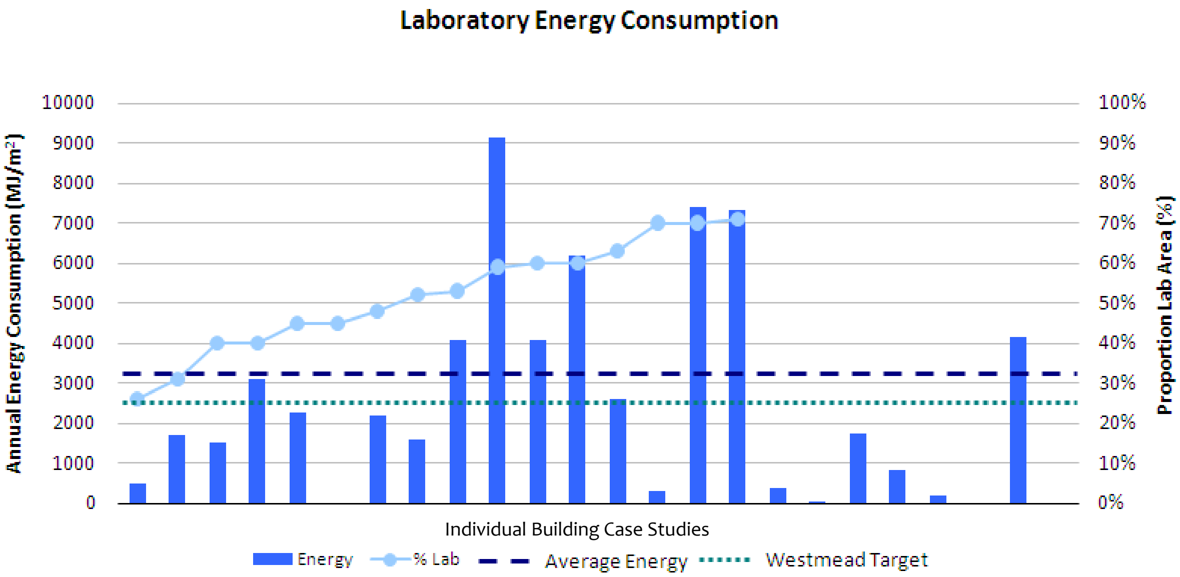


FIGURE 6.1 Annual energy consumption for 23 laboratory buildings with comparable conditions to the Westmead laboratory, using published energy data provided by the building owners.

Energy and Greenhouse Gas Emissions

Benchmarks:

- *Maximum Annual Energy Use (design): 2500MJ/m²*

Data was gathered on the energy consumption of several laboratory buildings and educational buildings containing laboratory facilities. The graph above shows the total annual energy consumption of each building (MJ/m^2) in relation to the proportion of laboratory space in the building. The two horizontal lines show the Westmead annual benchmark as an approximate 20% reduction in comparison to the average annual energy consumption of the data collected.

The design of the Westmead laboratory will target this 20% reduction through a combination of passive design strategies like building shading, as well as through the installation of efficient equipment and systems. This will significantly decrease the project's greenhouse gas emissions.

Water

Benchmarks:

- *Maximum Annual Water Use (design): 65L/m²*

For regional context, Green Star Education v1 was used to provide an design potable water consumption benchmark. Following this, a review of water consumption data for other buildings of similar typology was undertaken to confirm that this benchmark is an improvement on international best practice. Further to this, benchmarks have been established for the specific technologies that will be implemented to reduce potable water consumption as follows:

- *Target Rainwater Collection: 90%*

6.0 BENCHMARKING

- *RO Water Plant Waste Water Reuse: 100%*

These recycled water benchmarks will be needed to achieve the overall water use benchmark. Based on a comparison to the NABERS Water rating program for office buildings, if the Westmead laboratory achieves its water use benchmark, it would approximately equate to a 5 Star rating in operation. This would be a significant achievement for a laboratory building.

Materials

Benchmarks:

- *PVC Reduction: 60% by cost*
- *Mercury: No mercury or low-mercury lamps specified*
- *Copper: No copper solders for stormwater systems*
- *Cement Replacement Target: 60% for in situ, 40% for precast, and 30% for stressed concrete*
- *Recycled Concrete Aggregate: 20%*
- *Recycled Steel: 90% of all steel to contain at least 50% recycled content*
- *Certified Timber (by cost, based on all timber on project): 95%*
- *Low TVOC content: 95% of all paints, carpets, sealants, and adhesives*
- *Composite timber products: To be E0 or contain no formaldehyde*

Benchmarks for materials to be used in the construction of the project have been guided by the Green Star Education v1 tool. A review of international case studies revealed that these benchmarks align with international best practice design for educational and laboratory facilities. The benchmarks stipulated for materials address issues of recycled content of materials, recyclability of materials, embodied energy, and toxicity of materials both in production and application.

Waste

Benchmarks:

- *90% diversion of construction and demolition waste from landfill.*

The benchmark for waste diversion from landfill includes both demolition and construction waste. The Green Star tools award 80% waste diversion as best practice. After a global review, it was found that the average waste diversion rate for similar buildings was slightly above 80%. The benchmark was therefore reviewed and set at 90% for the Westmead laboratory.

Indoor Environmental Quality (IEQ)

Benchmarks:

- *Temperature Band (offices, classrooms, circulation): ASHRAE 55 or better*
- *Target Daylight Factor (non-laboratory spaces): 5% to 10%*
- *Target Floor Plate Area with External Views (non-lab spaces): 90%*

