Energy and Environmental Audit for Bangunan Menara Seri Wilayah and Bangunan Kastam, Putrajaya: Analysis and Recommendations

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***Abstract*— The rapid growth of building in Malaysia contributes to increasing of energy consumption as building is among the major user of electricity in Malaysia. Optimization of energy consumption should be done in order to save the expenses on electricity, indirectly helps the environment from pollution. Energy audit and environmental audit are the process which can be implemented on the building to optimize the energy consumption. Audit has been executed on Bangunan Kastam and Bangunan Menara Seri Wilayah in Putrajaya. The objectives of the study are to identify the performance of environmental and energy efficiency in two buildings with different audit history, to asses energy performance, thermal improvement and visual comfort of Bangunan Menara Seri Wilayah and Bangunan Kastam, and to recommend a solution to optimize the energy efficiency and environmental aspects of the building. The audit covered the illuminance of the building, indoor building temperature, relative humidity and carbon dioxide percentage in indoor air quality. Malaysian Standard 1525 (MS1525) was used as quality control for illuminance, temperature and relative humidity, while Department of Occupational Safety And Health, 2005(DOSH 2005) was used as quality control for carbon dioxide percentage in air. The process of audit executed was data collection during on-site survey, analysis on data obtained and recommendation for improvement of performance. Thus, this study shows the performance of a building, Bangunan Kastam, which had undergoes an audit process previously, by comparing to Bangunan Menara Seri Wilayah which never undergoes any assessment on environmental and energy efficiency. Energy and environmental audit are able to optimize the efficiency of building without compromise on ergonomics aspect to the people in the building.**

***Keywords*- energy efficiency, energy audit, environmental audit, illuminance, relative humidity, temperature, carbon dioxide**

I. Introduction

As the population of the human being is increasing and the industry is developing, the demand of electricity is affected and rapidly increasing. Some energy consumption in an electrical system can be reduced by optimizing the efficiency Energy consumption is an indicator of a country's industrial progress and the standard of living of its people [1]. The third largest energy consumer in Malaysia is residential and building sector. In 2009, the commercial and residential sector accounts for about 13% of total energy consumption in addition to 48% of electricity consumption in Malaysia. Energy performance, thermal improvement and visual comfort of building sector are issues to be deeply studied in order to enhance the energy security [5]. Energy efficiency can be achieved by wisely taking various energy saving measures during the design stage of the building [2]. Energy management is a judicious and effective use of energy to maximize profits, minimize cost and enhance competitive positions [3]. An energy audit is purposely to improve the energy efficiency with consideration of cost and requirement of standards [4]. Environmental audit can be defined as "a measure of environmental risks, and an assessment of environmental opportunities". The project was purposely executed to identify the performance of environmental and energy efficiency in two buildings with different audit history, to asses energy performance, thermal improvement and visual comfort of Bangunan Menara Seri Wilayah and Bangunan Kastam, and to recommend a solution to optimize the energy efficiency and environmental aspects of the buildings. The aspects covered in the audit including the illuminance of the building, indoor building temperature, relative humidity and carbon dioxide percentage in indoor air quality. Malaysian Standard 1525 (MS1525) was used as quality control for illuminance, temperature and relative humidity, while Department of Occupational Safety And Health, 2005(DOSH 2005) was used as quality control for carbon dioxide percentage in air. The process taken during audit was data collection during on-site survey, analysis on data obtained and recommendation for improvement of performance. The effects of environmental audit may enable the organization to take corrective and preventive actions to avoid accidents in working place as well as can reduce the unnecessary operation cost. Besides, environmental audit may ensure compliance with environmental legislation and government regulation [6].

II. ENERGY AUDIT PROCESS

Energy audit should be executed by a competent person having adequate technical knowledge on Building Services installations [7].

A. Phase I

Preliminary Analysis : Initial site visit and preparation required for detailed auditing. First step to be taken was to determine the scope of the audit. Later, an initial site visit should be executed to gain information on the building to be audited [7].

