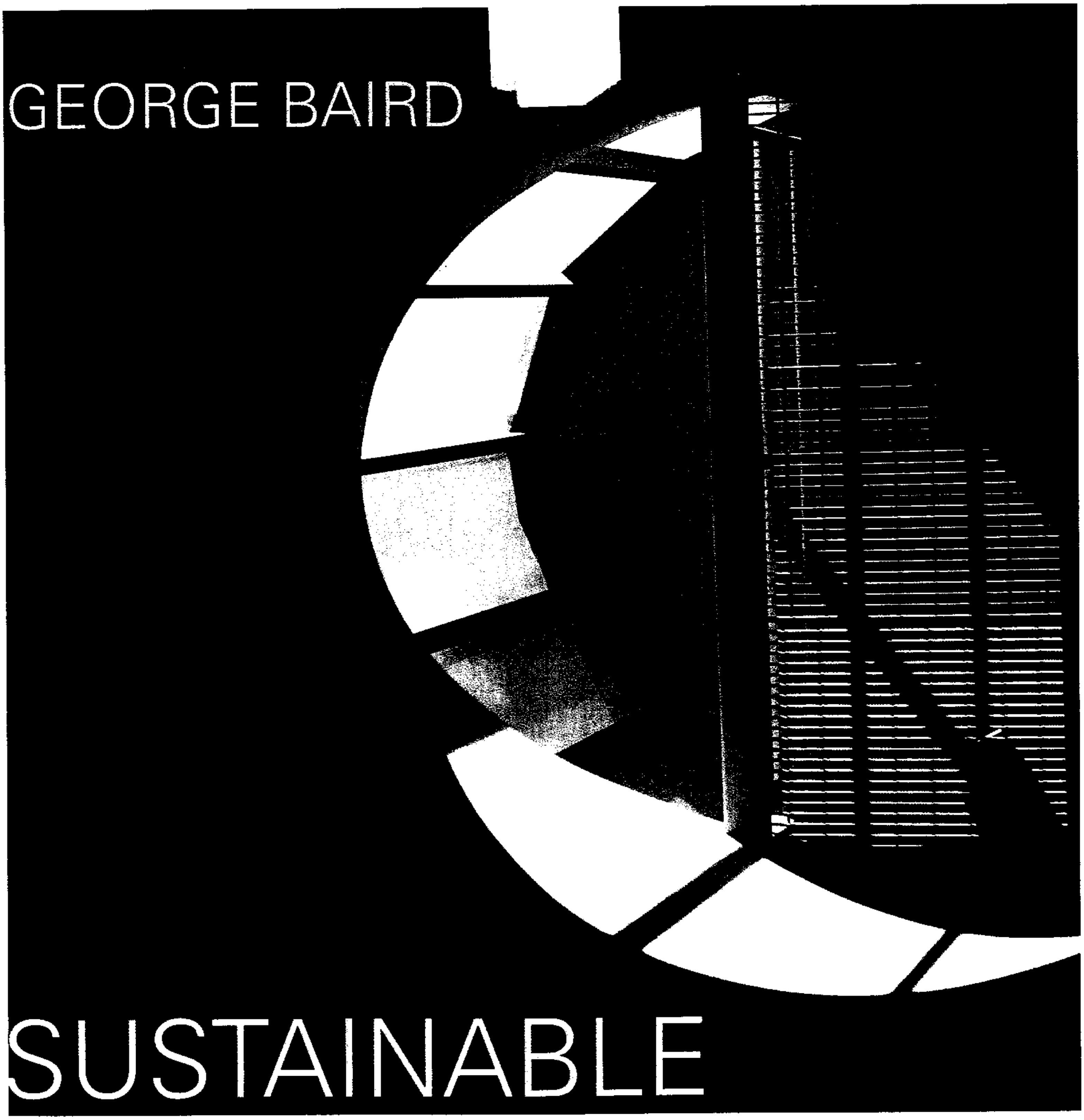
GEORGE BAIRD



SUSTAINABLE BUILDINGS IN PRACTICE

WHAT THE USERS THINK

ROUTLEDGE

Current assessment methods of sustainable buildings do not adequately account for the users' needs. Given that, over the life of a building, total salary costs far outweigh both operating costs and combined capital and rental costs, the occupants' needs are not something which should be sensibly ignored.

