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Investigating the Performance of Indoor Environment and Energy Management Implementation System in Office Building

Siti Halipah Ibrahim [1*], F. Julaihi [1], Azhaili Baharun [1], D. R. Koesmeri [2], Mohd Nasrun Mohd Nawi [2]

[1] Department of Civil Engineering, Faculty of Engineering, University Malaysia Sarawak (UNIMAS), 94300 Kota Samarahan, Sarawak, MALAYSIA

[2] School of Technology Management and Logistic, Universiti Utara Malaysia, Sintok, Kedah, MALAYSIA

[*] Corresponding author: ihalipah@unimas.my

Abstract

One of the fastest growing trends in the field of innovations is energy efficiency. This area can contribute to the sustainability development of the country by reducing the energy intensity of the economy. Energy and environment plays a key role in achieving the desired economic growth for the country. Worldwide industries use 40 percent energy for material and consumption protection to fulfil human needs. One of the approach in order to reduce the emission of greenhouse gases to the environment is by conserving energy. This could be executed by implementing energy management especially in office buildings. Energy management can also increase the efficiency of energy in the building. This study focus on the performance indoor environment and energy management system implementation in office building. Energy management is one of the contemporary challenges, thus study adopts an exploratory approach by using a tool developed by UNIDO called EnMS or Energy Management System. Findings show that by implementing indoor environment and energy management can reduce electricity consumption up to 30%. However, the awareness on energy management in Malaysia is still very low. The lack of awareness towards energy conservation among users can be enhanced by implementing indoor environment and energy management. Therefore, serious initiatives by the organization are needed to promote the effectiveness of indoor environment and energy management.

Keywords: indoor environment, energy management, building

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INTRODUCTION

The World Energy Outlook projected world primary energy demand would grow by 1.6% per year from 2006 to 2030. The energy usage in developing countries like Malaysia is expected to increase due to economic expansion which will exhaust the limited energy resources. The energy crisis also will increase the gap between demand and supply of energy. Today's world is looking for energy solution and alternative due to the threat of energy shortage, sky rocket energy price, unsecure of energy supply and the issue of enormous wastage. The world community should think globally and act locally to solve this issue by creating a long-term programme in order to optimize the limited source of energy (Anandarajagopal et al. 2011).

Malaysian Government has highlighted that energy efficiency is one of the important elements in its energy policy framework. One proven method in managing energy efficiency is through indoor environment and energy management. Energy management helps to improve environmental quality and maximize profits by minimizing energy demand. Reducing energy demand helps to reduce cost. For Malaysia, the industrial sector is the second largest consumer of energy. Until 2013, the buildings had consumed 40% of world's energy and this shows a 30% increment in energy consumption from the past 30 years. Factors like population growth, increasing demand of services provided by buildings and increase level of human comfort along with increase of time spent in the building assure that this upward trend in energy demand will continue. Rahman et al. (2010) stated that almost 42% of total annual energy

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(a) Sarawak Energy Berhad (SEB) building

Fig. 1. Map of OMU Pond I and sampling station (Anonymous 1975)