6.0 BENCHMARKING

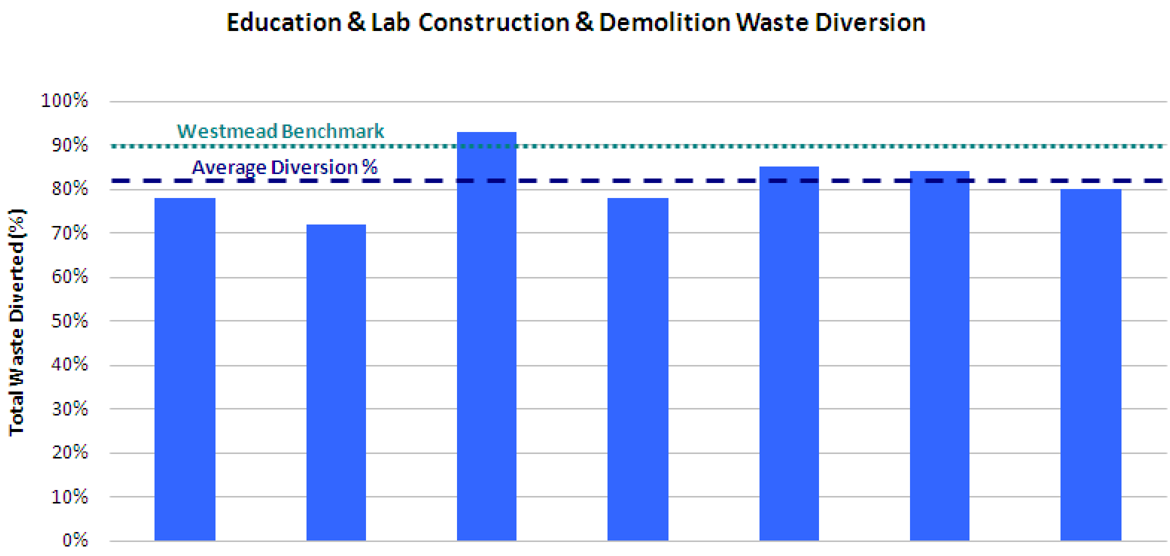


FIGURE 6.2 Based on similar laboratory buildings researched in the benchmarking process, the average waste-to-landfill diversion rate is slightly more than 80%. Westmead will target a rate of 90% to exceed best practice.

- *Lighting Levels (laboratories): 400Lux*
- *Lighting Colour Rendition (laboratories): >85CRI*
- *Lighting Levels (offices): 320Lux*

Benchmarks for aspects of the indoor environment in the non-laboratory areas have been guided by the standards set in Green Star Office Design v3. Data from buildings of similar typology from across the globe has been gathered in order to set benchmarks for the laboratory spaces. This data was assessed in the context of building envelope, climate, site location, and site orientation and transformed into regionally contextual benchmarks for the project.

7.0 WATER-SENSITIVE URBAN DESIGN MEASURES



FIGURES 7.0, 7.1 AND 7.2 The WSUD measures proposed for the project include the use of bio-swales within the site to slow stormwater and treat it prior to releasing it into stormwater systems, as well as the use of low-flow, WELs-rated tapware and ultra-low-flow urinals.

BENCHMARKS

The design team has proposed to achieve the following water-sensitive urban design benchmarks:

- ► Maximum Annual Water Use (design): 65L/m²
- ► Target Rainwater Collection (based on roof area): 90%
- ► Irrigation: No potable water use
- ► RO Water Plant Waste Water Reuse: 100%

ASSESSMENT

Water benchmarks and targets will be assessed by using the practices required by the Green Building Council of Australia's Green Star rating system and the NABERS Water program.

INITIATIVES

Stormwater

Bio-retention pits and treatment systems will be investigated for adjacent green spaces; these could detain and treat storm water to ensure that peak storm water flows are not increased for 1-in 2-year storms. For 1-in-20-year storm events, the design team will seek to ensure that all stormwater leaving the site has been treated in accordance with the *Urban Stormwater Best Practice Environmental Management Guidelines* (CSIRO 1999) and *Australian Runoff Quality, A Guide to Water Sensitive Urban Design* (Engineers Australia, 2006). The design team will also consider installing a subterranean collection tank for detaining stormwater for reuse in the building's cooling towers where feasible prior to releasing it into the city stormwater system.

Site Irrigation

Where feasible, the new development will use vegetation with minimal or no irrigation requirements for landscape areas. The design team will investigate systems with the goal of using no potable water for irrigation purposes.

7.0 WATER-SENSITIVE URBAN DESIGN MEASURES

Rainwater Capture

The design team proposes the use of rain water for toilet flushing, cooling tower make-up, and irrigation purposes. Where appropriate, the development will incorporate dual-reticulation of hydraulics services to enable the use of non-potable sources in the building.

Water Efficiency

The project will use water-efficient tapware based on the Water Services Association of Australia's National Water Conservation Rating and Labelling Scheme as follows: 5 Star taps, 4 Star water closets, and 5 Star urinals. The potable water use for irrigation and recycled water will be metered for the building, in addition to water for all site wash down and irrigation demand. The design team will also investigate metering water use for each of the laboratory spaces, since research shows this is an effective way of reducing potable water use.

A condensate reuse system that collects condensation from the building's air-handling units will be targeted by the design team as a way to reduce potable water consumption.

Fire System Water Consumption Minimisation and Capture

A bypass valve and a storage tank, sized to house the total quantity of water expelled during a single test, will be included in the design of the fire water system such that testing any water used for testing will be able to be salvaged and reused on site.

Water Monitoring

Water meters will be installed, in line with standard Green Star requirements for all large-scale water uses including cooling towers, hot water services, and kitchen facilities. These meters will be linked back to the BMS. In addition to metering large scale water use, each individual laboratory will be monitored as well.

Process Water Metering

Meters will be provided at each laboratory to gauge water use and identify those labs that are using excessive amounts of water. These metered approaches have been shown to help a building's maintenance staff identify wastage and improve overall water conservation.

MANAGEMENT

These water initiatives will be managed as part of the services provision for the project and documented against benchmark requirements in Green Star and NABERS Water.

8.0 ENERGY EFFICIENCY

Energy efficiency is a key component of the sustainability strategy for the Westmead laboratory, especially since laboratory buildings are among the most energy intensive building types.

BENCHMARKS

The design team has proposed to achieve the following energy and environmental quality design benchmarks:

Energy Benchmarks

► Targeted Maximum Annual Energy Use for the Overall Building (design): 2,500MJ/m²

► Targeted Maximum Annual Gas Use for Heating and Hot Water for the Overall Building (design): 65MJ/m²

► Targeted Alternative Energy Generation On-site: 20%

► Lighting Allowance for Primary, Secondary and Tertiary Laboratory Spaces (design): 14W/m²

► Lighting Allowance for Support, Education and Circulation Spaces (design): 8.6W/m²

► Lamp and Ballast Efficacy for Primary, Secondary and Tertiary Laboratory Spaces: 90Lumens/Watt

► Refrigerants: Zero Ozone Depleting Potential (R11 and R12 cannot be used)

Indoor Environmental Quality Benchmarks

► Temperature Band (Support areas, Education areas, Circulation): ASHRAE 55 or better

► Target Daylight Factor (Support areas, Education areas, Circulation, Write-up research areas): 5% to 10%

► Target Floor Plate Area with External Views or Views to a Day-lit Atrium (Support areas, Education areas, Circulation, Write-up research areas): 90%

► Lighting Levels (Primary, Secondary, Tertiary laboratory spaces): 400Lux

► Lighting Color Rendition (Primary, Secondary, Tertiary laboratory spaces): >85CRI

► Lighting Levels (Support areas, Education areas, Write-up research areas): 320Lux

► Acoustics Design for Building Service Noise: Comply with Table 1 of AS/NZS2107:2000

ASSESSMENT

Energy benchmarks and allowances will be assessed based on the energy model developed for the project based on the Green Star energy calculation methodology. This model will also be assessed against the Laboratories for the 21st Century benchmarking program and the case study information outlined in the Benchmarking section to ensure international best practice.