This book presents an unbiased evaluation of 30 of the most cutting-edge, sustainable buildings in the world, in terms of the users' perceived comfort, health and productivity. The author has visited the buildings, interviewed the design teams and examined the findings of a 60-question standardised user questionnaire. The book provides:

- 30 case studies covering mixed-mode, passive and environmentally sustainable commercial and institutional buildings;
- Detailed insights into the principles underlying the design of sustainable buildings worldwide, over several climatic zones and 11 countries, together with clear explanations and illustrations of innovative design practice;
- A discussion of common issues and the lessons that may be learnt from a study of the performance of sustainable buildings in practice, from the point of view of the people who use them.

This important book will be of great benefit to architects and engineers, and facility managers of commercial and institutional buildings, as well as developers and researchers, academics and students in these fields.

George Baird is a Professor of Building Science at the School of Architecture, Victoria University of Wellington. A Fellow of the UK's Chartered Institution of Building Services Engineers and New Zealand's Institution of Professional Engineers, he is an experienced researcher and writer and has been involved in the teaching of architects and building scientists for 40 years.

ARCHITECTURE/ENGINEERING

Cover images: George Baird

ISBN 978-0-415-39932-6

Routledge
Taylor & Francis Group
an informa business

29

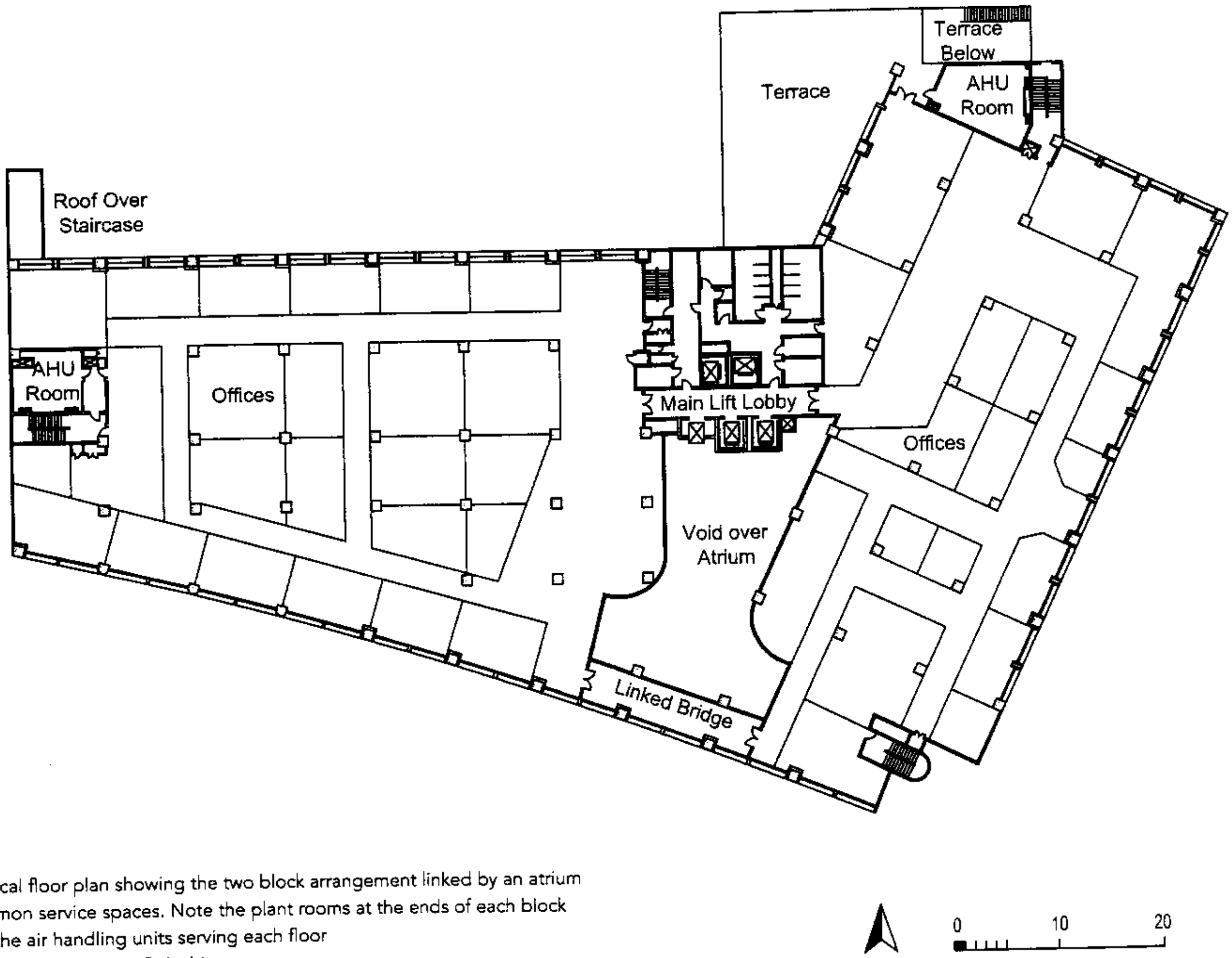
Ministry of Energy, Water and Communications (MEWC) Building Putrajaya, Malaysia