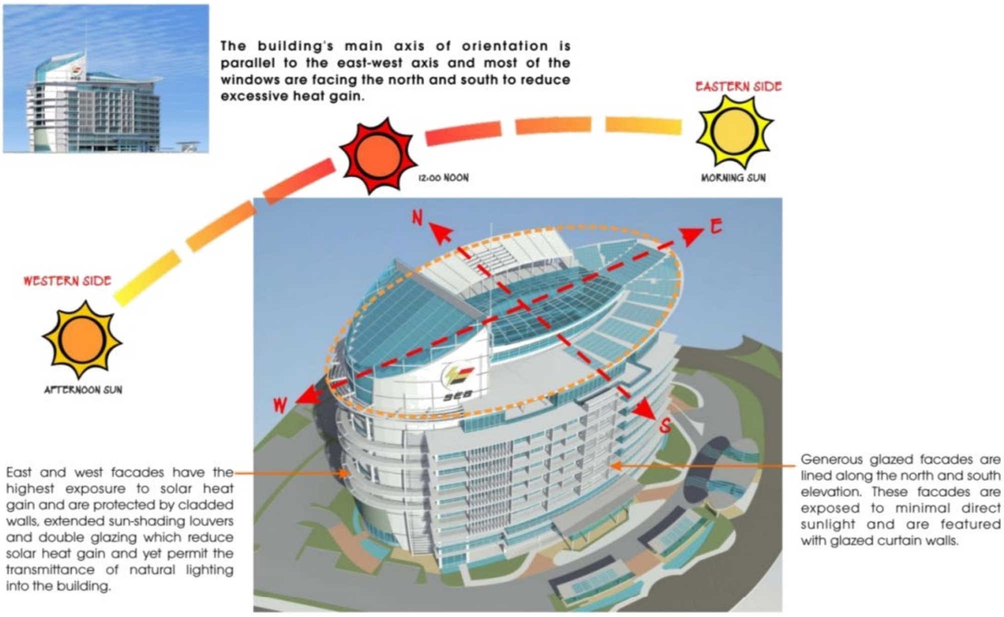
consumption is associated with building sector. Study conducted on energy usage in most of the building indicate that office buildings are the highest energy consumption about 70-300 kWh/m^2 per annum; 10-20 times that of residential buildings (Wai et al. 2011).

However, the optimization energy potential for each office building is different depending on various factors based on location, climate, building type and construction. Therefore, energy performance is closely related to indoor environment and energy management where good energy performance will help to enhance and increase the effectiveness of indoor environment and energy management. Indoor environment and indoor environment and energy management is defined as the judicious and effective use of energy to maximize profits and to minimize energy demands, and simplified as "foresighted, organized and systematic production, distribution and use of energy under ecological and economical target setting". The ISO 50001 indoor environment and energy management standard mandates that organizations or companies have sustainable indoor environment and energy management systems in place, have completed a baseline survey of energy use, and have made a commitment to continuing the improvement of energy performance. This standard requires necessities for an indoor environment and energy management system, involving a systematic approach for continually improving energy efficiency and energy performance but it does not govern any specific performance criteria with respect to energy even though the standard applies to all organizations. If building energy efficiency is improved by 22%, 45 million tonnes of CO_2 can be saved, nearly 14% of the agreed total savings of 330 million tonnes (Loganthurai et al. 2012).

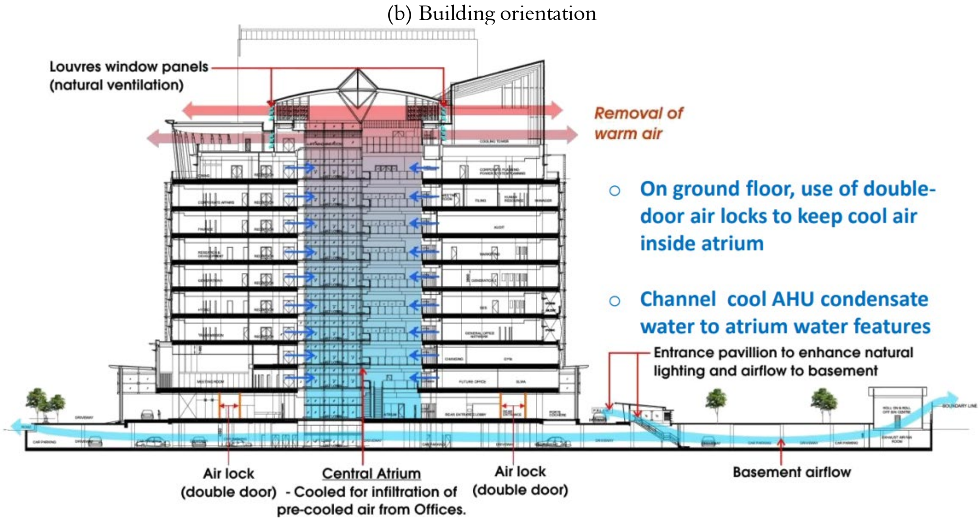
METHODOLOGY

One of the fastest growing trends in the field of innovations is energy efficiency. This area can contribute to the sustainability development of the country by reducing the energy intensity of the economy and contribute to enhancing the competitiveness of goods and services. A study on the effectiveness of energy efficiency is chosen to be studied in depth to further understanding the benefits of indoor environment and energy management. The study has been conducted at Sarawak Energy Berhad (SEB) building as shown in **Fig. 1** located in Kuching which was built and completed in 2010. This is the first certified green building and awarded with the GBI rating system in Sarawak, Malaysia (Saidur et al. 2009, Spyropoulos and Balaras 2011).