The Indoor Environmental Quality benchmarks will also be assessed using the Green Star methodologies with the exception of the following:

8.0 ENERGY EFFICIENCY

- Temperature Band (offices, circulation): ASHRAE 55 Adaptive Comfort or better (refer to the Adaptive Comfort section below)

INITIATIVES

Energy-efficient Equipment

The design team will specify and select all new equipment so that it meets current best practice for energy efficiency. For appliances, products supplied with the Energy Star or TESAW labels will be used. These should be within 1 Star of the best available appliance on the market based on Australian Government standards.

On-site Alternative Energy Generation

The design team will investigate the potential for the on-site generation of electricity using alternative fuels, including solar photovoltaics, bio-fuels, wind and gas in order to meet a target of 20% of the building's demand. The design team will seek external funding sources through the NSW Government, including the potential use of the green loans program administered by the Department of Environment, Climate Change and Water (DECCW) .

Adaptive Comfort Conditions

Designing for adaptive comfort is one of the key design strategies for non-laboratory space within the project, since this allows the mechanical system to provide for a wider temperature band in occupied spaces (as opposed to keeping the entire building cooled to 22.5°C). By using established standards, such as the ASHRAE 55-2004 standard as shown in Figure 5.2, the designers can relax the temperatures and reduce the requirement for mechanical cooling (i.e. reduce energy use) in spaces that are not continuously occupied and in open and individual offices. The design team will pursue this strategy in areas like write-up, the atrium spaces, circulation spaces, and back of house support areas that could effectively be provided with mixed-mode ventilation or a relaxed temperature set point band for the air-conditioning system.

Metering and Commissioning

The design team will investigate the installation of real-time, digital electricity usage meters for the project, including the metering of major electrical loads, as well as metering of water and electricity use in individual labs in order to encourage conservation and efficiency.

The design team will incorporate a comprehensive commissioning and building tuning plan into the design, construction, and operation of the project. This will be a core component of the integrated design process and following through into building operation. Commissioning will occur for all major systems, such as mechanical, hydraulics, and controls. An independent commissioning agent will be employed to overview the design process and well as post occupancy building tuning which will occur over a minimum of a heating and a cooling period.

Energy-efficient Lighting Strategies

It is proposed that the Westmead laboratory will use occupancy sensors and high-efficiency lighting in buildings. The design team will avoid using incandescent or halogen lamps and instead design with T5 fluorescent fixtures in classrooms and offices. The design team will use LED light fixtures where possible to extend lamp life and reduce re-lamping costs and waste. For corridors, the design team will use high-efficiency fixtures with maximum on-centre spacing to reduce energy use and will avoid using purely decorative luminaires or light sources with poor efficacy. High-frequency ballasts (at least 32,000 Hertz) for fluorescent light fixtures will be specified.

8.0 ENERGY EFFICIENCY

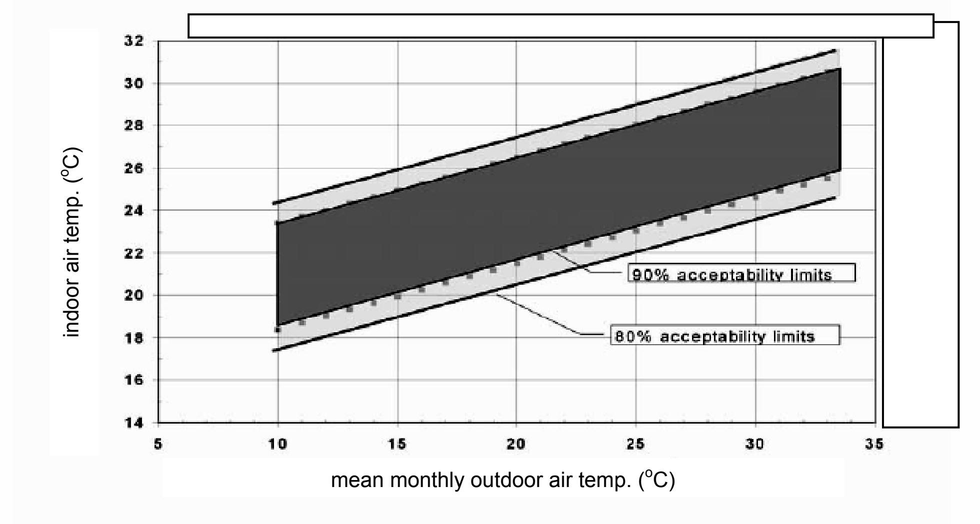


FIGURE 8.0 The ASHRAE 55-2004 chart for adaptive comfort indicates the conditions at which occupants will feel comfortable given outdoor air temperatures.

The building will be designed to take advantage of maximum daylight, while avoiding glare and thermal comfort issues. Daylight guidelines of at least 250 Lux in at least 90 percent of the NLA, where feasible and appropriate, or with a Daylight Factor of at least 2 percent at 760mm above finished floor level will be used to reduce the need for electric lighting.

Dark Sky Lighting Requirements

The design team will attend to diurnal patterns and biodiversity by minimising dark sky issues by installing low cut-off luminaires that direct light on surfaces and not toward the sky. The team will also design site lighting in accordance with Australian Standard 4282-1997 (*Control of Obtrusive Effects of Outdoor Lighting*) and ensure that at least 95 percent of outdoor spaces do not exceed the minimum requirements of AS1158 for illuminance levels.

Systems Descriptions

The project will target specifying and selecting all new equipment so that it meets current best practice for energy efficiency. For appliances, products supplied with the Energy Star or TESAW labels will be used, where possible and appropriate. These should mostly be within 1 Star of the best available appliance on the market based on Australian Government standards.

The design team will also investigate the use of night purge systems for office and write-up areas. Such systems automatically open windows during cool evening hours, allowing thermal mass in the building to cool. This stored coolth is then released during the warmer daytime hours.

Car park ventilation energy consumption will be reduced through the use of variable speed drives (VSD) and carbon monoxide sensors. The use of occupancy sensors to reduce lighting and fan use will also be investigated during detailed design to further reduce energy use. Systems containing refrigerants will be housed in a moderately air-tight containers and the design team will investigate the use of a refrigerant leak detection system at all critical points. In such a system, upon alarm, factory-installed standard refrigerant recovery systems will ensure no leakage occurs.

In order to reduce energy loads, the design will implement the following initiatives:

►**General:**

8.0 ENERGY EFFICIENCY

- An integrated building management system for systems controls.

- Occupancy sensors for lighting throughout the building

- High-performance façade materials with external shading devices to reduce solar cooling demand by 40% at peak condition and even greater at non peak times.

- Good insulation that exceeds Section J requirements

►**Central atrium:**

- Tempered spill air from adjacent spaces.