B. Phase II

Walk-through Energy Audit: Conducting site survey and measurement.

C. Phase III

Detailed Energy Audit: Analysing data collected

III. ENVIRONMENTAL AUDIT

A. Pre audit

To conduct a study on the audit process on illuminance, indoor building temperature and relative humidity referring on MS1525, and to conduct a study on carbon dioxide in air quality according to DOSH 2005. The details and required information regarding the building was collected.

B. On-site audit

The area was divided equally into few sections to obtained average measurement. Room index can be used to determine the minimum number of required assessment areas in order to gain accuracy. Measurement of illuminance, temperature, relative humidity and carbon dioxide in air, were taken at each section. The data obtained then tabulated.

C. Post audit

In data analysis, the parameters with values and trends that deviate from standards were screened and spotted. Malaysian Standards 1525 (MS1525) was used to set the standards value of illuminance, relative humidity and temperature in the building. While Department of Occupational Safety and Health.2005 (DOSH 2005) was used to set the standards for the value of carbon dioxide in air. Analyses on the results were implemented and result was presented in graphic. Next was report writing .Recommendations was proposed in the report to improve the energy efficiency and environmental quality of the building.

TABLE 1. ENERGY AUDIT LIST OF EQUIPMENT

Equipment	Model	Usage
Power Analyzer	Kyoritsu 6300-01	Power Logging
Power Logger	Eniscope 5	Power Logging
CO_2 Meter	Psensor RH	CO_2 Measurement
Temp & RH Meter	HT 305	Temperature and Humidity Measurement
Lux Meter	Tento 540	Lumen Measurement
Anemometer	AM-4203HA	Air Flow Measurement
Ultrasonic Flowmeter	Panametrics PT868	Chilled Water Audit

IV. STANDARD MEASUREMENT FOR ENVIRONMENTAL AUDIT

According to Malaysian Standard 1525, the comfort room temperature is between 23°C to 26 °C with acceptable air velocity range is 0.15 to 0.50 m/s. Relative Humidity for indoor comfort condition must be between 55% to 70% [8].

TABLE 2. MALAYSIA STANDARDS 1525

	Type	Standards MS 1525
Illuminance, Lux	Office, Hall, Library, Meeting room	300-400 Lux
	Lift Lobby, Toilet	100 Lux
	Cafeteria, Stalls	200 Lux
Temperature, °C	Indoor building	22 °C – 26 °C
Relative Humidity, %	Indoor building	55% - 70%

TABLE 3. DOSH 2005 ON INDOOR AIR QUALITY

Element	Standards
CO_2 (ppm)	< 1000

V. CASE STUDY

A. Bangunan Seri Wilayah, Putrajaya

1) Building description

Bangunan Menara Seri Wilayah, Kementerian Wilayah Persekutuan & Kesejahteraan Bandar Blok 2C1, Putrajaya consists of eight levels office building. The whole ground level and fifth level are offices without daylight exposure. While all the other levels are offices with daylight exposure at certain spots.

TABLE 4. BUILDING DESCRIPTION OF BLOCK 2C1 MENARA SERI WILAYAH

Description	Gross Floor Area	Net Floor Area
Area(m^2)	47,708	33,816

TABLE 5. BUILDING POPULATION

Level	Total Floor Area (Gross)		Population
	(ft^2)	(m^2)	
Ground			20
Level 1	22,874	2,125	60
Level 2	22,874	2,125	32
Level 3	22,874	2,125	79
Level 4	22,874	2,125	20
Level 5	22,874	2,125	63
Level 6	22,874	2,125	51
Level 7	22,799	2,118	26

2) Operating schedules of most active equipment

TABLE 6. OPERATING SCHEDULES OF BLOCK 2C1 MENARA SERI WILAYAH

Building System	Description	Schedule	Hours
Lighting	Office area	6.00 am 6.00 pm	12
	Common area (Core)	24 hrs	24
	Façade Light	7.00 pm – 12.00pm	5
	Landscape Light	7.00am – 7.00pm	12
Air conditioning	Air handling Units(AHU)	6.00am / 7.00am – 7.00pm	12
	Fan Coil Units (FCU)	24 hrs	24
	Chilled Water Pump (Primary Pump)	7.00am – 7.00pm	12
	Chilled water Pump (Small pump)	7.00pm- 7.00am	12
	Precision Air-conditioning (datacenter)	24 hrs	24