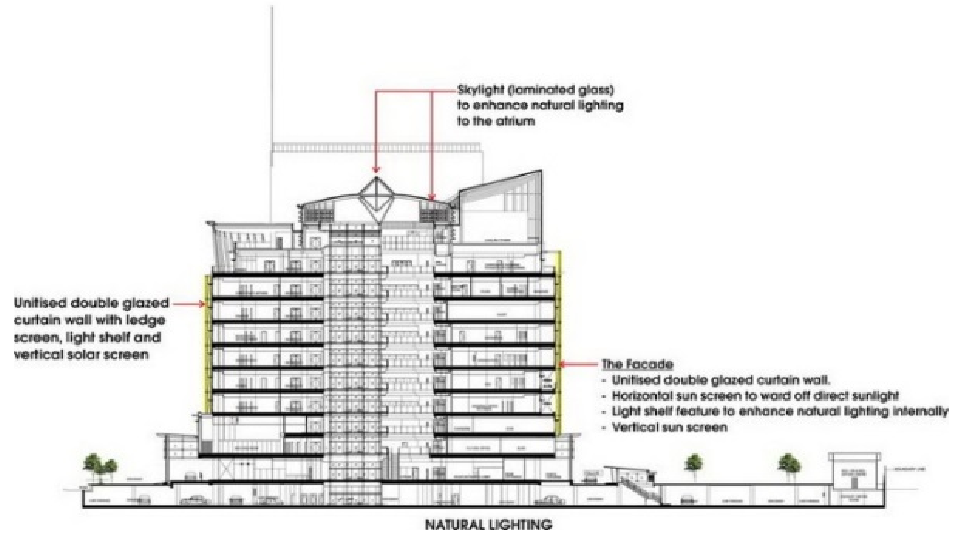
This study is conducted on the housekeeping aspect mainly on lighting system for the purpose of energy efficiency improvement. The electricity bills consumption from 2012 to 2014 has been analysed thoroughly. The building was installed with 290 units of digital power meters to obtain readings for the whole building. Digital power meter efficiently records all energy use of the SEB building. Monthly readings of energy usage are recorded for monitoring purposes. The data is then analysed using the Indoor environment and energy management System (EMS) tools developed by UNIDO for monitoring works and to enhance the utilization of energy in the building. The analysis by EnMS provides the life cycle cost data when indoor environment and energy management is implemented by the organization (Kok et al. 2013, Rahman et al. 2010).



(b) Building orientation



(c) Thermal comfort and natural ventilation in the building



(d) Natural lighting

Fig. 1 (continued). Map of OMU Pond I and sampling station (Anonymous 1975)