with Maisarah Ali and Shireen Jahnkassim

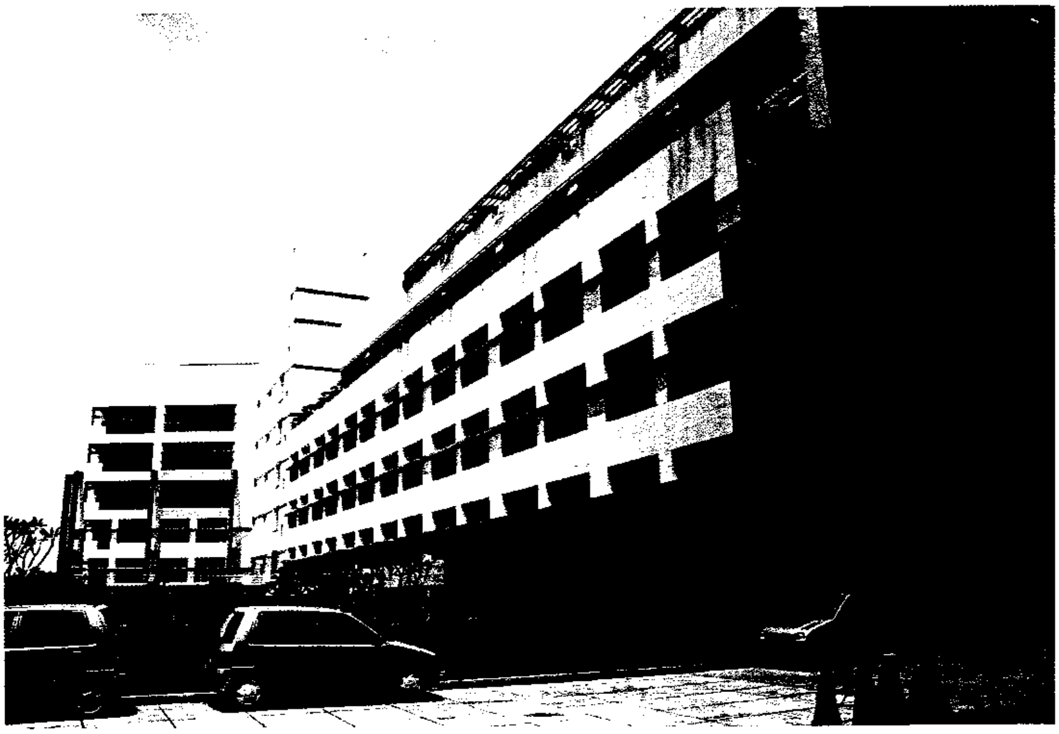
THE CONTEXT

Completed in September 2004 following a two-and-a-half-year construction period, this six-storey office building has an air-conditioned area of just over 19,200m^2, surmounting two levels of parking. Comprised of two linked blocks, it is located at the north-eastern corner of Government Complex Parcel E in Precinct 1 of the city of Putrajaya, the Administrative Capital of the Malaysian Federal Government.

The building houses the Ministry of Energy, Water and Communications. It was designed to be a showcase building for energy efficiency and low environmental impact and to exemplify the Malaysian Government's commitment to 'achieving sustainable development through energy efficiency and conservation' (MEWC, 2006). As well as leading by example, the Ministry wanted '[to] dispel the notion that it is not financially viable to employ energy efficiency in buildings', the hope being 'that it will inspire a greater



29.1 Typical floor plan showing the two block arrangement linked by an atrium and common service spaces. Note the plant rooms at the ends of each block housing the air handling units serving each floor
Source: Adapted from SNO Architects



29.2 View along the north façade. The lower three levels have the characteristic 'punched-hole' windows with light-shelves, while the two upper levels have a triple horizontal band of louvred shading devices. Note too the unglazed west façade to the right of the photograph

29.3 The view from the south-west, with the glazing and shading arrangement evident, and the canopy roofs just visible on the top of each block. The main entrance is to the left on the southern façade under the extended portico. The vertical strip of glazing punctuating the southern façade indicates the location of the atrium and the thermal flue can be seen above

number of similar buildings, both in the public and private sectors' (Danker, 2004: 24, 84).