3) Type of lamp

TABLE 7. TYPES OF LAMP AT BLOCK 2C1 MENARA SERI WILAYAH

Area	Type	Operating hours
Office, main lobby and cafeteria.	Down light	8.00 am - 9.00 pm
	Fluorescent Lamps (24")	8.00 am - 9.00 pm
	Fluorescent Lamps (36")	8.00 am - 9.00 pm
Parking	Down light	24 Hours
	Fluorescent Lamps (24")	24 Hours
	Fluorescent Lamps (36")	24 Hours

B. Bangunan Kastam, Putrajaya

1) Building description

TABLE 8. BUILDING INFORMATION- 2G1A BANGUNAN KASTAM

Blok		No. of Person	Number of storey	Rough estimated Floor Area (m²)
2G1A	2G1A - Zon 1	527	8 Floors	3,646.32
	2G1A - Zon 2		8 Floors	7,404.94
	2G1A - Zon 3		8 Floors	12,092.10

TABLE 9. BUILDING INFORMATION – 2G1B BANGUNAN KASTAM

Blok		No. of Person	Number of storey	Rough estimated Floor Area (m²)
2G1B	2G1B - North	1119	10 Floors	24,159.35
	2G1B - South		9 Floors	27,309.85

2) Operating schedules of most active equipment

Building System	Description	Schedule	Hours
Lighting	Office area	6.00 am – 6.00 pm	11
	Common area(Core)	24 hrs	24
	Façade Light	7.00 pm – 12.00 pm	5
	Landscape Light	7.00am – 7.00pm	12
Air conditioning	Air handling Units(AHU)	6.00am/7.00am – 7.00pm	12
	Fan Coil Units (FCU)	24 hrs	24
	Chilled Water Pump (Primary Pump)	7.00am – 7.00pm	12
	Chilled water Pump(Small pump)	7.00pm- 7.00am	12
	Precision Airconditioning (datacenter)	24 hrs	24
Ventilation	Fresh Air fan Smoke exhaust Fan, Toilet Exhaust fan	7.00am- 7.00pm	12

3) Type of lamp

TABLE 11. TYPE OF LAMP AT 2G1A AND 2G1B BANGUNAN KASTAM

Type	Operating hours
DownLight	8.00 am - 9.00 pm
Halogen	8.00 am - 9.00 pm
Fluorescent T5	8.00 am - 9.00 pm
Fluorescent T8	8.00 am - 9.00 pm
Filamen	8.0 am - 9.00 pm

VI. RESULTS AND ANALYSES

A. *Bangunan Seri Wilayah*

Based on the Fig. 1, 62.5% of audit points were experiencing under range of MS 1525 illuminance. Malaysian Standards 1525(MS 1525) states that for office building in Malaysia, the illuminance should be in range of 300 lux to 400 lux. Only 25% of audit points met the range and 12.5% were over the range of MS 1525. As stated in MS 1525, the indoor temperature for building in Malaysia must be in range of 23°C to 26°C. However, in Bangunan Seri Wilayah, the indoor temperature obtained was stated to be under range at 75% of all audit points. The rest 25% of audit points were in the range of standards.

100% of audit points for relative humidity and CO_2 ppm in Bangunan Seri Wilayah meet the requirement of MS 1525. The requirement of MS 1525 is between 55% to 70% for humidity and Department of Safety And Health (DOSH, 2005) mentioned that the suitable CO_2 ppm in building is C1000, where C stands for ceiling limit [12].