- Tempered control of atrium conditions, focussing on passive measures where feasible.

- Maximise daylighting to reduce electrical lighting energy consumption.

- Exterior sun shading to reduce solar gain and daylight glare.

- Potential for mixed-mode or tempered supply air.

►**Office areas:**

- The design team is investigating the use of a hybrid displacement ventilation system, which could translate to energy savings due to reduced chiller use.

- Minimal and high-efficiency lighting, coupled with task lighting

- Exposed structure to reduce material use and activate thermal mass to reduce mechanical cooling requirements.

►**Laboratory spaces:**

- Maximise daylighting within the performance constraints of the laboratory's environmental tolerance.

- Efficient ventilation systems and control.

- Proposed automatic sash closers on fume hoods to save energy through reducing conditioned air lost to the fume cupboard ventilation system when sashes are left raised.

- Innovative air quality monitoring systems to manage supply air and conserve energy via reducing air change rates when air quality and temperature is maintained. This initiative is expected to provide significant energy savings.

- Right-sizing of laboratory electrical loads. The project team are undertaking actual monitoring of the existing facility to ensure electrical capacities and cooling capacities are not oversized for the application.

Solar Thermal Systems

The design will provide a solar thermal hot water system on the roof to reduce energy demand by using the sun's energy to pre-heat water for use in the building. A standard solar thermal module system will be selected with full back up hot water provision from a gas system.

MANAGEMENT

Energy initiatives will be managed with energy model analysis and design specifications as part of the services provision for the Westmead laboratory project.

9.0 MATERIALS AND WASTE DISPOSAL

BENCHMARKS

Recycling and Reuse

► Construction and Demolition Waste Diversion from Landfill: 90%

Materials Benchmarking

► PVC Reduction (by cost): 60%

► Mercury: No mercury or low-mercury lamps specified

► Copper: No copper solders for stormwater systems

► Cement Replacement Target (based on flyash or equivalent): 60% for in situ, 40% for precast, and 30% for stressed concrete

► Recycled Concrete Aggregate: 20%

► Recycled Steel: 90% of all steel to contain at least 50% recycled content

► Certified Wood (by cost, based on all wood on project): 95%

ASSESSMENT

Assessment will be based on the implementation of a waste management plan for the Westmead laboratory and in line with the methodologies outlined in the Green Star rating tool. The building will also be designed to ensure a NABERS Waste rating could be achieved in operation.

9.0 MATERIALS AND WASTE DISPOSAL

INITIATIVES

Materials

The design team will seek to ensure that a minimum of two (2) percent of all material, based on the project's contract value, represents reused products or materials that are not steel, concrete or timber. Where applicable, the design team will investigate materials with a lifecycle approach that considers embodied energy to maximise the environmental benefits of the development.

No CFC or HCFC will be used in refrigerant systems, nor CFC/HCFC and Halons used in fire suppression devices. No asbestos is to be used in the project.

Materials with ozone-depleting substances in their manufacture will not be used. For paints, VOC limits shall be in accordance with the Good Environmental Choice Australia (GECA) standard GECA-23-2005. For adhesives and sealants, VOC limits shall be in accordance with the limits adopted by the South Coast Air Quality Management District (California, USA) Rule 1168. Carpet VOC levels shall meet or exceed those of the Carpet and Rug Institute's Green Label Plus (USA). All timber is to be from FSC-certified, recycled or plantation or re-growth forests which are sustainably managed. Wood products may not contain formaldehyde.

Construction Waste Management

A construction waste management plan will be incorporated into the project in order to ensure that more than 90% of the waste from building construction, demolition and tenancy demolition associated with the existing buildings on the site is diverted from landfill.

Operational Waste

The Westmead laboratory will be designed with dedicated recycled waste storage facilities to ensure that waste can be sorted and processed to target achieving a NABERS Waste rating. The NABERS Waste program provides an operational protocol for measuring waste generation, reduction and recycling and is geared toward office buildings. However, it is the only formal program available to building maintenance staff to institute a comprehensive waste management program once the building has been occupied and will be further investigated during detailed design.

MANAGEMENT

Management will be based on the provision of the waste management plan as a contractual obligation of the contractor for each building project.

10.0 TRANSPORT & SOCIAL SUSTAINABILITY

FIGUREs 10.0 AND 10.1 A Better Place has proposed to provide electrical car charging facilities in Australia. The Westmead project can be future-proofed with infrastructure to allow for this when the technology becomes available. In addition, the facility will be designed with bicycle storage and change facilities according to Green Star requirements.

The design team seeks the opportunity to create education and environmental awareness by providing information that contributes to a more sustainable way of living. This includes initiatives to stimulate the use of public mass transport, monitor and communicate environmental results, and provide a space for creativity, diversity and innovation. The following strategies proposed are key to this strategy and will be investigated.

Education and Environmental Awareness

Media screens: to display real-time transport information (to stimulate and facilitate the use of public transport), weather, travel, events and community information as well as data on water and energy consumption and generation.

Resources monitoring: BMS information will be made available to occupants and the broader Westmead health care community. This helps on promoting public awareness, leading to longer term behavioural change, and contributes to the achievement of performance targets.

Sustainable Transport

Electric car charging stations: for 5% of the car parking associated with the project, to stimulate the procurement and use of low emissions vehicles.

Car share: The design team will investigate local car share companies to provide 2-3 car share locations for the parking associated with the project.

Small car parks: in accordance with the requirements of Green Star to encourage the use of fuel efficient vehicles.

Cyclist facilities: The laboratory will incorporate dedicated, covered bicycle parking and change facilities for occupants, as well as visitor bicycle parking according to Green Star guidelines.

10.0 TRANSPORT & SOCIAL SUSTAINABILITY

Building Occupant Satisfaction

In addition to the potential for As-Built (Green Star) and Energy in operation certification (NABERS Energy, potentially extended to NABERS for Water and Waste), the project will investigate the potential for post-occupancy certification from the standardised PROBE/ BUS Dataset method (Post Occupancy Review of Buildings and their Engineering – Building Use Studies Ltd Method) to gauge occupant satisfaction with the building and its internal conditions. The method would evaluate, as a minimum, occupant satisfaction with:

►Overall building design;

►Personal control (lighting, cooling, heating, etc);

►Speed and effectiveness of management response after complaints have been made;

►Temperature, air movement, air quality, lighting and noise;

►Overall comfort, health and productivity.

APPENDIX: PRELIMINARY GREEN STAR MATRIX

This Green Star matrix is based on the project target of a 4 Star Green Star Education v1 rating. The points achieved column is preliminary only; the final Green Star strategy will be determined in design.