The brief called for the building to demonstrate, without compromising the comfort of the occupants, energy savings of 50 per cent compared with the operation of a more conventional office building, at an additional capital cost of not more than 10 per cent. No easy task in a climate with year-round temperatures ranging from 22 to 34°C and high humidity levels at this virtually equatorial location of around 3°N latitude. Integral to this demonstration was a commitment, not only to comprehensively monitor and give extensive feedback on the performance of the building, but also to provide a study and research opportunity for professionals and academics (MEWC, 2004), and a demonstration of the feasibility of meeting what at that time was the new 2001 Malaysian Standard for non-residential building energy efficiency.

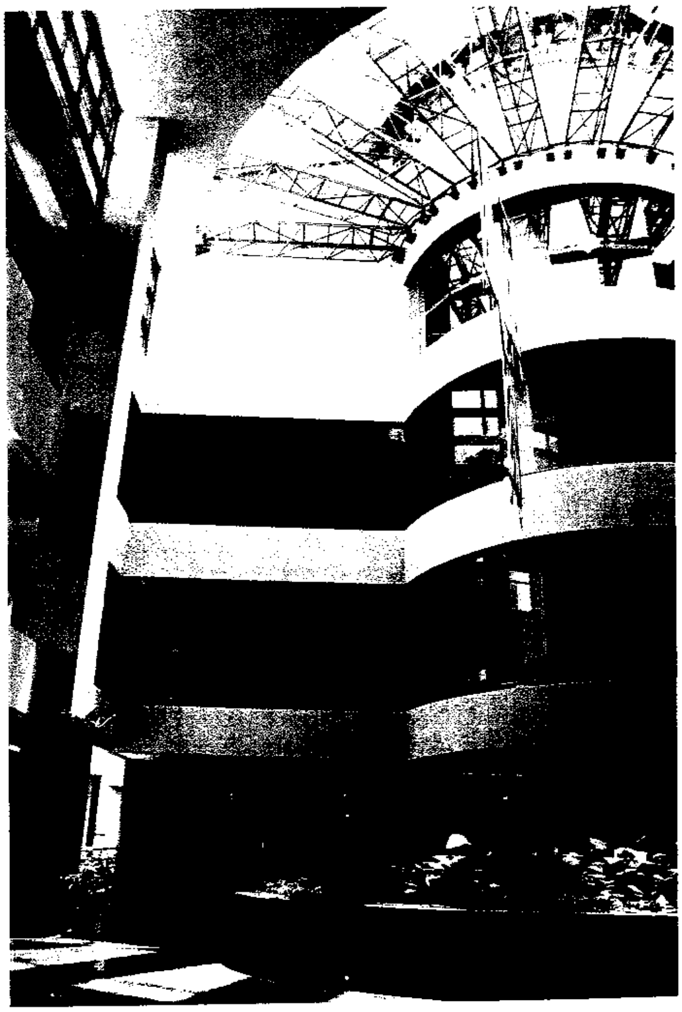
The building was the overall winner of the 2006 ASEAN Energy Award, in the new and existing building category.

THE DESIGN PROCESS

A large team of designers was involved in this project, the developer for which was Putrajaya Holdings Sdn Bhd. The lead architect was Ar Saifuddin bin Ahmad of SNO Architects, Kuala Lumpur, who developed the concept of the two blocks linked by a common atrium space and services area (see Figure 29.1), located and oriented in keeping with the overall plan for Parcel E, but with a building envelope designed

29.4 Close-up exterior view of the two main types of fenestration with their different shading/light-shelf arrangements. The lower levels have 'punched-hole' windows with light-shelves, while the upper levels have a triple horizontal band of louvred shading devices

29.5 Interior view of the naturally ventilated atrium space. The glazing at the upper level provides daylight to the space, and beyond that, the thermal flue acts to provide air movement



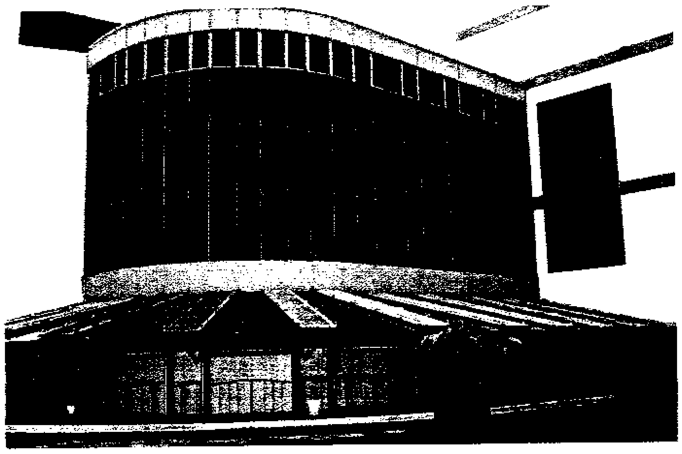
to minimise heat gains and maximise the use of daylight (Saifuddin, 2006). The firm of Norman, Disney Young was responsible for the basic mechanical and electrical engineering systems design.