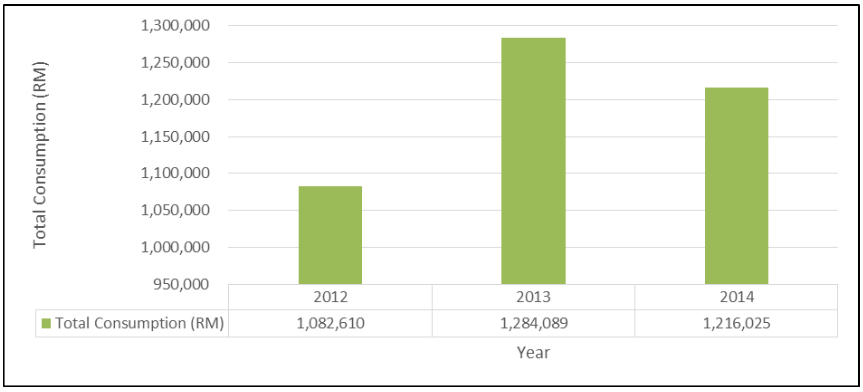


Fig. 2. Total Consumption (RM) for SEB Building

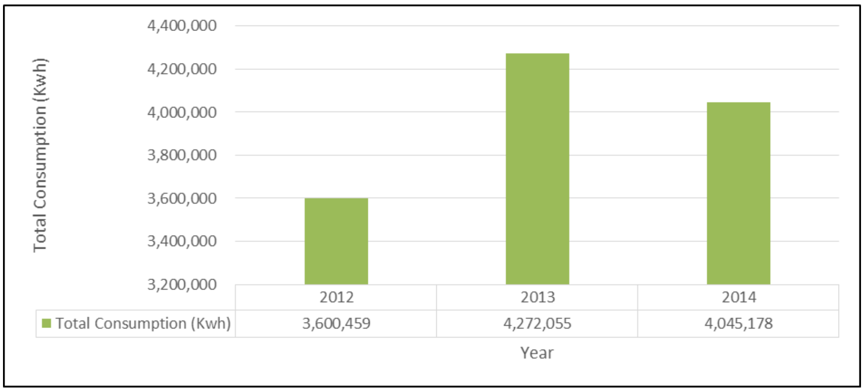


Fig. 3. Total Consumption (Kwh) for SEB Building

RESULTS AND DISCUSSION

Electricity Consumption in the Building

Fig. 2 shows the cost of energy consumption in Ringgit Malaysia (RM). **Fig. 3** indicates the electricity consumption (kWh) from 2012 to 2014 for all appliances for SEB building. Energy consumption cost increased about 18.6% in 2013 compared to 2012. However, the electricity consumption for SEB building decreased from 4,272,055 Kwh to 4,045,178 Kwh in 2014 by 5.3% (Iwaro and Mwasha 2010).

Referring to both **Fig. 2** and **3**, the reduction total consumption in 2014 compared to 2013 was due to the new policy implemented by the property department which focused on energy practise and housekeeping awareness where the staff were required to switch off their computers when they are not in use during lunch break and before leaving the office for the day. The orientation towards implementing paperless also contributed to energy usage reduction. The monitoring on air-conditioning system performance also contributed to the reduction of energy usage (Iwaro and Mwasha 2010, Wei et al. 2001).

Implementation of Energy Saving on Lighting System

The normal fluorescent lights had been replaced with Compact Fluorescent Lamp (CFL) in the new headquarters. The selection of CFL was made due to its benefits to conserve energy and to reduce cost. On average, the lighting appliances in the building consumed about 30% out of its total energy consumption. The efficiency of energy in the building can still be optimized by changing the current CFL to ENERGY STAR Qualified LED bulb. According to LED light bulb makers, Switch Lighting, an Energy Star-certified LED light bulb signifies reliability and performance as well as energy-saving performance. By changing the current CFL bulb to ENERGY STAR Qualified LED bulb, it would only use 15-20% of the energy used by an incandescent bulb and it would last up to 40 times longer.

Life Cycle Cost for Lightings

Fig. 4 shows the life cycle cost for option 1 – using the current LED bulb (Non-ENERGY STAR Qualified) and option 2 – using ENERGY STAR LED bulb. The simulation result shows the life cycle cost of lighting appliances which is projected for 10 years, by changing the current CFL bulb to ENERGY STAR

Life Cycle Costing (LCC)				
	Option 1	Option 2		
Cost	- 511,966.00	- 436,966.00	Discount Rate	10%
Year 1	- 153,589.80	- 87,393.20	Savings Inflation	3%
Year 2	- 158,197.49	- 90,015.00		
Year 3	- 162,943.42	- 92,715.45		
Year 4	- 167,831.72	- 95,496.91		
Year 5	- 172,866.67	- 98,361.82		
Year 6	- 178,052.67	- 101,312.67		
Year 7	- 183,394.25	- 104,352.05		
Year 8	- 188,896.08	- 107,482.61		
Year 9	- 194,562.96	- 110,707.09		
Year 10	- 200,399.85	- 114,028.30		
LCC	-RM1,426,580.74	-RM944,143.99		

