ENVIRONMENT DESIGN GUIDE

LIGHTING AT THE NEW AUSTRALIAN GREENHOUSE OFFICES, CANBERRA

David Oppenheim

The new Australian Greenhouse Offices in Canberra aimed to set new environmental standards, by halving the energy use and greenhouse gas emissions of a standard building, achieving a better than 5-Star rating when assessed against the Australian Building Greenhouse Rating (ABGR) scheme, achieving autonomy in water use (i.e. generally, no town water required, providing a solar hot water system that is predicted to completely satisfy the hot water load), reducing construction waste and reducing operational waste. A key element in achieving these goals was to develop a building with high levels of usable daylight, and a very energy efficient electric lighting scheme that is also capable of responding to varying levels of daylight.

This Note details the daylight and lighting strategies used in designing this building, and then provides details of a post-occupancy daylight analysis.

1.0 INTRODUCTION

The Australian Greenhouse Office (AGO) is responsible for delivering the Government's greenhouse gas emission reduction policy. New office space was required for expanding staff numbers as a result of an increasing role in delivering this Government policy. A strategic decision was taken to locate the AGO in the then unoccupied basement of the John Gorton Building (JGB) in Parkes, Canberra.

In 2001 architects Daryl Jackson Alastair Swayn (DJAS) developed the design concept for the proposed underground facility, which met both the need for A-grade office accommodation and the requirements of the National Capital Authority (NCA) for new buildings within the Parliamentary triangle. In April 2002, DJAS were appointed to carry out and complete this design.

Design work was completed by August 2002. Construction began in December 2002 with the demolition of the existing unwanted elements in the basement and the creation of the apertures for the courtyards and skylights. The project was completed in November 2003.

2.0 PROJECT DETAILS

Nett lettable Area: 3,200 m2

Construction and fitout budget: $8.5 million

Building owner

Department of Finance and Administration

Tenant

Environment Australia (Australian Greenhouse Office)

Year of completion

November 2003

Architect

Daryl Jackson Alastair Swayn

Project manager

Integrated Construction Management Services

Mechanical consultant

GHD

Electrical consultant

Barry Webb & Associates

Structural, civil and hydraulic engineers

Hughes Trueman

ESD Consultant

Sustainable Built Environments (SBE)

Access & Disability compliance

Eric Martin & Associates

Acoustic engineer

Eric Taylor Acoustics

Landscape architect

Clouston Associates

Fire services engineer

Fire Safety Science

Cost manager

Wilde & Woollard

Builder

ISIS Projects Pty Ltd.

Photographer

David Oppenheim

3.0 BRIEF

The brief for this project was to provide new offices for 180 staff of the AGO in the existing basement of the JGB, which had a nett lettable area of 3,200 square metres. The base building budget was $5.5 million. The fitout budget was $3.0 million.

The JGB is located in Parkes, Canberra and is bounded by King Edward Terrace, Parkes Place, King George Terrace and Administration Place.

The basement of the JGB had originally been used as a Communication Centre for ASIO and was constructed in 1976. The Department of Finance and

Administration (DOFA) wished to utilize this disused space in its desire to consolidate its accommodation. As the prime Commonwealth agency for environmental matters, the AGO saw the environmental benefits in reusing the facility. The project then logically became a test case in the implementation of the AGO's core ideas concerning the built environment.

4.0 ENERGY AUDITS, TARGETS AND COMPUTER MODELLING

4.1 Energy audit

As noted above, the existing basement building had been unoccupied for some time. The existing above ground JGB that houses Environment Australia (the name of the Department at the time of the project) was measured to use 588 MJ/m^2 per annum for the ground to fifth floors. This was the only relevant energy audit to hand, and was used as a guide.

4.2 Energy benchmarks and targets

The Commonwealth portfolio sets a target of 10,000 MJ / person per annum, and the existing John Gorton building achieves approximately 4,500 MJ / person per annum. A target of 4,000 MJ / person per annum was set for this building. Another target set for this new building was a 5-Star rating under the ABGR scheme, which in the ACT requires the building to emit no more than 71 kg of CO_2/pa corrected for use effect.