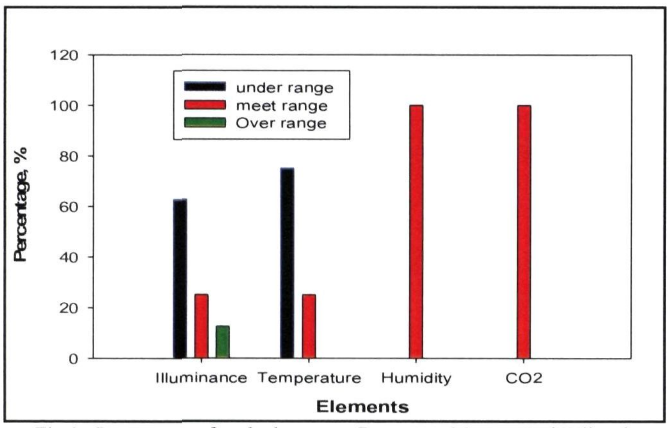

Fig.1. Percentage of each element at Bangunan Menara Seri Wilayah

1) *Illuminance*

Based on Fig. 2 the average illuminance was inconstant at different level. All area of the building was office area, which requires minimum 300 lux and maximum 400 lux, based on MS 1525. At level 1, level 4, level 5, level 6 and level 7, the average illuminance was under the standards and at level 2, the illluminance was over the standards. At level 3, the illuminance met with the standards of MS 1525. From the data obtained, most lux of illuminance was contributed by daylight exposure. The lighting system of the building was unable to deliver enough luminance through all over the level.

2) *Temperature*

The graph in Fig. 3 shows that only indoor temperature in level G and level 1 met with the standards of MS 1525 which in range of 23°C to 26°C. Temperature in other levels was below the standards.

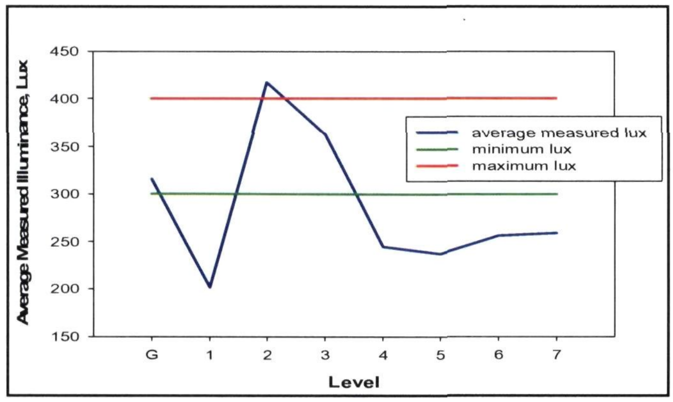

Fig. 2. Average measured illuminance of each level at Bangunan Menara Seri Wilayah

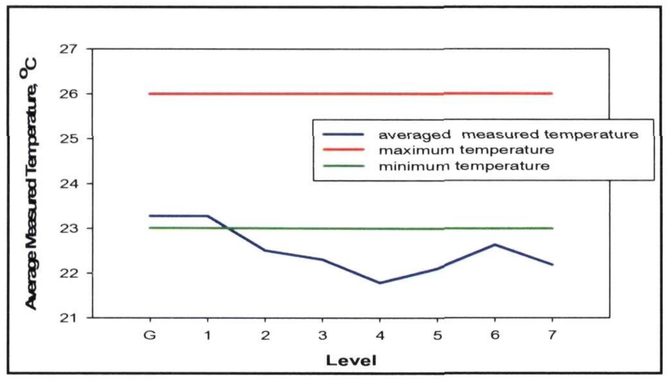

Fig. 3. Average measured temperature of each level at Bangunan Menara Seri Wilayah

3) *Relative Humidity*

The graph in Fig. 4 shows that all levels of the building met the standards of relative humidity which in range of 55% to 70%, according to MS 1525.

4) *Co2*

The graph in Fig. 5 shows that all levels of the building met the standards of air quality indoor building which CO_2 must be below 1000 ppm according to DOSH 2005.