Category	Title	Credit No.	Points Available	Points Achieved
Management				
	Green Star Accredited Professional	Man-1	2	2
	Commissioning - Clauses	Man-2	2	2
	Building Tuning	Man-3	1	1
	Independent Commissioning Agent	Man-4	1	1
	Building Guides	Man-5	2	2
	Environmental Management	Man-6	2	2
	Waste Management	Man-7	2	2
	Learning Resources	Man-10	1	1
	Maintainability	Man-11	1	1
		TOTAL	14	14
Indoor Environment Quality				
	Ventilation Rates	IEQ-1	3	1
	Air Change Effectiveness	IEQ-2	2	0
	Carbon Dioxide Monitoring and Control and VOC Monitoring	IEQ-3	1	1
	Daylight	IEQ-4	3	1
	Thermal Comfort	IEQ-5	3	0
	Hazardous Materials	IEQ-6	0	NA
	Internal Noise Levels	IEQ-7	2	2
	Volatile Organic Compounds	IEQ-8	4	2
	Formaldehyde Minimisation	IEQ-9	1	1
	Mould Prevention	IEQ-10	1	0
	Daylight Glare Control	IEQ-11	1	1
	High Frequency Ballasts	IEQ-12	1	1
	Electric Lighting Levels	IEQ-13	1	0
	External Views	IEQ-14	1	0
		TOTAL	24	10
Energy				
	Conditional Requirement	Ene-	Conditional Requirement	Yes
	Greenhouse Gas Emissions	Ene-1	20	3
	Energy Sub-metering	Ene-2	1	1
	Peak Energy Demand Reduction	Ene-3	2	0
	Lighting Zoning	Ene-4	1	1
	Unoccupied Areas	Ene-7	2	1
	Stairs	Ene-8	1	1
	Efficient External Lighting	Ene-9	1	1
	Shared Energy Systems	Ene-10	1	0
		TOTAL	29	8
Transport				
	Provision of Car Parking	Tra-1	2	2
	Fuel Efficient Transport	Tra-2	1	1
	Cyclist Facilities	Tra-3	4	4
	Commuting Mass Transport	Tra-4	5	5
	Transport Design and Planning	Tra-6	1	1
		TOTAL	13	13

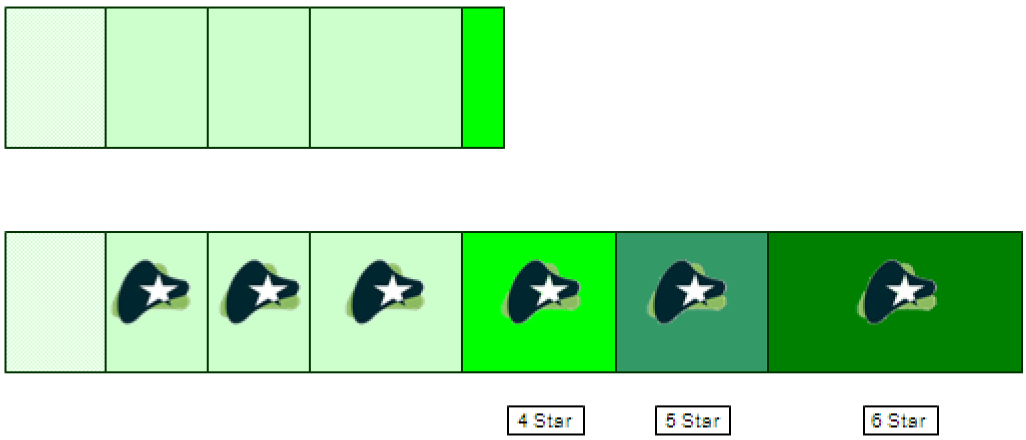
APPENDIX: PRELIMINARY GREEN STAR MATRIX

Water				
	Occupant Amenity Water	Wat-1	5	2
	Water Meters	Wat-2	1	1
	Landscape Irrigation	Wat-3	0	NA
	Heat Rejection Water	Wat-4	4	2
	Fire System Water	Wat-5	1	1
	Potable Water Use in Laboratories	Wat-6	2	0
		TOTAL	13	6
Materials				
	Recycling Waste Storage	Mat-1	2	2
	Building Reuse	Mat-2	0	NA
	Recycled Content & Re-used Products and Materials	Mat-3	1	0
	Concrete	Mat-4	3	1
	Steel	Mat-5	2	0
	PVC Minimisation	Mat-6	2	1
	Sustainable Timber	Mat-7	2	1
	Design for Disassembly	Mat-8	1	0
	Dematerialisation	Mat-9	1	0
	Flooring	Mat-11	3	2
	Joinery	Mat-12	1	0
	Loose Furniture	Mat-13	3	0
		TOTAL	21	7
Land Use & Ecology				
	Conditional Requirement	Eco -	Conditional Requirement	Yes
	Topsoil	Eco-1	1	0
	Reuse of Land	Eco-2	1	0
	Reclaimed Contaminated Land	Eco-3	2	0
	Ecological Value of Site	Eco-4	4	1
		TOTAL	8	1
Emissions				
	Refrigerant ODP	Emi-1	1	1
	Refrigerant GWP	Emi-2	2	0
	Refrigerant Leaks	Emi-3	2	2
	Insulant ODP	Emi-4	1	1
	Watercourse Pollution	Emi-5	2	1
	Discharge to Sewer	Emi-6	2	0
	Light Pollution	Emi-7	1	1
	Legionella	Emi-8	1	1
		TOTAL	12	7

Sub-total weighted points: 49

Innovation				
	Innovative Strategies & Technologies	Inn-1	5 points in total for Inn-1,2&3	0
	Exceeding Green Star Benchmarks	Inn-2		0
	Exceeding Green Star Scope	Inn-3		0
		TOTAL	5	0

Total weighted points: 49



GREEN STAR STRATEGY

ISSUE

WESTMEAD MILLENNIUM INSTITUTE AND WESTMEAD RESEARCH HUB

15 JULY 2010

ARUP

Revision	Date	Filename	0001_ESD_draft Green Star strategy_draft_WMI_arup_080710.pub		
Draft 1	08/07/2010	Description	First draft		
			Prepared by	Checked by	Approved by
		Name	Russell Fortmeyer	Russell Fortmeyer	Alex Hole
		Signature			

Revision	Date	Filename	0002_ESD_issue Green Star strategy_draft_WMI_arup_150710.pub		
Issue	15/07/2010	Description	Issue		
			Prepared by	Checked by	Approved by
		Name	Russell Fortmeyer	Russell Fortmeyer	Alex Hole
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CONTENTS

1.0 OVERVIEW OF GREEN STAR STRATEGY

The Westmead Millennium Institute and Westmead Research Hub's new laboratory building on the Westmead campus will be designed with best practice sustainable design strategies that balance energy efficiency, water conservation, good indoor air quality, and operational and maintenance cost -effectiveness.