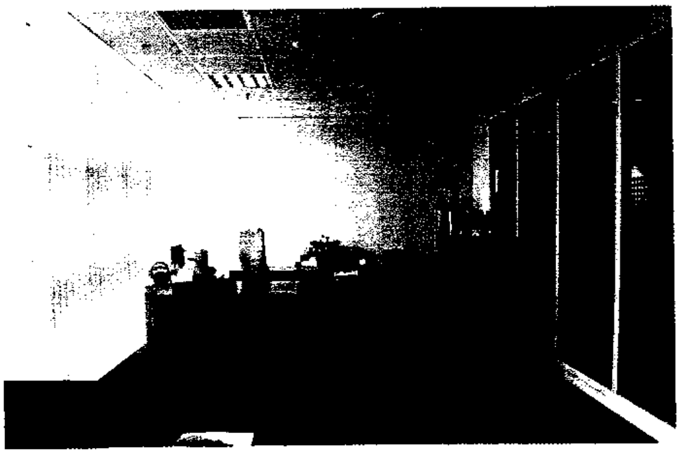
Design input in relation to the minimisation of the energy consumption of these systems (as well as their subsequent monitoring), was provided by a group of specialists led by Poul Kristesen (2006) under the auspices of the Danish International Development Assistance (DANIDA) programme (MEWC, 2004). Their computer modelling indicated that the 50 per cent savings target could be met, with a predicted energy use index of around 100kWh/m^2.year, less even than the 135kWh/m^2.year set by the new Malaysian Standard.

29.6 External view of the vertically glazed thermal flue with automated louvred openings at the top for air to exit the atrium. The sloping glazing at low level provides daylight to the atrium and is fitted with retractable sailcloth shades to control glare

29.7 Typical perimeter single-person office. Note the vertical louvres for glare control on the left, and the glazed partition on the right which enables some daylight penetration to the adjacent corridor

29.8 Typical open plan office adjacent to atrium space





THE DESIGN OUTCOME

Building layout, construction, and passive environmental control systems

The site for the building is in the north-east corner of Parcel E. Roughly L-shaped in plan (see Figure 29.1), the layout is designed to give the majority of the façades a northerly or southerly orientation in order to minimise direct solar heat gain (Figures 29.2 and 29.3). The walls are well insulated and light in colour (by comparison with some of the neighbouring buildings), while the top floor has 100mm of insulation and an additional canopy roof (Figure 29.3).

Single-glazed throughout and predominantly non-openable, the building fenestration (Figure 29.4) has been designed to minimise solar heat gain and optimise the penetration of daylight. The windows on the upper floors have a triple set of external louvres, one at high level functioning as a shading device, the others at intermediate levels acting as both shading device and partial light-shelf (they have an open structure to enable air to pass though). On the lower floors, what the designers term the 'punched-hole' windows (Suifuddin, 2006) are heavily recessed to provide an initial measure of shading and are fitted with a solid external light-shelf at around mid-height which provides additional shading as well as enabling daylight penetration up to 6m depth. There is no glazing on the western façade, other than some minor windows into an emergency stairwell, while the windows on the easterly (ESE) façade have been given a deeper light-shelf than those on the north and south to help cope with low-angle morning sun (Figures 29.2, 29.3, and 29.4).

While the two main blocks are fully air conditioned, their linking four-storey high atrium and entrance area is naturally ventilated (Figure 29.5), and acts as a transition space from a climatic as well as a functional point of view. Fully open at the lower level to allow entry of outside air, the atrium is surmounted by a two-storey, fully glazed, easterly-oriented, thermal flue, designed to draw air up through the space using natural convection, to exit via automated louvres at high level (Figure 29.6).

While the deep plan of the building makes it difficult to provide daylight to the entire floor plate, there has been an attempt to prioritise permanent work areas on the perimeter of the building (Figure 29.7), with secondary functions (storage areas, meeting rooms, etc.) in the interior (KTAK, 2006, Paper 3). In addition, the use of glazed interior partitions and the location of some offices adjacent to the atrium provide an additional link to the ambient daylight condition (Figures 29.8 and 29.9).

