# Sustainable Design Practice in Government's Office Buildings in Malaysia: A Brief Literature.

**Yakubu Aminu Dodo[1], Mohd Zin Kandar[2], Dilshan Remaz Ossen[3], Yaik-Wah Lim[4], Yong Razidah Rashid[5] & Mohd Sabere Sulaiman[6]**

[1]Ph.D. Research Candidate, Faculty of Built Environment, Universiti Teknologi Malaysia
[2]Associate Professor, Faculty of Built Environment, Universiti Teknologi Malaysia.
[3]Senior Lecturer, Faculty of Built Environment, Universiti Teknologi Malaysia.
[4]PhD. Research Candidate Faculty of Built Environment, Universiti Teknologi Malaysia
[5]Technical Researcher Representative, Public Works Department (JKR) Kuala Lumpur, Malaysia
[6] Head of Research Project, Public Works Department (JKR) Kuala Lumpur, Malaysia

E-mails: [1]dyaaminu@yahoo.com

ABSTRACT

Infrastructure development has impact our environment negatively and caused climate change. The current trends in office design worldwide have shifted to energy efficient and environmental friendly buildings. Studies show that JKR designs don't consider seriously, aspect of energy efficiency. This study is a review of existing literature on office design practice in Malaysia. This Study inferred that current office buildings could achieve Building Energy Index (BEI) between 65 to 135 kWh/m2/yr as demonstrated by Green Energy Office (GEO) and Low Energy Office (LEO) buildings in Malaysia. Thus, the future standards for government office buildings must be responsive to dynamic environment to achieve sustainable design.



Keywords: energy efficiency, government's office, Malaysia & sustainable design

## 1 Introduction

Public Works Department JKR has over the years become the driving forces on development and construction of government buildings such as office, schools, police stations and residential quarters for government staff. JKR has design standard office building for government since 1960's. Currently some buildings for government office were design by appointed consultants.

The current trends on office building design worldwide has shifted on office that is not only efficient and environmental friendly but also provides high level of comfortable and user response space layout in order to suite to new office space usage. Thus the future standard for government office building design must be responsive with dynamic works environment focusing on the whole building design solution, which are comfortable, energy efficient and create productive environment.

Studies shows current office building in Malaysia consumes high energy with average Building Energy Index (BEI) of about 200 to 300 kWh/m$^2$/yr, whereas the BEI between 65 to 135 kWh/m$^2$/yr is achievable if the building were design with high consideration on climatic and energy efficient consideration as demonstrated by GEO in Bangi and LEO Building in Putrajaya. In hot and humid climates like in Malaysia, natural sunlight have drawback of increasing heat gain into the building, which in turn increases the use of air-condition load if designer does not carefully understood the impact of solar radiation. Use of daylighting is not considered as an important design criterion in most government buildings. The main reason is the misconception of differentiating sunlight and daylight characteristics.

Generally sunlight transmits solar heat gains but proper daylight does not consist of heat gain. Direct uses of natural light (sunlight & daylight) contribute to direct solar heat gain and glare on the office occupants. Furthermore high cooling load and energy consumption are unresolving issues that the building owners have to bear.

According to Robbins (1986), the benefits of daylight can be summarized as:- Quality of Light, Importance of daylight as a design element, View, Use of daylight apertures as fire exits in emergencies, Energy conservation, Energy consumption and peak demand cost savings resulting from the use of daylight, No cost change in construction, Opportunity to develop integrated structural and mechanical systems, Psychological and physiological benefits not obtainable with electric lighting or windowless buildings & The genuine desire to have natural light in a room or space

## 2. Methodology

This study investigate current government office design layout and design profile towards understanding of the level of; daylighting, occupant visual, office space, layouts, design, comfort and energy efficient buildings. A review of existing literature on office design practice in Malaysia and elsewhere were carry out using Google scholars and ISI web of knowledge.