4.3 Energy modelling

Energy modelling was undertaken by Ian Lindquist from GHD using the computer program BEAVER (ESP2). It predicted that the energy performance of the AGO office building would be 302 MJ/m^2 per annum, compared to the PCA target of 452 MJ/m^2 per annum.

4.4 Regulations for daylight and lighting

It is noted that the Building Code of Australia (BCA) has no requirements to provide daylight in office spaces. It is further noted that AS 1680.1, Table 3 requires that maintained lux levels for office workers be 320 lux.

5.0 NABERS RATING

A NABERS rating (using Draft Final Version 14 December 2002) for the building was completed in January 2003, based on drawings and predicted outcomes. The building was assessed at 90 points and achieved a 62% Platinum Rating. This is a very good score. By comparison, the first winner of the *UK Green Building of the Year Award* scored 47%. A 'normal' building will probably score around 30%. The purpose-built rammed earth and PV powered Environmental Technology Centre at Murdoch University gets only a 60% rating - the highest score to date recorded in an Australian building. The highest score achieved anywhere is 65% for the Landcare Research headquarters building in Auckland, a new-build office/laboratory that aimed at very high sustainability scores.

6.0 PROCESS TO MAXIMISE ESD EFFECTIVENESS

A two stage design charette process was used to maximise the ESD effectiveness of the project. The first meeting was an ESD Zero Resources Workshop held on 19 April 2002 with the client and the project team. A preliminary briefing document was prepared by ESD consultants, SBE, and an output document was prepared by the project team to inform the next workshop. This next workshop was the ESD Buildability Workshop held on 3 May 2002, once again with the project team and the client. A final report on the outcomes of this process was delivered in May 2002. A further meeting was held soon after to consider the summary list of the 24 identified ESD opportunities. These opportunities were itemised by capital cost, economic payback, and environmental savings, (CO_2 and litres of water). Against each of these opportunities was the ESD consultant's recommendation. Using this information, the client then instructed the team on which initiatives to pursue. A traditional design, documentation and construction process followed after this.

The recommendations made with respect to daylight and lighting was the use of light courts, light shelves, T5 lamps with dimmable ballasts, and the use of non-PVC wiring. All of these recommendations were adopted, except the last which was considered to be outside the brief.

7.0 EXISTING CONDITIONS

The basement space is situated underneath the carpark which is located in front of the John Gorton Building. There is no natural lighting at all.

There is one secure, main pedestrian underground link to the above-ground John Gorton building to the north, and two escape risers on the north and south perimeter walls. The existing basement structure has 500mm thick reinforced concrete floor slab, walls and ceiling that are fully lined internally with a metal skin to provide radio wave shielding. This heavyweight underground structure offered very high thermal mass and insulative properties.

8.0 ARCHITECT'S DESIGN APPROACH

In order to achieve a high level of daylight in the project, the architects located ten large apertures in the existing concrete roof of the basement, thus creating six skylights and four courtyards. These were strategically distributed across the building plan, bringing natural light into the space and significantly reducing the demand for artificial lighting.