Fig. 4. Life Cycle Cost for Electricity Consumption for Lightings

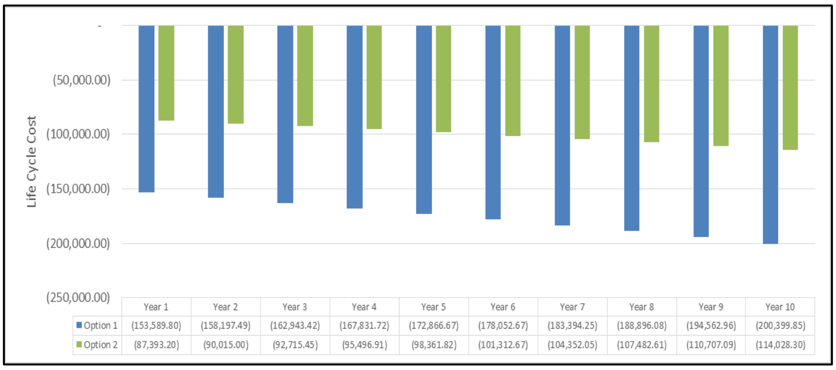


Fig. 5. Comparison of Life Cycle Cost for Option 1 and Option 2

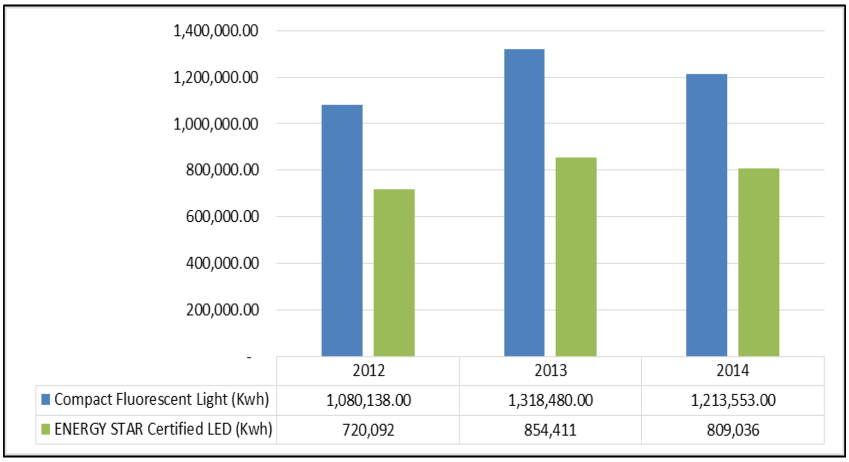


Fig. 6. Comparison of the Total Electricity Consumption by CFL and ENERGY STAR LED

Qualified LED bulb. The discount rate of 10% is an incentive given by the government for certified green building in Malaysia. The savings inflation is the minimum saving projection for each year which is a minimum 3%. As shown in **Fig. 5**, Option 2 provides better life cycle cost compared to Option 1. On average, the implementation of Option 2 can help to reduce the operational cost by 33.8% (Müller et al. 2013).

Comparison of energy consumption by CFL and ENERGY STAR qualified LED

Fig. 6 shows the comparison of energy consumed by CFL bulb and ENERGY STAR Qualified LED bulb. A significant reduction can be seen upon the implementation of ENERGY STAR Qualified LED bulb by more than 30% (Chiu et al. 2012, Eicker 2009).

Life Cycle Costing (LCC)					
	Option 1	Option 2			
Cost	- 1,127,121.00	- 1,167,121.00		Discount Rate	10%
Year 1	- 563,560.50	- 361,807.51		Savings Inflation	3%
Year 2	- 580,467.32	- 372,661.74			
Year 3	- 597,881.33	- 383,841.59			
Year 4	- 615,817.77	- 395,356.83			
Year 5	- 634,292.31	- 407,217.54			
Year 6	- 653,321.08	- 419,434.07			
Year 7	- 672,920.71	- 432,017.09			
Year 8	- 693,108.33	- 444,977.60			
Year 9	- 713,901.58	- 458,326.93			
Year 10	- 735,318.63	- 472,076.74			
LCC	-RM2,334,882.62	-RM1,902,188.81			