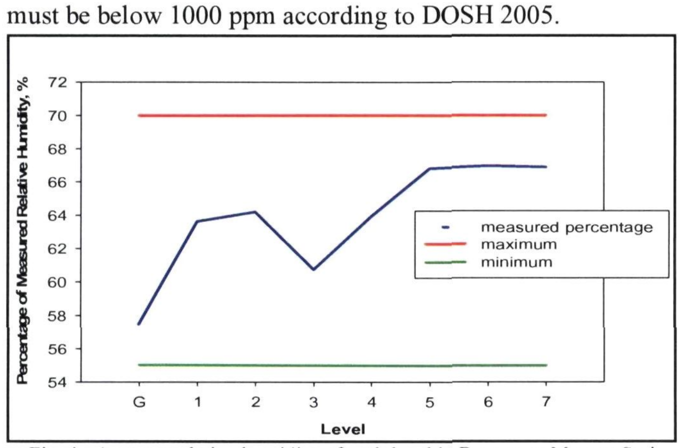

Fig. 4. Average relative humidity of each level in Bangunan Menara Seri Wilayah

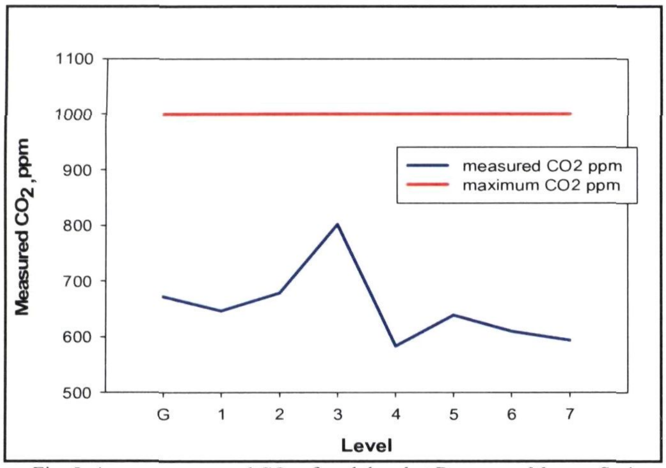

Fig. 5. Average measured CO_2 of each level at Bangunan Menara Seri Wilayah

B. *Bangunan Kastam*

In overall, Bangunan Kastam was efficiently reaches the standards of MS 1525 for temperature and relative humidity, and met the standards of DOSH 2005 for CO_2 percentage. However, 67% lighting system in Bangunan Kastam were over the standards, and 23 % remaining met the standards, as shown in Fig. 6.

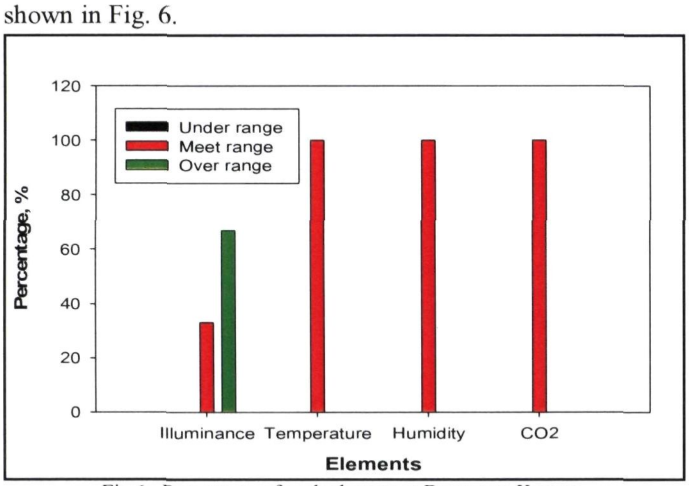

Fig.6. Percentage of each element at Bangunan Kastam

1) *Illuminance*

Graphs in Fig. 7 shows that in 2G1A building, the illuminance at office area was over the standards of MS 1525 at level 1, level 2, level 3, level 4, level 5, level 6, level 7 and level 8. The illuminance of office area was below the standards of MS 1525 at level 9 and level 10. Area of office, library, meeting room, lounge, hall and library requires minimum 300 lux and maximum 400 lux, based on MS 1525. For 2G1B- North building, the illuminance met the standards of MS 1525 in level 1 and level 5, while the illuminance was over the standards of MS 1525 in level 2, level 3, level 4, level 6, level 7, level 8, level 9 and level 10. For 2G1B- South building, the illuminance met the standards of MS 1525 in level 2, level 3, level 4, level 5 and level 6, while the illuminance was over the standards of MS 1525 in level 7, level 8 and level 9. The illuminance was under the standards of MS 1525 in level 1.