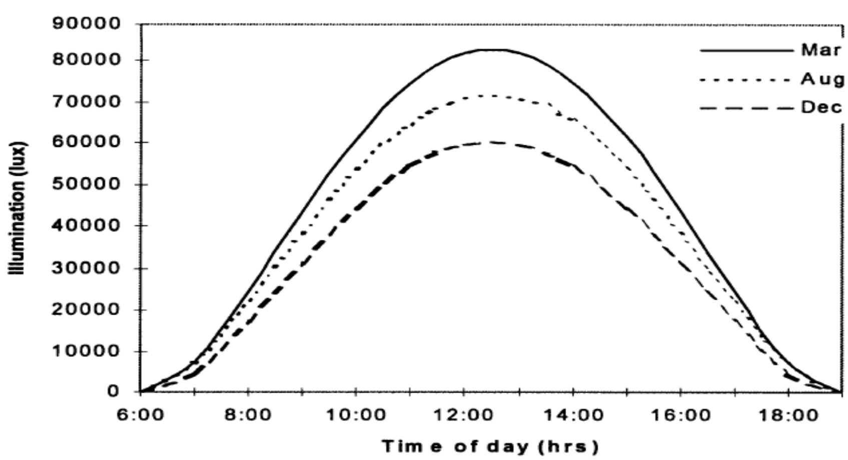
## 3. Literature Review

The price of electricity used during peak demand times is higher than the price of electricity used when the overall demand wanes. Effectively using the daylight available during those business hours not only reduces the total electricity demanded by lighting and HVAC systems, but also reduces peak demand, minimizing the use of the most expensive electricity. Saving one kilowatt-hour (kWh) of energy during daylight hours saves a building more money than saving that same kWh at midnight.

Natural light consists of direct sunlight and daylight. Direct sunlight results unwanted heat gain into the buildings, whereas, daylight is useful for illuminating the spaces. Thus, the balance between daylight penetration and direct sunlight shading is an important design issue to achieve comfort and energy saving. This is even more critical in Malaysian tropical climate, with high and uniform intensity of solar radiation. Since Malaysian sky is dominant by intermediate sky, the formation of clouds results inconsistent external illumination. Thus, it is challenging to create uniform daylight distribution and avoid glare problem in the building design. Understanding of the daylight design strategies and local climate conditions are essential.

### *2.1 Principles of Thermal Comfort for Hot Humid Climate*

The main causes of climatic stress in Malaysia are high temperature, solar radiation, humidity and glare. The factors influencing thermal comfort consist of personal and environmental variables; the former depending on a person's activity and clothing level and the latter depending on air temperature, humidity, radiation and air movement. Hot and humid areas, where the values for all of the above are generally high possess two major problems, i.e. the avoidance of excessive solar radiation and the evaporation of moisture by breezes of ventilation.




Source: (Zain-Ahmed et al., 2002b)

Figure 1: Daylight availability at Subang, Malaysia

Source: (Authors field work)
Figure 2: Example of daylight in office buildings

Incorporating natural light into an office space creates an opportunity to improve the environmental performance of the project, while promoting individual well-being and enabling capital building investments to provide better economic returns. The most basic goals in office space design are to create a place where work can be accomplished and communication can occur. Today, light is instrumental in creating that productive environment, because 90 percent of the communication in the workplace occurs visually.

Light also impacts the mood, health, and behavior of the employees it touches. Both natural and electric light can illuminate a space, but they do not impact people equally. Studies have corroborated a long-held belief that there is a strong correlation between positive mood and daylight exposure. Recent studies also imply that incorporating outdoor views into the office will positively affect employee motivation, satisfaction, productivity, and comfort, which can manifest in improved employee retention and workforce output.

Table 1: Lighting performance indicator

| # Performance indicator | Interpretation |
|---|---|
| 1 WORK PLANE ILLUMINANCE | |
| < 100 lx | Too dark for paper and computer work |
| 100-300 lx | Too dark for paper work / acceptable for computer work |
| 300-500 lx | Acceptable for paper work / ideal for computer work |
| > 500 lx | Ideal for paper work / too bright for computer work |
| 2 ILLUMINANCE UNIFORMITY ON THE WORK PLANE | |
| $E_{min}/E_{max} > 0.5$ | Acceptable |
| $E_{min}/E_{max} > 0.7$ | Preferable |
| 3 ABSOLUTE LUMINANCE | |
| > 2000 cd/m2 | Too bright, anywhere in the room |
| > 1000 cd/m2 | Too bright, in the visual field |
| < 500 cd/m2 | Preferable |
| < 30 cd/m2 | Unacceptably dark |
| 4 DAYLIGHT FACTOR | |
| < 1 % | Unacceptably dark, negligible potential for daylight utilization |
| 1-2 % | Acceptable, small potential for daylight utilization |
| 2-5 % | Preferable, large potential for daylight utilization |
| > 5 % | Ideal for paper work, too bright for computer work, total daylight autonomy |