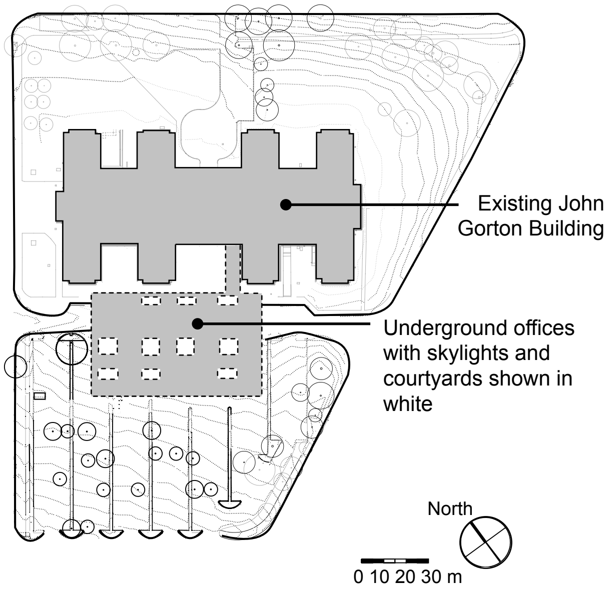

Figure 1. Site plan

The layout of the skylights and courtyards responds to the existing car park layout, and works with the existing structural grid below in order to preserve the maximum number of car parking spaces.

The architects believed that a building with skylights and courtyards need not impart a sense of being underground. Their goal was to create an environment where the perception of being underground is diminished or eliminated. To achieve this, the fitout responds by maximising openness and transparency to ensure that available views and natural light are provided to as many occupants as possible. Glazed partitioning is used in preference to solid, especially above 2100mm.

9.0 ESD CONSULTANT'S DAYLIGHT APPROACH

The ESD Report produced by the ESD consultants in May 2002 discussed the daylight opportunities that existed for the project through the use of the courtyards, the skylights and the light shelves.

In the same Report, it also recommended that light scoops and internal reflectors (light shelves) be installed to reduce light levels near the windows, and increase them in mid span.

10.0 SKYLIGHTS

The skylights consist of double-glazed window units from *Inglass* with internal motorised louvres on a time clock to track the sun across the day, shading the workspace below, while maximizing natural light. They are supported by fine steel structures that match the light shafts within the John Gorton Building, which was also refurbished by DJAS in 1998. The scale of these new elements that protrude above ground level is modest in order to minimise blocking the view of the main building.