This report has been prepared by Arup to provide an overview of potential Green Star rating strategies for the Westmead Millennium Institute and Westmead Research Hub research laboratory proposed for the Westmead Hospital campus on Hawkesbury Road in Westmead.

It is proposed that the design of the Westmead laboratory will aim to achieve the following:

►A minimum 4 Star Green Star Design Education v1 rating provided by the Green Building Council of Australia;

The Green Star rating schemes are voluntary holistic sustainable design rating tools which have been set up and are managed by the Green Building Council of Australia. These tools are used to guide the design process, and address a wide spectrum of environmental performance measures dealing with social, economic, and environmental issues. Green Star tools target performance levels in the general areas of water, waste, IEQ, management, energy, emission and transport and with specific targets for medical equipment and trade waste pollution.

The *Engineering Services and Sustainable Development Guidelines TS11* (Version 2.0, December 2007) requires that all NSW Health projects costing over $10 million achieve a minimum 4 Star Green Star Health Care rating. While the Health Care rating tool is applicable to buildings that include patient care and typical hospital functions, it is not applicable to research laboratories. The Green Buidling Council of Australia, which administers Green Star, has recommended adopting the Education rating tool instead. This is explained in the following section:

Using Green Star Education v1 in lieu of Green Star Health Care

Currently the Westmead laboratory will be comprised of Class 5, 7a and 8 spaces according to the BCA 2010. While there are individual Green Star tools which rate these BCA classifications, they all have required area proportions which are not met by the project. In this case, the GBCA has advised projects such as Westmead to pursue a formal certification by using the Green Star Education tool, which can be modified through Credit Interpretation Requests (CIRs) to account for laboratory-specific design requirements. This will be a hybrid approach, where the project may use the Green Star Education tool for most of its credits, but propose an alternative compliance path for credits that

Functional Spaces	Max Annual CO2 Emissions [kgCO2-e/m²]
Teaching / classroom spaces	82
Dry Labs/specialty learning spaces and libraries	88
Office/administrative spaces	79
Common spaces	57
Wet labs	Varies on density of fume cupboards
Car Parks	52

FIGURE 1.0 Green Star Conditional Energy Requirements for Universities (Green Star Education v1).

1.0 OVERVIEW OF GREEN STAR STRATEGY

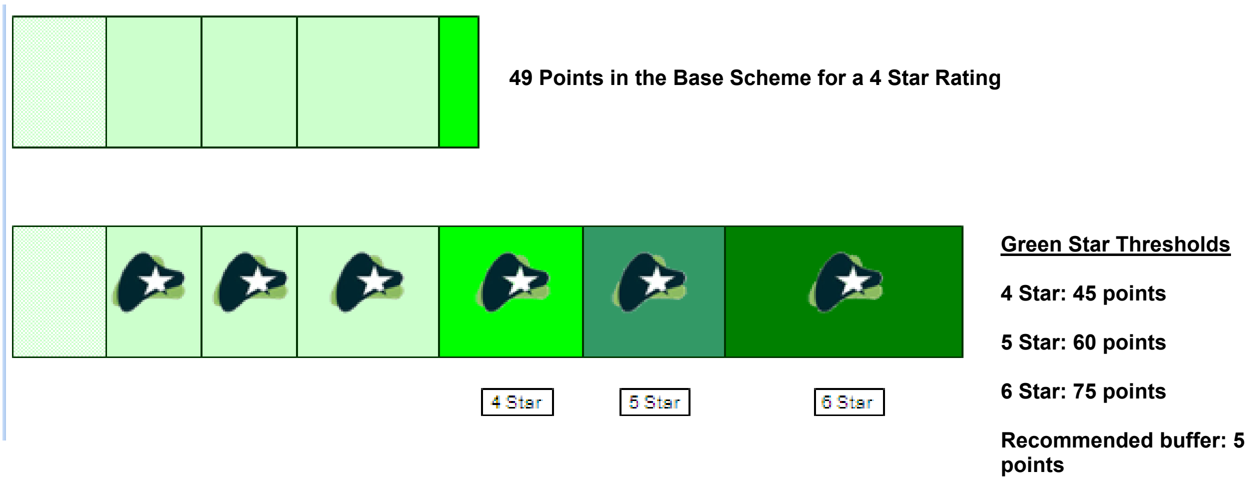

FIGURE 2.0 This graph shows the current base scheme's Green Star target of 4 Stars, or 49 points. This would comply with the requirements of NSW Health's TS11 guidelines. The project may wish to pursue a 5 Star rating given other considerations, but this will require more analysis as part of the design process.

don't apply, such as the Energy (Ene-1) credit for annual energy consumption. The GBCA is developing a so-called custom tool for rating buildings that don't directly comply with specific rating tools, but this is currently not available. It may be that the project will use the custom tool if it is released prior to detailed design.

Conditional Requirements

In order to qualify for a rating, conditional requirements with regard to energy efficiency must be incorporated into the design. In the Green Star Education v1 tool, each type of space has minimum benchmarks for annual operational carbon emissions. Refer to Figure 1.0 for specific benchmarks. Early analysis of the energy demands for research laboratories, in comparison to university teaching laboratories, suggest that the Green Star benchmarks are not readily applicable to this building type. It is Arup's understanding through the most recent discussions with the Green Building Council of Australia that a project team can propose an alternative methodology for the energy credits to demonstrate compliance with Green Star's intention.

Otherwise, the *Green Star Education V1 Standard Practice Benchmark* document shows that these minimum benchmarks are likely to be achievable for new buildings, as they are slightly below the current standard practice for academic buildings in Australia. Note that these benchmarks only include energy or base building operation. Energy required for equipment (laboratory, information and communication technology etc.) is excluded.

4 Star Green Star Rating Benchmark

The minimum amount of credits for a 4 Star Green Star rating is 45 weighted points. To protect against risks in the design process, it is recommended to target 50 weighted points as part of an initial ESD program. An initial analysis of the credits that would form a baseline for the project is included in Section 2.0 on pages 8 and 9, which indicates the project could quite easily and within a conventional cost plan achieve 49 weighted points. This is outlined below. The total points in each category are shown on page 7.

2.0 BASE GREEN STAR STRATEGY INITIATIVES

Base Green Star Strategy

Management

All ESD initiatives listed in the Management Category would need to be targeted and taken into account at the start of the scheme design phase. This includes design, construction, commissioning and facilities management processes that apply sustainability standards, as well as the provision of learning resources to building occupants that inform about building sustainability initiatives and a comprehensive building management control system.

IEQ

In this category, the easier credits include CO2 monitoring and control and VOC monitoring, effective noise protection from building services and outdoors/adjoining spaces, low-VOC paints and floors, daylight glare control through blinds and installation of high frequency electronic ballast for lighting equipment.