Fig. 7. Life Cycle Cost for Electricity Consumption for Air-Conditioning System

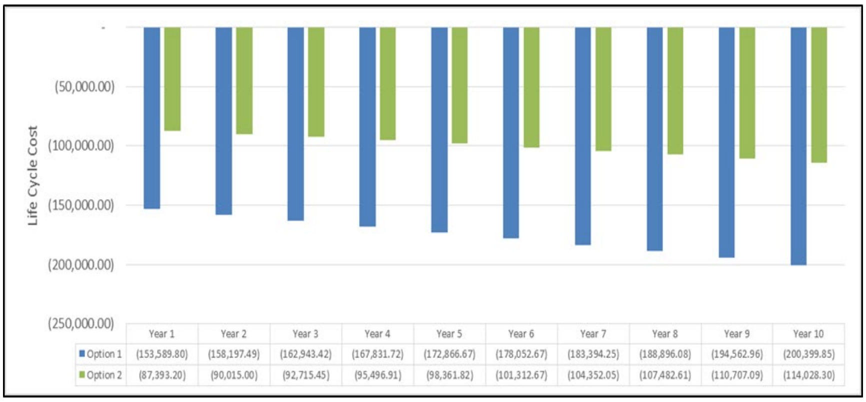


Fig. 8. Comparison of Life Cycle Cost for Option 1 and Option 2

Implementation of energy saving air-conditioning system

The air-conditioning system in SEB building is a centralised unit system that had been installed with two (2) air handling unit (AHU) of 11kW for every floor level. Sarawak Energy building uses the air chilled water plant. All AHU units are located in a specific AHU room on every level. Centralized air-conditioning systems are set at 24°C to cater for the building's high cooling demand with extended but stable 10 operation hours from 7 am to 5 pm during week days. This system is preferred by the management team due to the system's controllable operation and it also can be scheduled via a building management system. The efficiency of energy in SEB building using inverter air-conditioning system that allows energy savings of up to 69%.

Life Cycle Cost for Air-Conditioning System

The life cycle cost based on simulation result of AC system with inverter which is projected for 10 years The discount rate of 10% is an incentive given by government for certified green building in Malaysia with the average saving inflation for each year which is a minimum of 3%. **Fig. 7** shows the life cycle cost for option 1 – using the conventional air-conditioning system and option 2 – using air-conditioning system with inverter. As shown in **Fig. 8**, changing the current AC system to air-conditioning system with inverter helps to reduce the operational cost by 18.5%.

Comparison of Energy Consumption by Non-Inverter Air-Conditioning System and Inverter Air-Conditioning System

Fig. 9 shows the comparison of energy consumed by conventional air-conditioning system and air-conditioning with inverter system. A reduction of 38% could be observed upon the changing of the current system to the inverter system (Holloway 2015).

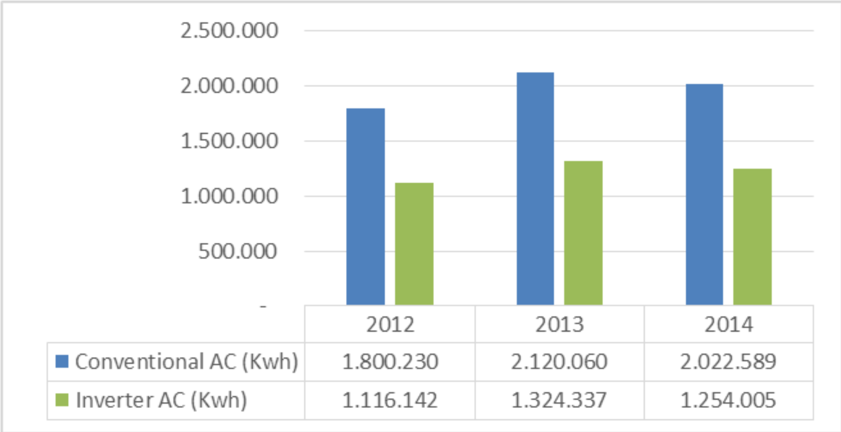


Fig. 9. Comparison of the Total Electricity Consumption by Conventional AC and Inverter AC