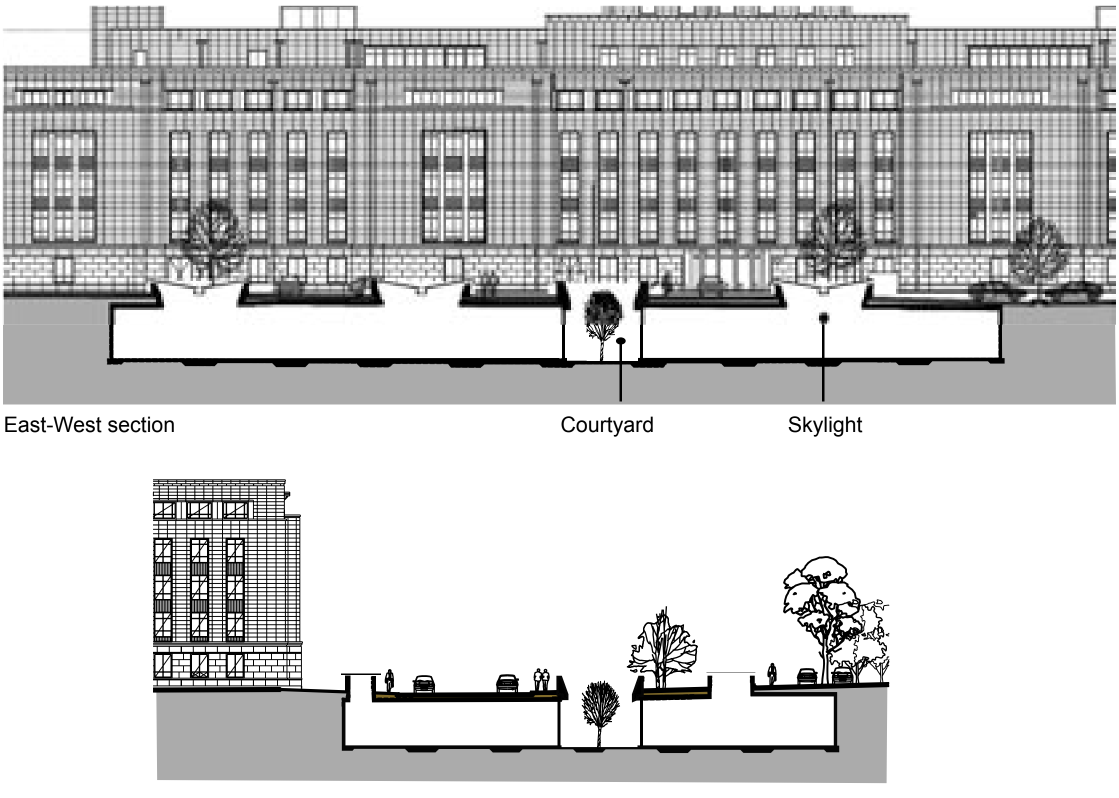

Figure 2. John Gorton Building elevation and section through basement

11.0 COURTYARDS

The courtyards are provided with aluminium framed, double-glazed windows. Automated external blinds with *Luxaflex* material and *Somfy* automation are used to exclude solar radiation yet maximize natural light. The original waterproof membrane to the concrete roof was cut and a new two-layer touch-on membrane from *Shelterbit* was used and connected into the existing membrane.

12.0 LIGHT SHELVES

Light shelves were introduced around the edge of the courtyards and under some skylights, in order not only to reduce the high lux levels normally experienced at these locations, but also to displace the daylight further into the building. Whether or not cleaning is required of these light shelves (and any associated costs) will be determined through use.

Figure 3. The courtyards penetrating underground office spaces

Figure 4. External and internal views of light shelves for courtyard

Figure 5. Suspended luminaires, and external screens on courtyard windows

Figure 6. External and internal views of skylight penetrations

13.0 DAYLIGHT MEASUREMENTS

13.1 On-site measurements

Daylight measurements were undertaken by project architect Ian Donlan from Daryl Jackson Alastair Swayn on Sunday 8 February 2004 at 12:30 pm and shortly thereafter. The skies were clear. Measurements were taken at the 32 points as shown on the plan below, and were taken when no electric lights were on. Table 1 shows the measurements as taken on the site on 8 February 2004. Figure 8 shows the plot of the recorded lux levels against the building cross-section.

13.2 Discussion on effectiveness of daylight strategy

In Figure 8, the solid horizontal line at the 320 lux level shows the required light level to be provided in office buildings. The solid line plot of lux levels, superimposed on the cross section, shows the measurement of the lux levels recorded as noted in Table 1. These were taken when there were no electric lights on. The dotted line plot of lux levels shows the anticipated levels if no light shelf had been present. These have been estimated by using the plot lines of points 13 – 15, but relocated to this area of the office.