Energy

In addition to energy sub-metering, lighting zoning, switch-off capabilities for unoccupied areas, provision of stairs and efficient external lighting, the team should assume the implementation of standard practice energy efficiency corresponding with a 20% improvement compared to minimum conditional requirements described above.

The *Green Star Education V1 Standard Practice Benchmarking Summary* assumes a standard practice university academic building system to have the following characteristics:

- ◊ Mechanical ventilation with a water-cooled chiller and gas-fired boiler;
- ◊ Building fabric comprising of an aluminium roof; concrete external walls; high performance glazing and a concrete floor or foundation;
- ◊ Standard practice lighting fixtures, practices, and efficiency;
- ◊ An electric storage hot water heater;
- ◊ 1 lift for every 3,000m² total GFA; and
- ◊ No on-site electricity generation.

The design of the Westmead laboratory would then be compared against the above design strategies as a baseline. For example, a trigeneration system could be incorporated into Westmead, where a gas-fired generator supplies electricity to the building with waste heat powering an absorption chiller to provide cooling and reduce conventional chiller use. If this were implemented, the project could conceivably have less greenhouse gas emissions per square metre associated with its electricity consumption than the baseline building summarised above because the baseline building does not include any on-site electricity generation.

It is assumed that the energy strategies would also rely on solar thermal hot water systems, which would significantly improve upon the electric hot water storage outlined in the base systems in Green Star. In addition, the NSW Health TS11 guidelines recommend a target of 20% of the facility's power to be supplied by alternative sources, including wind, solar, biodiesel, or gas (as in a trigeneration system). These are examples of technologies, outlined in the project's ESD Part 3A report, that would help the building achieve a higher level of energy efficiency. The current energy points assumed in the 4 Star Green Star scheme are very low due to the high risk nature of using the

2.0 BASE GREEN STAR STRATEGY INITIATIVES

Green Star Education tool for a laboratory project. In actuality, the project will achieve significantly more points in this category.

Transport

All transport points should be achievable given the location of the building near major transportation routes associated with the hospital. This includes reduced number of car parks, preference for fuel-efficient vehicles, sufficient cycle facilities for visitors and staff, as well as a program to improve transport modes of low environmental impacts.

Water

3 Star WELS-rated toilets, urinals, taps and showerheads are required to achieve minimum potable water efficiency. Additionally, water meters for all major uses and equipment to reduce water usage from fire system tests shall be installed.

Materials

Sufficient recycling storage shall be provided for occupants. Concrete and steel shall contain a minimum amount of recycled content. In addition, materials shall be selected to reduce environmental impacts, including, but not limited to, reduction in PVC use, the specification of certified timber, and timber products containing no formaldehyde.

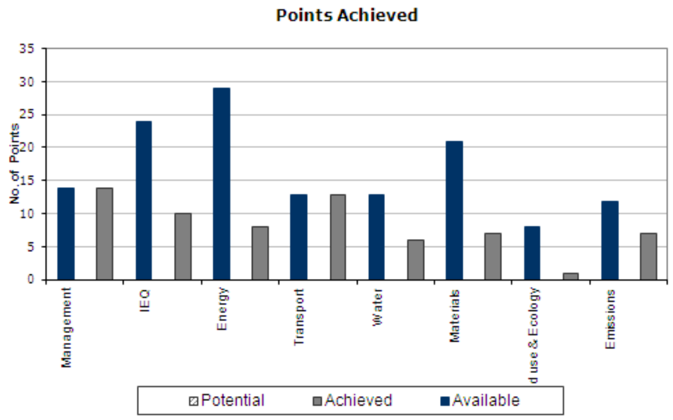

FIGURE 3.0 This chart summarises the points targeted for each category based on the spreadsheets on pages 8 and 9, using Green Star Education v1.

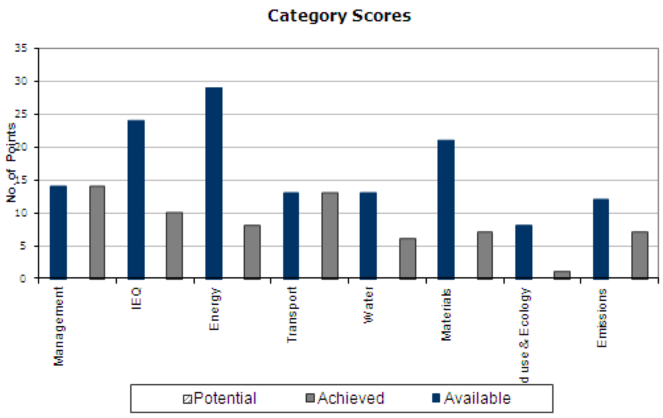

FIGURE 4.0 This chart summarises the category scores based on the spreadsheets on pages 8 and 9, using Green Star Education v1.

2.0 BASE GREEN STAR STRATEGY INITIATIVES

Emissions

The HVAC system shall not contain any refrigerants with Ozone Depletion Potential (ODP) and include installation to avoid refrigerant leaks. All insulation materials shall be ODP free. Light pollution shall be minimized. Cooling tower management shall include high standards for minimization of Legionella risk.

Challenges

The following are additional available points that could be targeted, but would require design team effort to ensure impacts to space planning and functionality are effectively addressed. In some instances, these credits are "challenges" because they might result in additional cost.

Improvements in Indoor Environment Quality

1 Point: 30% of Space has minimum daylight levels exceeding the daylight factor of 2%.

1 Point: Formaldehyde minimization in all engineered wood products.

Improvements in Energy Efficiency

Additional points in greenhouse gas emissions can be achieved given the use of alternative mechanical systems or on-site generation, such as through a trigeneration plant. This will need further investigation in design. The key challenge to comply with the TS11 recommendation for 20% alternative energy generation on-site is meeting this target within the cost plan. A cost benefit analysis will need to be undertaken to weigh the benefits of alternative technologies, including solar photovoltaics, trigeneration systems with an option for bio-fuels, geothermal or wind.

Improvements in Water Efficiency

1 Point: 5 star WELS toilets and urinals, 4 star WELS taps and showerheads.

2 Points: Achieve a 50% reduction in use of potable water for heat rejection.

Improvements in environmental impact of materials

2 Points: High-quality flooring material for all areas, including warranties for durability > 10 years and take back at end of life, eco-preferred content 5-20%, Producer EMS according to ISO 14001 with clauses for materials, waste, energy and emissions minimization.

3.0 STRETCH GREEN STAR TARGETS

If the WMI project were to target a 5 Star or 6 Star Green Star Education v1 rating, the client and design team would need to further investigate the following opportunities. Please note that not every opportunity would need to be included in the project, but a set of additional strategies or technologies that would aid the project in achieving a higher Green Star rating.