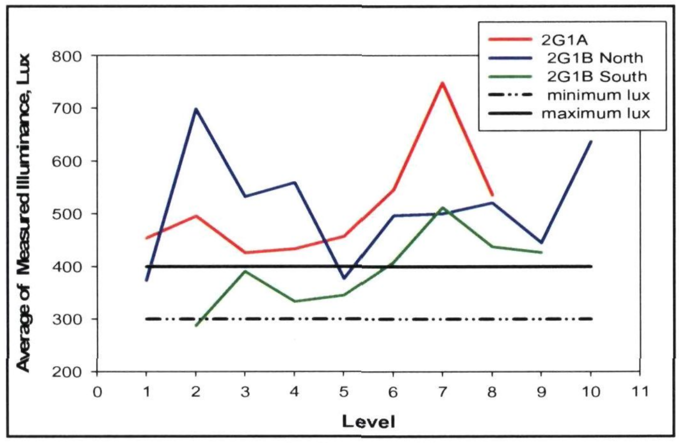

Fig. 7. Average of measured illuminance of office, library, meeting room, lounge, hall and library at each level in Bangunan Kastam

Graphs in Fig. 8 shows that the illuminance in 2G1A, 2G1B- North and 2G1B-South for entrance hall, toilet and lift lobby was over the standards of MS 1525. The standards of illuminance for entrance hall, toilet and lift lobby are 100 lux.

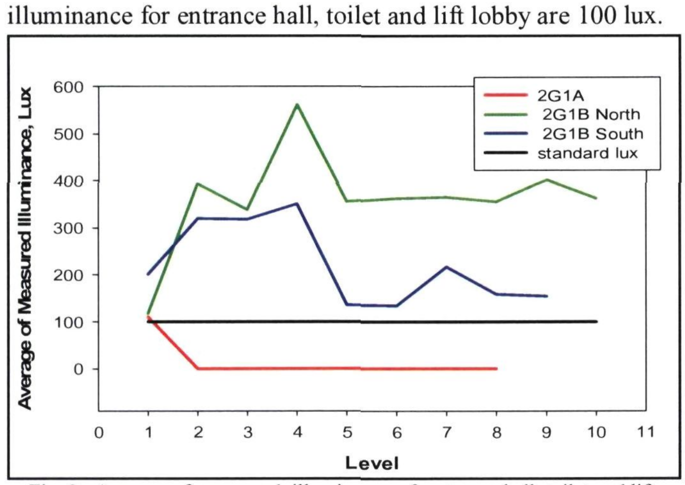

Fig. 8. Average of measured illuminance of entrance hall, toilet and lift lobby at each level in Bangunan Kastam

Stall and cafeteria area only located in level 1 of 2G1A and 2G1B- South building and the illuminace was over the standards of 200 lux of MS 1525, as shown in Fig. 9.

2) *Temperature*

The graph in Fig. 10 shows that only indoor temperature in level 4 of 2G1A building was below the standards. Temperature in other levels in 2G1A, all level in 2G1B- North and all level in 2G1B- South met with the standards of MS 1525 which in range of 23°C to 26°C.