Active environmental control systems

As already noted, apart from the atrium area and a few emergency openings, the building has a sealed envelope and is fully air conditioned, with a chilled water supply from a nearby gas-fired district cooling plant. Each floor of each block has an air handling unit located at one end of its floor plate (Figures 29.1 and 29.10). These AHUs supply chilled air to their respective office floors via a zoned variable air volume system, designed to maintain an inside temperature of 24°C.

The fresh air supply rate is controlled via CO_2 sensors, and electrostatic air filters (Figure 29.10) are used to clean the mixture of fresh and return air before supplying it to the offices. Separate and independent electrically driven split system air conditioners are used where continuous 24/7 operation is required (for computing and telecommunications installations, for example).

In keeping with the care taken over daylighting, the artificial lighting has been kept down to an installed load of around 11W/m² while maintaining an average illuminance of 350 lux.

A comprehensive building energy management and control system monitors and controls the operation of these environmental control systems as well as reporting on the building's energy consumption in some detail (Figure 29.11). Arguably just as important, a highly qualified in-house energy manager oversees this aspect of the building's operation (MEWC, 2004) and provides guidance documentation for the building users.

Rainwater from the canopy roof is collected in rooftop tanks and used for plant irrigation, while a 3kWp grid-connected photo-voltaic array is used to power a water feature in the atrium.

29.9 Open-plan office – note various environmental sensors at high level as well as typical ceiling layout

29.10 Typical plant room (see Figure 29.1 for locations) housing the air handling unit serving a floor of one of the blocks. Note the louvred fresh air inlet in the centre of the wall to the left of shot, the bank of eight electrostatic filters at intake to the AHU, the supply air duct issuing from the top of the AHU, and the chilled waterpipe connection from the district cooling plant

29.11 Central building control system – visible to staff and visitors through a window from the adjacent entrance area

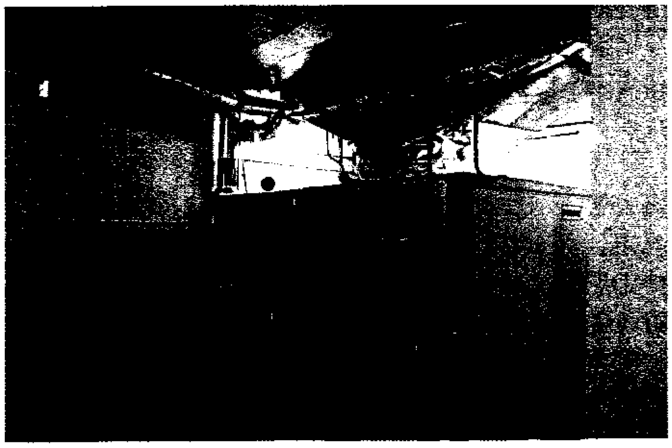


TABLE 29.1

Average scores for each factor and whether they were significantly better, similar to, or worse than the BUS benchmarks

Factor	Score	Rating (Worse / Similar / Better)	Factor	Score	Rating (Worse / Similar / Better)
OPERATIONAL FACTORS					
Image to visitors	5.52	Similar	Cleaning	4.99	Similar
Space in building	5.10	Better	Availability of meeting rooms	5.44	Better
Space at desk – too little/much[4]	4.86	Similar	Suitability of storage arrangements	4.87	Better
Furniture	5.36	Better	Facilities meet requirements	5.22	Similar
ENVIRONMENTAL FACTORS					
Temp and Air in Winter			Temp and Air in Summer		
Temp Overall	5.16	Better	Temp Overall		
Temp – too hot/too cold[4]	4.51	Worse	Temp – too hot/too cold[4]		
Temp – stable/variable[4]	4.54	Similar	Temp – stable/variable[4]		
Air – still/draughty[4]	4.13	Better	Air – still/draughty[4]		
Air – dry/humid[4]	4.21	Similar	Air – dry/humid[4]		
Air – fresh/stuffy[1]	3.95	Similar	Air – fresh/stuffy[1]		
Air – odourless/smelly[1]	3.55	Similar	Air – odourless/smelly[1]		
Air Overall	4.96	Better	Air Overall		
Lighting			**Noise**		
Lighting Overall	5.10	Better	Noise Overall	4.99	Better
Natural light – too little/much[4]	4.32	Similar	From colleagues – too little/much[4]	3.49	Similar
Sun & Sky Glare – none/too much[1]	3.68	Similar	From other people – too little/much[4]	3.53	Similar
Artificial light – too little/much[4]	4.10	Better	From inside – too little/much[4]	3.17	Similar
Art'l light glare – none/too much[1]	3.91	Similar	From outside – too little/much[4]	2.99	Worse
			Interruptions – none/frequent[1]	3.19	[illegible]
CONTROL FACTORS[b]			**SATISFACTION FACTORS**		
Heating (7%)	2.90	Similar	Design	5.44	[illegible]
Cooling (22%)	3.04	Similar	Needs	5.26	[illegible]
Ventilation (8%)	3.17	Similar	Comfort Overall	5.20	[illegible]
Lighting (18%)	3.95	Similar	Productivity %	+16.00	[illegible]
Noise (8%)	3.46	Similar	Health	4.77	[illegible]