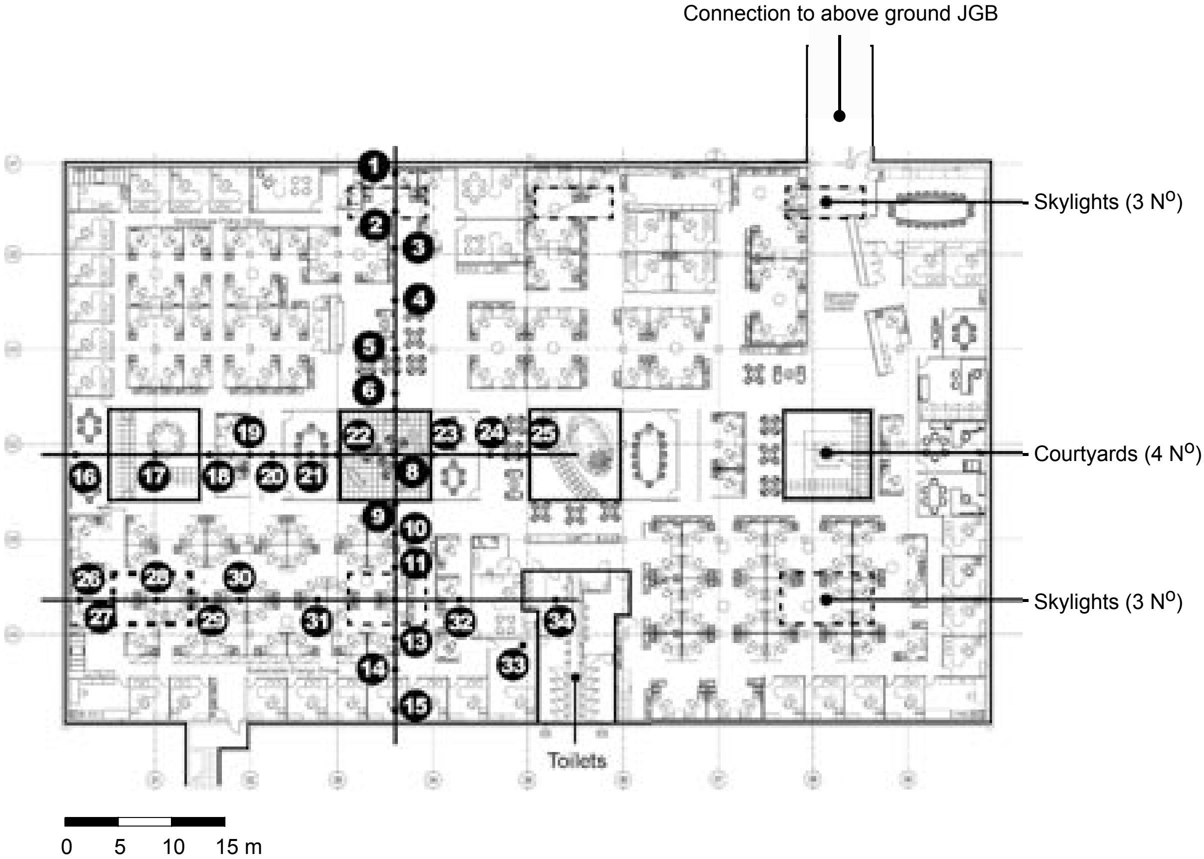

Figure 7. Plan showing locations of daylight measurements

Location	Lights off & blinds on auto	Readings below 320 lux	Location	Lights off & blinds on auto	Readings below 320 lux
1	1350		18	2250	
2	381		19	496	
3	708		20	237	X
4	250	X	21	583	
5	852		22	1240	
6	2800		23	1840	
7	4860		24	950	
8	Off the scale		25	4240	
9	5280		26	330	
10	1940		27	1775	
11	1558		28	3540	
12	6290		29	3350	
13	2390		30	1410	
14	889		31	2650	
15	184	X	32	4180	
16	886		33	Not accessible	
17	Off the scale		34	0	