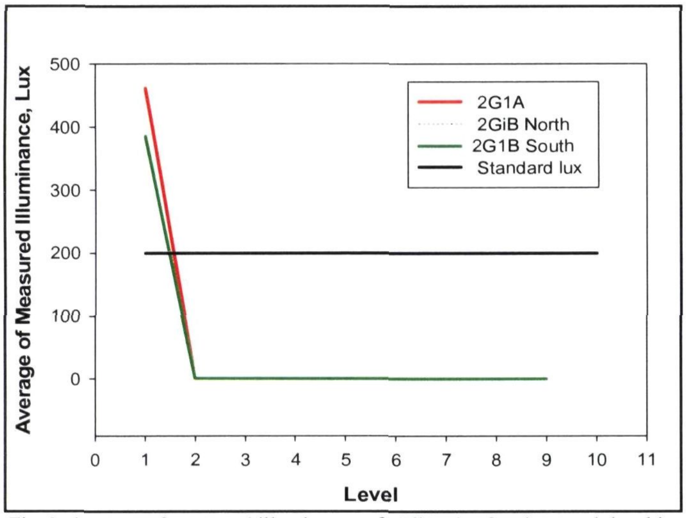

Fig. 9. Average of measured illuminance of stall and cafeteria at each level in Bangunan Kastam

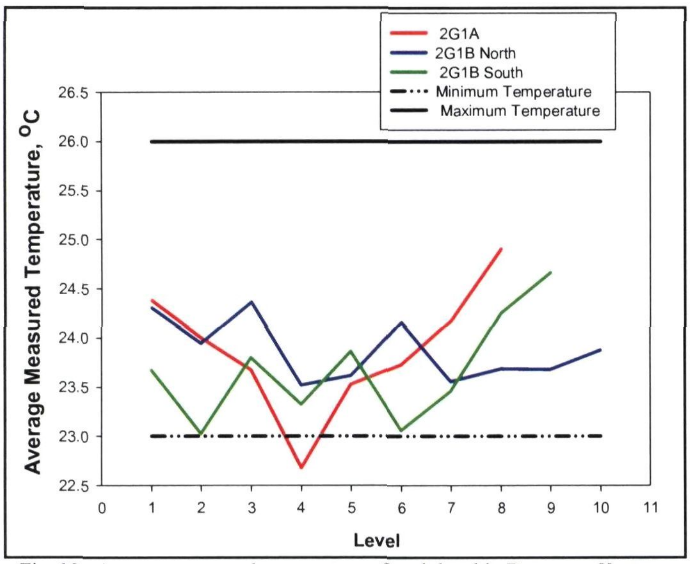

Fig. 10. Average measured temperature of each level in Bangunan Kastam

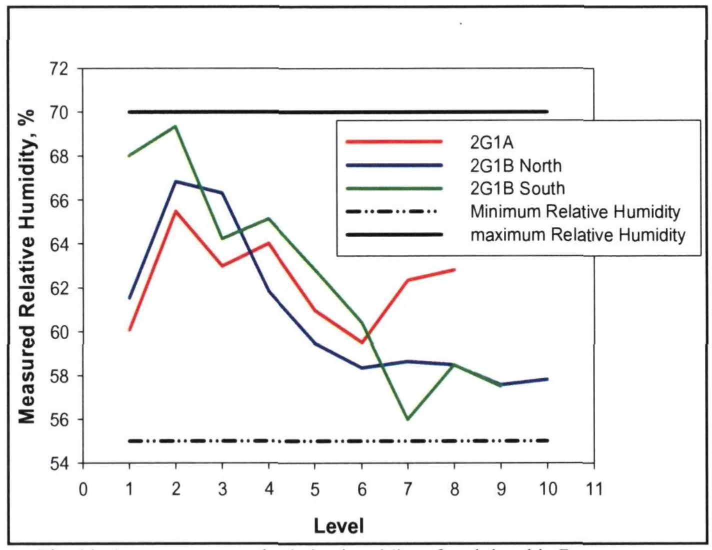

Fig. 11. Average measured relative humidity of each level in Bangunan Kastam.