Source: (Dubois, 2001a)

### *2.2 Lighting Quality and Standard*

There are several standards used for electric lighting. In Malaysia, the Malaysian Standard 1525:2007 has outlined illuminance levels recommendations for various tasks and applications as shown in Table 1. The recommended daylight factor (DF) for an effective daylight-lit office space is 1.5%. This standard should be employed as benchmark in lighting study in Malaysia. However, other criteria such as illuminance uniformity, luminance value, luminance ratio, etc. are not mentioned.

Table 2: Recommended average illuminance levels

| Task | Illuminance (Lux) | Example of Applications |
|---|---|---|
| Lighting for infrequently used area | 20 | Minimum service illuminance |
| | 100 | Interior walkway and car-park |
| | 100 | Hotel bedroom |
| | 100 | Lift interior |
| | 100 | Corridor, passageways, stairs |
| | 150 | Escalator, travellator |
| | 100 | Entrance and exit |
| | 100 | Staff changing room, locker and cleaner room, cloak room, lavatories, stores. |
| | 100 | Entrance hall, lobbies, waiting room |
| | 300 | Inquiry desk |
| Lighting for working interiors | 200 | Gate house |
| | 200 | Infrequent reading and writing |
| | 300 – 400 | General offices, shops and stores, reading and writing |
| | | Drawing office |
| | 300 – 400 | Restroom |
| | 150 | Restaurant, Canteen, Cafeteria |
| | 200 | Kitchen |
| | 150 – 300 | Lounge |
| | 150 | Bathroom |
| | 150 | Toilet |
| | 100 | Bedroom |
| | 100 | Class room, Library |
| | 300 – 500 | Shop / Supermarket/Department store |
| Localized lighting for exacting task | 200 – 750 | Museum and gallery |
| | 300 | Proof reading |
| | 500 | Exacting drawing |
| | 1000 | Detailed and precise work |
| | 2000 | |

Source: (Department of Standards Malaysia, 2007)

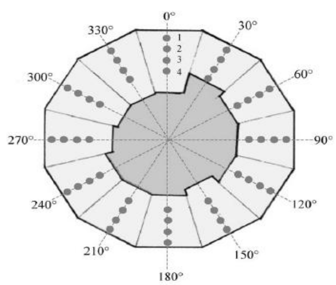
Dubois (2001a) had studied various lighting quality standards from different sources such as IES and CIE. A combination of these standards was used for daylight analysis as shown in Table 2. Some of these recommendations were adapted from electric lighting standards. Therefore, daylight may give better tolerances. This study was carried out under temperate climate. Thus, the recommended DF is considerably high for tropical climate in Malaysia.

### *2.3 Neutral Temperature Zone in Malaysia*

The analytical method of evaluating the comfort zone for Malaysia have been studied by several authors (Rajeh, 1989; Zain Ahmed, Sayigh and Othman, 1997; Abdul Rahman and Kannan, 1997, Hamdan et al., 2007), using the “Neutrality Temperature”. This is the temperature at which the respondents in the various studies experienced neither warm or cool, which is a state of “neutral” or “comfortable”. It is the midpoint of the comfort zone, as an average value for many experimental subjects. There are four factors that can combine together to produce different neutral temperature for the individual: thermal environment, level activity, thermal insulation of the clothing and physiological state of the individual. For adults the neutrality temperature ranges from 17°C to 30°C.