Table 1. Daylight measurements

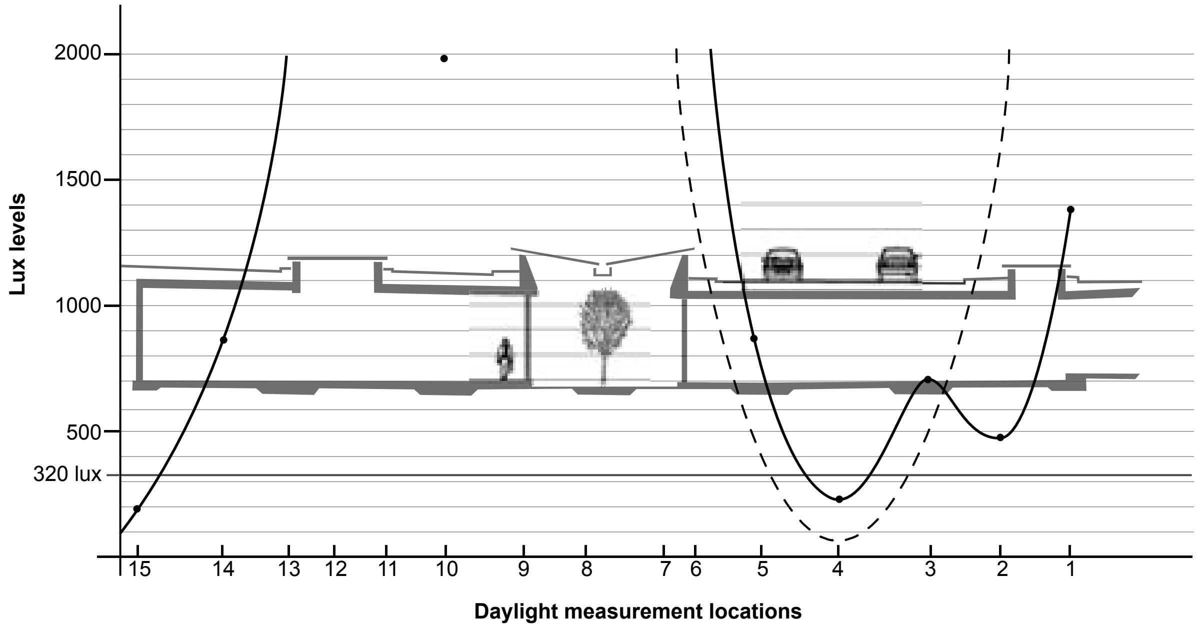

Figure 8. North-south cross-section showing plot of daylight levels

Two points are discernible from this diagram.

Firstly, the lux levels under the northern skylight show the positive reduction of the high daylight levels directly under the skylight. These have been displaced, as predicted, well into the central areas of the office. It appears that this displacement has been in the order of 1 to 2 metres. This will result in savings in the operation of the electric lights that are fitted with electronic ballasts that can reduce artificial light levels when daylight levels are above the required 320 lux.

Secondly, the architect's design to provide several large open courtyards and glazed skylights has proved successful by providing a very well daylit space. The data shows most areas are above the required 320 lux light level. Only three points out of the 33 points measured are not, being points 4, 15 and 20. Point 4 (250 lux) is located in the middle between two skylights. Point 15 (184 lux) is located on the southern most wall; again well away from the skylight. Point 20 (237 lux) is once again located in the middle of two skylights. All of these locations are at the extremes of the distance from skylight / courtyard edges. It should be noted that high daylight levels are acceptable in office areas, since the eye is so adaptable. The problem of glare on computer screens is a separate issue that is addressed by the placement, and type, of the monitors.

13.3 Summary of daylight strategy

The daylight strategy for the project has been shown to be very successful. Site visits undertaken before the conversion of the basement into the new AGO offices were, from a visual point of view, depressing and oppressive. There was no natural light or visual relief. It was a most uninviting space.

The daylight design has radically altered this. The intent, which was achieved, was to provide a delightful, well daylit environment, as well as to reduce the need for electric lighting and its consequential greenhouse gas emissions. For any building, let alone one which is basically underground, this has been achieved to a very high standard.

The courtyards are a very clever design solution to provide both daylight and visual relief. The high levels of daylight normally experienced at the window edge to the courtyards have been moderated by the use of light shelves, and this excess light thrown back deeper into the building. This has evened out the light levels, and reduced the need for electric light.

The courtyards and skylights have been deliberately placed in an even pattern across the whole office area, in order to provide a more balanced and uniform level of natural light. If the skylights had been concentrated in one area, then this even level of daylight would not have been achieved, with some areas over lit and others under lit. This is confirmed by the light levels recorded on the subject day that show that nearly all spaces were above the required 320 lux level.

The skylights have also been successful; they provide daylight where there was once none. For example, the measurements taken beneath the northern skylight show that where there would have been virtually no natural light (it being approximately 20 metres from the closest daylight source), it has been provided to an acceptable level. Once again the use of light shelves under the skylights has tempered the high light levels associated with daylight directly from the zenith, and redirected them further back into the office space.

In summary, this has been a very successful daylight outcome in most difficult circumstances.