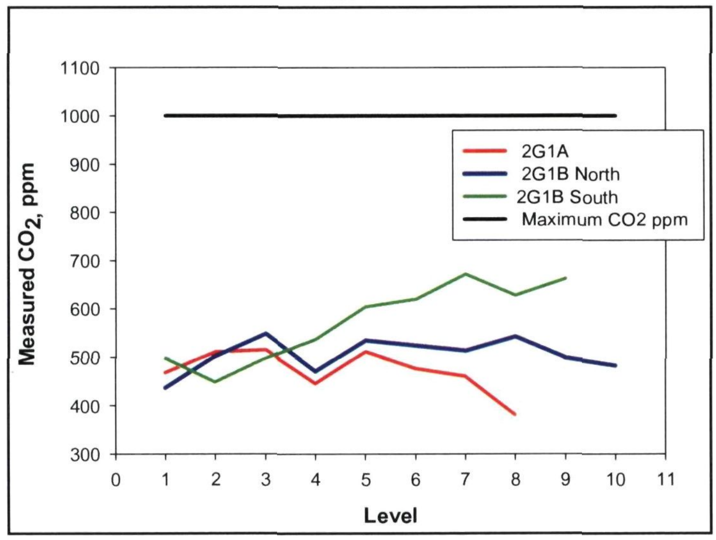

Fig. 12. Average measured CO_2 of each level in Bangunan Kastam

3) Relative Humidity

The graph in Fig. 11 shows that all levels of the 2G1A, 2G1B-North and 2G1B-South buildings of Bangunan Kastam met the standards of relative humidity which in range of 55% to 70%, according to MS 1525.

4) CO_2

The graph in Fig. 12 shows that all levels of 2G1A, 2G1B-North and 2G1B-South buildings of Bangunan Kastam met the standards of air quality indoor building which CO_2 must be below 1000 ppm, based on DOSH 2005.

VII. CONCLUSION

Based on the results obtained and analysis executed on both building involved in auditing process, energy efficiency of Bangunan Kastam was higher than energy efficiency of Bangunan Seri Wilayah. Illuminance in Bangunan Menara Seri Wilayah was inconstant as there were areas with illuminance below standards which was the major area, areas with illuminance in standards and areas with illuminance over standards which mostly were area with daylight exposure. It showed that lighting system in Bangunan Seri Wilayah was not in standards and needs for improvement. Differently, illuminance in Bangunan Kastam was majorly over the standards, with minor portion of areas with standards illuminance. It showed that saving recommendation should be applied to the building to get energy optimization. In term of indoor building temperature, Bangunan Kastam stated better measurement compared to Bangunan Seri Wilayah as 100% of the audit spots in Bangunan Kastam reached the standards of MS 1525, compared only 25 % of Bangunan Seri Wilayah. Both building reached the standards of MS1525 for relative humidity and DOSH 2005 for carbon dioxide percentage in indoor building air quality.

VIII. RECOMMENDATION

A. Light Emitting Diodes (LEDs) as an alternative to conventional lighting

The advantages of Light-emitting diodes (LEDs) are the small size, high reliability, high color-rendering index, long life, energy saving and environmental protection .A conventional incandescent light bulb of 60–100 W emits approximately 15 lm/W, and standard fluorescent lights emit up to 100 lm/W [9]. Some highly efficient white-light LED lighting fixtures can achieve efficacy of over 40 lumens per watt [1] A standard Phillips TLD 36W/840 fluorescent tube and LED lamps were compared in a fitting consecutively, fed by a pure 230Vrms sinusoidal. The LED lamp driver drew a current THD of 7.2% at power factor of 0.98 at rated power. The driver circuit stated total losses of 5W with 88% of electrical conversion efficiency [18].

B. Green building practices

To reduce a building's energy consumption, natural ventilation and daylight exposure are two methods which can be implemented as an alternative for cooling and lighting system in the building. Through the application of daylight exposure, the peak-cooling load can be reduced by 10% and the annual electricity consumption can be reduced by 13 % [5]. By considering the climate of the location during designation of building and in combination with well-established technologies such as glazing, shading, insulation, and natural ventilation, approximately 43 % of energy reduction can be achieved [5]. In order to achieve thermal comfort without mechanical cooling, the most efficient building designation is to combine the natural ventilation and solar protection [14].

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