The observed range of neutrality temperatures is therefore effectively 13 degree. Kandar and Behzad (2009), reviewed studies done worldwide on double skin facade technology, investigation was carried out on the current development in double skin façade study and possible implementation in building design in Malaysia to improve building performances. It concluded that each building need its specific design of façade related to its location, occupancy policy, climate condition, facilities and so on. LEO Building and Security Commission Building has proved that the double skin application influenced their energy usage.

Table 3: case studies of existing building in Malaysia on daylight consideration for energy efficiency

| **Case Studies** | **Gross Floor Area** | **Energy Index** | **Commentary on the buildings** |
|---|---|---|---|
| **Kompleks TunRazak (KOMTAR) Building**<br><br>Hijjas Kasturi A case study was conducted on KOMTAR, Penang, Malaysia by Sharifah and Sia (2004) | 25,000m² | | The results showed that huge amount of glass surrounding the floor area yielded generous distribution of DF. The DF was found ranged from 6% (nearest to window) to 2% (further away from window). |
| **Mesiniaga Building, Subang Jaya, Malaysia**<br><br>T.R. Hamzah & Yeang in 1992, Figure Plans of MenaraMesiniaga (Walczak, E. L., 2002) | 6503 m². | | The building is an environmental filter, an analogy for synthesis and analysis.<br>Headquarters for IBM in Subang Jaya near Kuala Lumpur. The architect Ken Yeang designed this building as an example of his bioclimatic skyscraper practices and principles. |
| **Low Energy Office (LEO) Building, Putrajaya, Malaysia**<br><br>The windows are primarily orientated to the North and the South and constitute 25 – 39 % of the façade area, depending on orientation. | 20,000 m² | 114 kWh/m²/year | Exterior shading is most efficient, as the sun is stop before it entering the building. In the LEO Building, two type of window façade are used: The punch hole window facades in the lower floors, and curtain wall windows with exterior shading louvers in the upper floors |

| | | | |
|---|---|---|---|
| **Green Energy Office (GEO) Building, Bangi, Malaysia**<br> | 4,000 $m^2$ | 35 $kWh/m^2/year$ | Relying on solar power for its energy, the building serves as a benchmark for sustainable energy solutions for the building sector in the country and surrounding region.<br>Placed Malaysia on the map, as the first completely self-sustaining building in Southeast Asia |
| **Security Commission Building, Kuala Lumpur, Malaysia**<br><br>Architects: Hijjas Kasturi Associates<br>Completed: 2000 | 25,000m<br>2 | | The façade is designed to be climatically responsive to the external environment.<br>The entire building facade has a hollow double skin, which forms a buffer between indoor and outdoor temperatures and climatic conditions. As a result, transparency to and from the building is optimized. |

Source: Author field work

## 4. Result & Discussion

Some researches previously studied the impact of solar shading, window size and room geometry on building daylight distribution and energy consumption as demonstrated by Zain-Ahmad (2002); Sharifah and Sai (2004); Ossen (2005); Loutzenhiser et al. (2007); Lim et al. (2009) Although there were effort to protect direct solar radiation by introducing shading device, there are little guideline found. Related study on daylight and solar radiation was reviewed.

Understanding of the daylight design and local climate condition is important to achieve the balance between daylight penetration and solar heat gain shading. The use of daylight in office buildings has been applied in several buildings in Malaysia such as LEO building and GEO building. This shows the great potential of daylight for energy efficiency. Daylight utilization is an effective strategy for energy saving as well as visual comfort.

## 5. Conclusion

Daylight is more efficient at providing light in comparison to electric lighting and producing less heat for the same amount of light. Zain-Ahmed et al. (2002a) stated that savings of a maximum of 10% can be achieved by using daylighting strategies alone. Moreover, Athienitis and Tzempelikos (2002) claimed that the daylight benefits in term of increased productivity and reduced absenteeism of office workers probably surpass the significant energy savings. Research shows office building in Malaysia have Building Energy Index (BEI) of 200 to 300 kWh/m2/yr, whereas the BEI between 65 to 135 kWh/m2/yr is achievable as demonstrated by GEO in Bangi and LEO Building in Putrajaya. Occupant's comfort (thermal & visual) unintentionally neglected by most designers, thus occupant's are 'forced' to adjust their working area position to achieve comfortable settings.