14.0 ELECTRIC LIGHTING

The lighting system consists of suspended luminaires fitted with 3 x 28W T5 fluorescent lamps and dimmable electronic ballasts that provide the artificial lighting to individual offices and the open plan office area. Two lamps provide an upward lighting component while the third lamp provides the downward lighting component. The upward and downward lighting components are individually controlled so that they can respond to the varying levels of natural light coming from the light wells and skylights.

15.0 LIGHTING CONTROLS

The lighting is controlled by a *Clipsal 'C' Bus* system incorporating lighting level sensors (for both the ceiling and desk tops), movement sensors and local area switches. The system operates as follows:

- Movement sensors will activate corridor lights progressively when the first person arrives. Only the upward lighting component is turned on, initially to 80%, and then adjusted to compensate for natural light.
- A local area switch controls a designated work area with the upward lighting component turning on to 80% and the downward lighting component turning on to 100%. The levels are then adjusted to compensate for natural light.
- Generally individual offices are located around the perimeter so only the downward lighting component is adjusted to compensate for natural light while the upward lighting component remains at 100%. This office lighting is also controlled by a local switch and a movement sensor.
- Approximately 10 minutes prior to the programmed end of the working day all luminaires in operation will turn the downward lighting component off and then on again. If a local switch is not activated, to retain lighting in an area or an office for a further two hours, then the lighting will turn off.
- Corridor lighting remains on to provide a safe egress and will only turn off after a time delay, when all office and area lighting has been turned off.
- For cleaning purposes a dedicated switch has been provided to activate the downward component only of selected luminaires to 90%, for a period up to 1 hour, after which time the lighting progressively turns off.
- Light fittings within the toilet areas (downlights with compact fluorescent lamps and wall mounted fittings) are activated by movement sensors.

The reaction time of the lighting system to changing levels of daylight is deliberately slow so that briefly passing clouds do not have the immediate effect of turning up light levels. Anecdotal evidence suggests that this control system works well. It is noted that the upward component of the light fittings maintain an even level of light across the whole ceiling, so that a fitting furthest from the courtyard will have a higher output than a fitting next to the courtyard.

16.0 BUILDING MANAGEMENT SYSTEM (BMS)

A standard BMS was installed and connected to the existing building. All the services, including the lighting system, have their outputs recorded by the BMS system. A 'resource board' has been constructed to provide up-to-date readouts and comparisons on the use of energy, water etc. by the tenancy.

17.0 CHALLENGES

A change to the landscape treatment in the courtyards created a temporary glare problem coming off the light coloured paving surface. This is being addressed by the installation of internal blinds on the north side off the courtyards.

18.0 CONCLUSIONS

The new offices for the Australian Greenhouse Office in Canberra have set high environmental standards in a very difficult design circumstance, and produced an engaging, productive and delightful workplace.

References

Web sites

www.lrc.rpi.edu/daylightDividends

This site is maintained by the Rensellaer Polytechnic Institute in Troy, USA. It has research and advice for building owners, architects, engineers, and contains a series of case studies.

www.abgr.com.au

This is the official site of the Australian Building Greenhouse Rating scheme.

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This is the official web site of the Green Building Council of Australia that has developed and maintains the Green Star scheme.

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Biography

David Oppenheim is a registered architect and Director of the Melbourne-based ESD consultancy, Sustainable Built Environments. He has been involved in energy efficient and low environmental impact architecture for three decades.

David has been involved in over 800 projects that have involved energy and environmental concerns. The designs of his built work have won awards both at state and national level since 1985. He co-founded the firm Taylor Oppenheim Architects in Melbourne in 1980, and building on the firm's green body of work and credentials, established Sustainable Built Environments on the vernal equinox, 2001.

David has been employed by the United Nations, and has represented Australia at two international energy forums involved with building design. He has a particular interest in educational facilities, and has been in several research projects in conjunction with Deakin University in Geelong, Victoria.

David was the principal ESD consultant from SBE for the above project.