NOTES: (a) unless otherwise noted, a score of 7 is 'best'; superscript [4] implies a score of 4 is best, superscript [1] implies a score of 1 is best; (b) the per cent values listed here are the percentages of respondents who thought personal control of that aspect was important.

TABLE 29.2
Numbers of respondents offering positive, balanced, and negative comments on 12 performance factors

Aspect	Number of respondents			
	Positive	Balanced	Negative	Total
Overall Design	26	3	7	36
Needs Overall	19	–	7	26
Meeting Rooms	18	1	9	28
Storage	5	1	14	20
Desk/Work Area	19	3	10	32
Comfort	14	3	2	19
Noise Sources	12	1	8	21
Lighting Conditions	16	1	10	27
Productivity	7	6	3	16
Health	8	4	3	15
Work Well	36	–	–	36
Hinder	–	–	30	30
TOTALS	180	23	103	306
PER CENT	58.8	7.5	33.7	100.0

USERS' PERCEPTIONS OF THE BUILDING

Overall response

For most (84 per cent) of the 148 or so respondents (56 per cent female, 44 per cent male), the building was their normal place of business, virtually everyone working five days per week and averaging 8.6 hours per day, of which 7.1 were spent at their desk and 6.1 at a computer. Some 46 per cent were over 30, 56 per cent less, and around 71 per cent had worked in the building for more than a year, mostly at the same desk or work area. Around 33 per cent shared with five or more colleagues, with the remainder equally divided between single offices, sharing with one other, or sharing with two to four others.

Significant factors

Table 29.1 lists the scores for each of the survey questions and indicates those aspects of the building that the staff perceived as being significantly better, similar to, or worse than the benchmark and/or scale mid-point. In this case, some 16 aspects were significantly better, only two significantly worse, while the remaining 19 aspects had much the same score as the benchmark (note the absence of wintertime data for this location).

In terms of operational aspects, this building scores very well on all eight counts – above the mid-point of the scale, and the same as or better than the benchmark, in every case. The score for space at desk (4.86) implied respondents felt they had too much space at their desks!

The users' responses to environmental factors were more variable. The overall scores for temperature and air were better than their respective benchmarks and well above their scale mid-points. However, there were indications that the temperature was felt to be on the cold and variable side, and the air a little on the humid side. While lighting overall scored significantly better than the benchmark and scale mid-point and respondents did not perceive glare to be excessive, there were indications of too much natural light. Respondents scored the building well for noise overall and for the low occurrence of interruptions, but indicated there was too little noise from all the potential inside and outside sources considered. Lighting and cooling were the only aspects where a moderate number of respondents (18 and 20 per cent respectively) rated personal control important – neither scored particularly highly, despite being equal to or better than their respective benchmarks.

Perceptions of the satisfaction variables (design, needs, overall comfort, productivity, and health) were all significantly better than their respective benchmarks, averaging well over 5.00 in most cases. Even health (the one exception) was significantly higher than the benchmark, and with a score of 4.77 significantly higher than the mid-point of the scale too, implying the staff felt healthier when in the building – a relatively unusual occurrence.

Users' comments

Overall, some 306 responses were received from staff under the 12 headings where they were able to add written comments – some 17 per cent of the 1776 potential (306 respondents by 12 headings). Table 29.2 indicates the numbers of positive, balanced, and negative comments – in this case 58.8 per cent were positive, 7.5 per cent neutral, and 33.7 per cent negative. The comments seemed to come in approximate proportion to the number of users on each floor.

In keeping with the general tenor of its overall scores, this building prompted a high percentage of positive comments and a creditable list of things that worked well – clean, comfortable and spacious with good computing facilities according to most of the respondents to this question. The main hindrances seemed to be concerned with power and computing outages.

The proportion of positive comments reflected the scores in most instances, the main exception being storage where the majority of comments were negative, despite this aspect scoring better than the benchmark and scale mid-point.