**Acknowledgement**

The authors will like to acknowledge JKR-UTM Research Team for their various contribution to this research project title *'Developing a comfortable and Energy Efficient Government's Office Building Design'* Vote no. 73751, Most especially JKR who finance this project and also thank the International Doctorial Fellowship (IDF) initiated by Universiti Teknologi Malaysia (UTM).

## References

Abdul Rahman, S., and Kannan, K.S., (1997). Air Flow and Thermal Simulation Studies of Wind Ventilated Classrooms in Malaysia. Special Issue World Renewable Energy Congress, Energy Efficiency and the Environment. Renewable Energy 8 (1-4), 264-266.

Athienitis, A. K. and Tzempelikos, A. (2002). A methodology for simulation of daylight room illuminance distribution and light dimming for a room with a controlled shading device. *Solar Energy*. 72 (4), 271–281.

Department of Standards Malaysia (2007). "Malaysian Standard: Code of Practice on Energy efficiency and Use of Renewable Energy for Non-Residential Buildings (1st Revision)". Malaysia. MS 1525:2007

Dubois, M. C. (2001a). *Impact of Solar Shading Devices on Daylight Quality: Measurements in Experimental Office Rooms*. Research Report. Lund, Sweden: Lund University.

Dubois, M. C. (2001b). *Impact of Solar Shading Devices on Daylight Quality: Simulations with Radiance.* Research Report. Lund, Sweden: Lund University.

Hamdan, M. A., Zin Kandar, M. and Roshida, A. M. (2007). Comfortable Housing Model in New Housing PPRT for Orang Asli. Research Report. Universiti Teknologi Malaysia.

Kandar, M. Z. and Behzad, R. (2009). "*The Future of Double Skin Façade Design and Installation in Malaysia's Building Industry In View To Support Malaysia's Green Building Index Program.*"International Conference on Construction Industry, Padang Sumatera, August 2009.

Lim, Y. W., Ahmad, M. H. and Ossen, D. R. (2009). Effect of solar shading, fenestration and room geometry on office building energy efficiency in hot humid tropic.3rd International Conference on Built Environment in Developing Countries. 2-3 December. Universiti Sains Malaysia, USM, Penang, Malaysia, 174-185.

Loutzenhiser, P.G., Maxwell, G.M. and Manz, H. (2007). An empirical validation of the daylighting algorithms and associated interactions in building energy simulation programs using various shading devices and windows. *Energy.* 32, 1855-1870.

Ossen, D. R. (2005). Optimum Overhang Geometry for High Rise Office Building Energy Saving in Tropical Climates. Ph.D., Faculty of Built Environment, Universiti Teknologi Malaysia.

Rajeh, M. (1989). Natural Ventilation in Terrace Housing of Malaysia: Effect of Air Well on Air Flow and Air Velocity, University of Queensland, Master Thesis.

Robbins, C. L. (1986). Daylighting: Design and Analysis. New York: Van Nostrand Reinhold Company.

Sharifah, F. S .F and Sia, S. J. (2004) Sunlight control and daylight distribution analysis: The KOMTAR case study. *Building and Environment*, 39: 713-717

Walczak, E. L. (2002). Menara Mesiniaga – Ken Yeang

Zain-Ahmed, A., Sayigh, A. M. and Othman, M. Y. (1997).Field study on the thermal comfort of students in an institution of higher learning. In: Proceedings of the First International Symposium on Alternative & Renewable Energy (ISAAF 97), 22-24 July 1997, Johor-Bahru, Malaysia, 550-557.

Zain-Ahmed, A., Sopian, K, Othman, M. Y. H and Abidin, Z. Z. (2002a). The Availability of Daylight from Tropical Skies: A Case Study of Malaysia. *Renewable Energy*. 25: 21-30.

Zain-Ahmed, A., Sopian, K, Othman, M.Y.H, Sayigh, A. A. M and Surendran, P. N. (2002b). Daylighting as a passive solar design strategy in tropical buildings: A case study of Malaysia. *Energy Conversion and Management*, 43:1725-1736.