On-site trigeneration plant with absorption chiller

A trigeneration plant can cost between $1 million and $3 million, depending on the size and configuration of the plant. The efficiency of such a plant can be maximised if it can feed other buildings adjacent to the laboratory site. Although such a plant will help reduce greenhouse gas emissions in comparison to grid electricity and would also reduce peak energy demand, the high cost must be weighed against other considerations. In addition, such systems can be provided at little to no capital cost as part of a Build-Own-Operate (BOO) scheme provided by an external contractor.

Displacement ventilation systems and/or mixed-mode capability for offices

The use of mixed-mode strategies—where office windows can be opened to supply cool air to spaces so that the air-conditioning system can be shut off—can help the building achieve a high level of energy efficiency. In addition, a raised floor displacement ventilation system can reduce the loads on the mechanical system chillers, resulting in improved efficiency. The costs for these approaches are highly dependent on the extent of such systems and how they are incorporated into the architecture, but are generally between $500,000 and $2 million above baseline costs.

On-site renewable energy generation systems

A solar photovoltaic system could potentially address 5% or more of the base building electricity needs. Such systems can cost between $500,000 and $3 million. An investment in an off-site wind farm would be a similar cost, but would likely generate energy more efficiently.

Rainwater and stormwater capture, storage and reuse

A rainwater capture system on the roof would be part of the base design for the project, but detention and reuse of all site stormwater would represent a larger investment in the order of $200,000 to $500,000 for tanks and treatment systems. This could also be addressed using a swale or wetland.

Alternative heat rejection strategies (i.e. green walls, water walls, geothermal)

Green walls can be used for heat rejection, but would represent a custom solution. Such an approach could qualify for innovation credits in Green Star. Geothermal systems, where a series of bore wells are drilled under the building’s footprint and water is run through them to reject heat from the building’s mechanical system, are increasingly common in Australia. A geothermal system can cost between $2 million and $5 million; in addition, such systems can be provided at no capital cost as part of a Build-Own-Operate (BOO) scheme provided by an external contractor.

Individually addressable lighting systems

Such systems include ballasts that act as web addresses so that each light in the building could be individually controlled and monitored. These systems result in energy savings through the life of the building. They generally cost between $300,000 and $1.25 million, depending on the extent of the use.

Innovation strategies, such as healthy building planning, urban agriculture programs and community engagement

Urban agriculture, where dedicated space is provided for growing food, can be incorporated into the landscape design for minimal cost. Such innovative approaches, however, may represent an ongoing operational cost that would need to be borne by other budgets.

4.0 FOUR STAR GREEN STAR STRATEGY

Category	Title	Credit No.	Points Available	Points Achieved
Management				
	Green Star Accredited Professional	Man-1	2	2
	Commissioning - Clauses	Man-2	2	2
	Building Tuning	Man-3	1	1
	Independent Commissioning Agent	Man-4	1	1
	Building Guides	Man-5	2	2
	Environmental Management	Man-6	2	2
	Waste Management	Man-7	2	2
	Learning Resources	Man-10	1	1
	Maintainability	Man-11	1	1
		TOTAL	14	14
Indoor Environment Quality				
	Ventilation Rates	IEQ-1	3	1
	Air Change Effectiveness	IEQ-2	2	0
	Carbon Dioxide Monitoring and Control and VOC Monitoring	IEQ-3	1	1
	Daylight	IEQ-4	3	1
	Thermal Comfort	IEQ-5	3	0
	Hazardous Materials	IEQ-6	0	NA
	Internal Noise Levels	IEQ-7	2	2
	Volatile Organic Compounds	IEQ-8	4	2
	Formaldehyde Minimisation	IEQ-9	1	1
	Mould Prevention	IEQ-10	1	0
	Daylight Glare Control	IEQ-11	1	1
	High Frequency Ballasts	IEQ-12	1	1
	Electric Lighting Levels	IEQ-13	1	0
	External Views	IEQ-14	1	0
		TOTAL	24	10
Energy				
	Conditional Requirement	Ene-	Conditional Requirement	Yes
	Greenhouse Gas Emissions	Ene-1	20	3
	Energy Sub-metering	Ene-2	1	1
	Peak Energy Demand Reduction	Ene-3	2	0
	Lighting Zoning	Ene-4	1	1
	Unoccupied Areas	Ene-7	2	1
	Stairs	Ene-8	1	1
	Efficient External Lighting	Ene-9	1	1
	Shared Energy Systems	Ene-10	1	0
		TOTAL	29	8
Transport				
	Provision of Car Parking	Tra-1	2	2
	Fuel Efficient Transport	Tra-2	1	1
	Cyclist Facilities	Tra-3	4	4
	Commuting Mass Transport	Tra-4	5	5
	Transport Design and Planning	Tra-6	1	1
		TOTAL	13	13

4.0 FOUR STAR GREEN STAR STRATEGY

Water				
	Occupant Amenity Water	Wat-1	5	2
	Water Meters	Wat-2	1	1
	Landscape Irrigation	Wat-3	0	NA
	Heat Rejection Water	Wat-4	4	2
	Fire System Water	Wat-5	1	1
	Potable Water Use in Laboratories	Wat-6	2	0
		TOTAL	13	6
Materials				
	Recycling Waste Storage	Mat-1	2	2
	Building Reuse	Mat-2	0	NA
	Recycled Content & Re-used Products and Materials	Mat-3	1	0
	Concrete	Mat-4	3	1
	Steel	Mat-5	2	0
	PVC Minimisation	Mat-6	2	1
	Sustainable Timber	Mat-7	2	1
	Design for Disassembly	Mat-8	1	0
	Dematerialisation	Mat-9	1	0
	Flooring	Mat-11	3	2
	Joinery	Mat-12	1	0
	Loose Furniture	Mat-13	3	0
		TOTAL	21	7
Land Use & Ecology				
	Conditional Requirement	Eco -	Conditional Requirement	Yes
	Topsoil	Eco-1	1	0
	Reuse of Land	Eco-2	1	0
	Reclaimed Contaminated Land	Eco-3	2	0
	Ecological Value of Site	Eco-4	4	1
		TOTAL	8	1
Emissions				
	Refrigerant ODP	Emi-1	1	1
	Refrigerant GWP	Emi-2	2	0
	Refrigerant Leaks	Emi-3	2	2
	Insulant ODP	Emi-4	1	1
	Watercourse Pollution	Emi-5	2	1
	Discharge to Sewer	Emi-6	2	0
	Light Pollution	Emi-7	1	1
	Legionella	Emi-8	1	1
		TOTAL	12	7

Sub-total weighted points: 49

Innovation				
	Innovative Strategies & Technologies	Inn-1	5 points in total for Inn-1,2&3	0
	Exceeding Green Star Benchmarks	Inn-2		0
	Exceeding Green Star Scope	Inn-3		0
		TOTAL	5	0

Total weighted points: 49