Overall performance indices

The Comfort Index, based on the comfort overall, noise, lighting, temperature, and air quality scores, works out at +1.23 which is significantly better than both the BUS Benchmark and the scale mid-point; while the Satisfaction Index, based on the design, needs, health, and perceived productivity scores, is +1.42, which is also significantly higher than the benchmark and the scale mid-point (noting these are both around zero on a -3 to +3 scale).

The Summary Index, being the average of the Comfort and Satisfaction Indices, works out at 1.33, while the Forgiveness Factor, calculated to be 1.03 in this instance, indicates that staff as a whole may be only slightly tolerant of minor shortcomings in individual aspects such as temperatures, air quality, lighting, and noise (a factor of 1 being the mid-point on a scale that normally ranges from 0.5 to 1.5).

In terms of the Ten-Factor Rating Scale, the building was 'Exceptional' on the 7-point scale with a calculated percentage value of 98 per cent. When All-Factors were taken into account, the percentage value worked out at 76 per cent – comfortably within the 'Good Practice' band.

OTHER REPORTED ASPECTS OF PERFORMANCE

Occupant survey

Prior to the work reported above, a questionnaire survey of indoor environmental performance had been conducted under the auspices of DANIDA (KTAK, 2006, Paper 5). That survey had 149 respondents and while not readily comparable, it is interesting to look at the overall results.

Office air quality and temperature, for example, were rated 'acceptable' to 'very good' by well over 90 per cent of respondents, echoing their high scores reported above. Somewhat less conclusive was the indication that while around 40 per cent of respondents perceived it as being 'too cold throughout the day' often or sometimes, around 40 per cent thought it was too hot.

In the case of lighting, around 80 per cent of respondents rated it as 'just right' while around 55 per cent of respondents claimed to be affected by glare at some time, more or less in keeping with the tenor of the results reported above.

Energy consumption and inside temperatures

As noted earlier, the client was committed to comprehensive monitoring and feedback on the project. The main manifestations of this have been a seminar (KTAK, 2006) on the lessons learned from the project and a report (MEWC, 2006) detailing the building's energy performance.

At the seminar, held in May 2006 after the building had been occupied for some 20 months, key officials from the Ministry and from DANIDA described the commissioning, operation and monitoring of the building. While many aspects were covered, it is perhaps worth noting that temperatures in the air-conditioned offices were recorded as being reasonably stable around the 24°C mark as one might anticipate, temperatures in the naturally ventilated atrium were relatively stable at around 2–3°C cooler than the outside air during daytime, and up to 2°C warmer at night.

The report notes that for 2005, with the building operating 2,930 hours, the area energy use index was 114kWh/m^2.yr. Also of interest was the fact that the CO_2 levels in the building were mainly in the 280–450ppm range, this being attributed to relatively low population densities combined with relatively high rates of air infiltration.

ACKNOWLEDGEMENTS

I must first of all express my gratitude to Energy Manager Abdul Rahim bin Mahmood for granting permission for me to undertake this survey. Thanks are also due to Nadrahanim Nordin Hanim, Technical Assistant to the Energy Manager for her overall help in conducting the survey, together with personnel from Pusat Tenaga Malaysia (the Malaysian Energy Centre) who assisted with the distribution of the questionnaires.

My particular thanks must go to Dr Puteri Shireen Jahn Kassim and Dr Maisarah Ali of the School of Architecture and Environmental Design at the International Islamic University of Malaysia for their generous assistance and direct involvement with various aspects of the study; and it is a pleasure to thank Ar. Saifuddin bin Ahmad, Director of SNO Architects, Poul E. Kristensen, Director of IEN Consultants, Steve Lojuntin of ECO Energy (and formerly with DANIDA), Messrs Seng, Bee, and Thong of Putra Pedana Construction Sdn Bhd, and again Energy Manager Abdul Rahim bin Mahmood for assisting my understanding of the building and its underlying design and operational processes.

REFERENCES

Danker, M. (ed.) (2004) *Low-energy Office: The Ministry of Energy, Water and Communications Building*, Putrajaya: Kementerian Tenaga, Air dan Komunikasi.

Kristensen, P. (2006) Transcript of interview held on 11 August, Kuala Lumpur.

KTAK (2006) 'Seminar on the KTAK Low Energy Office – Lessons Learned', Ministry of Energy, Water and Communications, Putrajaya, 6 May.

MEWC (2004) *MEWC Low Energy Office Building in Putrajaya: Energy Efficient Design Features*, Putrajaya: Ministry of Energy, Water and Communications.

MEWC (2006) *Energy Performance of LEO Building*, Putrajaya: Ministry of Energy, Water and Communications.

Saifuddin, A. (2006) Transcript of interview held on 17 August, Kuala Lumpur.