CONCLUSION

Based on the data simulation, it is proven that practicing indoor environment and energy management helps to increase the life cycle cost more than 20% in 10 years. ENERGY SAVER certified LED bulb helps in reducing the operation's life cycle cost by 30%. Although the initial cost of changing the current LED bulb to ENERGY SAVER LED bulb is higher, the operational cost for the long run is lower as ENERGY SAVER LED bulb can last up to 15 years meanwhile the normal LED bulb lasts only up to 3 years. The application of air-conditioning system with inverter also helps to reduce energy consumption by 38%. It is also beneficial in long term as inverter air-conditioning system lasts longer due to its smart inverter technology which creates a smoother and more stable operation. However, the awareness on indoor environment and energy management in Malaysia is still very low. The lack of awareness towards energy conservation among users can be enhanced by implementing indoor environment and energy management. Initiatives need to be taken in direction of realizing the importance of indoor environment and energy management as it contributes to beneficial outcomes for the organization. The organization should proof that indoor environment and energy management can help in reducing the impact of energy costs of the organization especially in terms of operational and maintenance cost (McMoham 2015).

Indoor environment and energy management shall be implemented in a continuous daily process, not merely as a one-off project. It needs to be part of day to day habits. This is the part where energy savings and energy performance improvements are actually made. Therefore, in an organization where energy consumption matters, the suggestions and recommendations mentioned earlier could help in reducing costs and consumption. Generally, in the greenhouse gases era, all buildings especially commercial and offices should implement indoor environment and energy management as it benefits the organization in many ways. Besides, it also helps to reduce or slow down the greenhouses gases and at the same time, promotes healthier lifestyle (Sivakumar et al. 2011).

REFERENCES

Anandarajagopal K, Sunilson, JAJ, Promwichit P (2011) Bombax ceiba Linn, bark extracts shows anti-microbial activity, Int J Pharm Res, 3(1): 24-6.

Wai CW, Mohammed AH, Ting LS (2011) Energy management key practices: A proposed list for Malaysian universities. Journal homepage: www. IJEE. IEE Foundation, Org, 2(4):749-60.

Loganthurai P, Parthasarathy S, Selvakumaran S, Rajasekaran V (2012) Energy Conservation Measures in a Technical Institutional Building in Tamilnadu in India. Energy Procedia, 1 (14): 1181-6.

Saidur R, Rahim NA, Masjuki HH, Mekhilef S, Ping HW, Jamaluddin MF (2009) End-use energy analysis in the Malaysian industrial sector. Energy, 34, 153–158. https://doi.org/10.1016/j. energy.11.004

Kok I, Hin Y, Yen-kwan IK, Loon CW (2013). Energy Efficiency Building Audit: Energy Audit Existing Buildings, 1718-1722.

Rahman MM, Rasul MG, Khan MM (2010) Energy conservation measures in an institutional building in sub-tropical climate in Australia. Applied Energy, 87(10): 2994-3004.

Spyropoulos GN, Balaras CA (2011) Energy consumption and the potential of energy savings in Hellenic office buildings used as bank branches—a case study. Energy and Buildings, 43(4): 770-8.

Iwaro J, Mwasha AA (2010) review of building energy regulation and policy for energy conservation in developing countries. Energy Policy, 38(12): 7744-55.

Wei CT, Barney K, Capehart L (2001) Guide to Energy Management (7th Edition), in the Fairmont Press, 2001.

Müller E, Poller R, Hopf H, Krones M (2013) Enabling energy management for planning energy-efficient factories, Procedia CIRP, 7: 622-7.

Chiu TY, Lo SL, Tsai YY (2012) Establishing an integration-energy-practice model for improving energy performance indicators in ISO 50001 energy management systems, Energies, 5(12): 5324-39.

Eicker U (2009) Low energy cooling for sustainable buildings, John Wiley & Sons, 23.

Holloway J (2015) A tale of two tests: why Energy Star LED light bulbs are a rare breed. Retrieved from http://www.gizmag.com/energy-star-led-light-bulbs

McMoham T (2015) The impact of inflation on savings, Inflation Data, Available at, www.inflationdata.com.

Sivakumar R, Pradeepchandran R, Jayaveera KN, Kumarnallasivan P, Vijaianand PR, Venkatnarayanan R (2011) Benzimidazole: an attractive pharmacophore in medicinal chemistry, International Journal of Pharmaceutical Research, 3(3): 19-31.