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Energy Saving Studies for a University Campus: An Educational-Based Approach

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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. Reduction on energy consumption should be implemented in order to save the expenses on electricity bill, indirectly helps the environment from pollution. Alongside with the importance of energy efficiency, many universities including Nilai University has imparted energy management subject in the electrical engineering module. As per ISO 50001:2011 - Energy management systems standards, energy audit is the main stage of Plan-Do-Check-Act process for continual improvement of energy management system. A preliminary audit (walk-through audit) was carried out at Nilai University campus involving classrooms, laboratories, chiller plant and administrative offices. Energy audit is mainly focused on energy saving studies such as energy bill analysis, load inventory data analysis, load consumption and load pattern analysis and energy saving measures (EEM) using measurement tools such as power data logger, lux meter and infrared thermography. The main objective of energy saving studies is to instill an understanding on the concepts of energy management and the importance of sustainable energy management for undergraduate students by taking on actual energy studies at campus buildings and chiller plant. The present case study at administration building foresees many energy-saving measures for implementation towards achieving the energy efficiency concept. The final EEM result shows that around 6% of the current load consumption has been reduced by adopting light emitting diode (LED) and lamps relocation at administration building.

Keyword: ISO 50001:2011- Energy management systems, Energy audit, energy efficiency measures (EEM), light emitting diode (LED), power data logger, lux meter and infrared thermography

Introduction

At colleges and universities, energy consumption has a large impact on both financial and environmental interests. New construction, aging infrastructure, financial constraints, increasing energy costs, and environmental responsibility are motivating institutions to re-evaluate their energy demand and related conservation programs. In a time of growing concern about increasing tuition costs and greater competition for qualified students, institutions must take every measure possible to reduce this large line-item in the budget.

Energy efficient campus buildings not only save money, but are also comfortable and have an abundance of natural light. These features contribute to a more effective learning environment. Due to the wide variety of building uses on campuses, energy demand changes from building to building. An energy audit is usually conducted to understand how energy is used within the plant and to find opportunities for improvement and energy saving and also to evaluate the effectiveness of an energy efficiency program. Based on

energy audit report, energy saving potentials could be identified and certainly can be included into the syllabus of energy management subject. Energy audit is mainly focused on energy saving studies such as energy bill analysis, load inventory data analysis, load consumption and load pattern analysis and energy saving measures (EEM) using measurement tools such as power data logger, lux meter and infrared thermography. The main objective of energy saving studies is to instill an understanding on the concepts of energy management and the importance of sustainable energy management for undergraduate students by taking on actual energy studies at campus buildings and chiller plant.

Literature Review

The type of industrial energy audit conducted depends on the function, size, and type of the industry, the depth to which the audit is needed, and the potential and magnitude of energy savings and cost reduction desired. Based on these criteria, an industrial energy audit can be classified into two types: a preliminary audit (*walk-through audit*) and a detailed audit (*diagnostic audit*). In a preliminary energy audit, readily-available data are mostly used for a simple analysis of energy use and performance of the plant. For detailed (or diagnostic) energy audits, more detailed data and information are required. Measurements and a data inventory are usually conducted and different energy systems (pump, fan, compressed air, steam, process heating, etc.) are assessed in detail.

A better understanding of the energy consumption pattern will lead to easier identification of more viable and cost-effective energy measures, thus reducing operating costs in the long run. Factors that contribute to energy consumption such as temperature, air-conditioning (chillers) and electrical appliances as well as peak hours are also investigated to determine their effects on energy consumption. Referring to Figure 1, a preliminary audit (walk-through audit) was carried out at Nilai University campus, which contains classrooms, laboratories, computer laboratories and administrative offices in its campus.

Figure 1: Plan layout of Nilai University campus

Methodology

For successful energy saving studies for campus buildings, energy audit is required which involves energy utilization analysis, Load inventory and load consumption analysis, load pattern analysis and energy saving measures. Gathering data through an inventory and measurement is one of the main activities where electrical appliances inventory list covers all designated locations around the campus. Energy utilization, load consumption and load pattern analysis involves the comprehensive analysis of energy usage (in term of

kWh) within a period of 24 hours during peak load if possible together with energy bills for few years to identify and evaluate ways to improve energy performance.Based on energy audit report, energy-efficiency measures for energy reduction that can be further analyzed based on load consumption data at reducing energy utilization and energy costs in buildings. Refer to Figure 2 on methodology of energy audit flow chart for energy management studies.

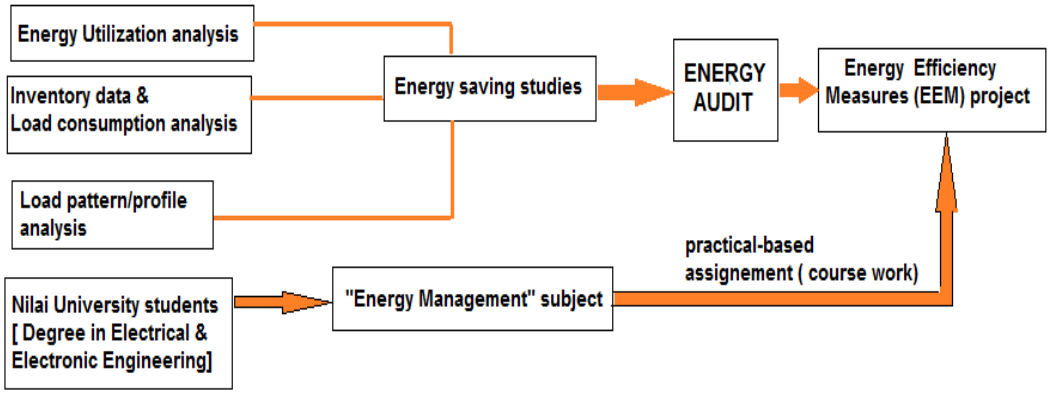

Figure 2: Energy audit flow chart for energy management studies

Energy Saving Studies: Energy Audit

Energy Utilization Analysis

According to Tenaga National Berhad (TNB), Nilai University campus electricity tariff billing account under Tariff C1 – Medium Voltage General Commercial Tariff category. Under this category, the total energy consumption payments (in Ringgit Malaysia – MYR) are segregated by Net Tariff consumption at RM 0.365 per kWh and maximum demand (MD) at RM 30.30 per Kw. Maximum demand (MD) is the capacity of electricity usage, and it works to assess the level of capacity (load) of electricity used by customers. The annual energy consumption at monthly basis is varies based on Nilai University academic calendar where we may oversee reduction in energy consumption during off-peak or semester holidays. Refer to Figure 2 below on annual net tariff data for year 2015.

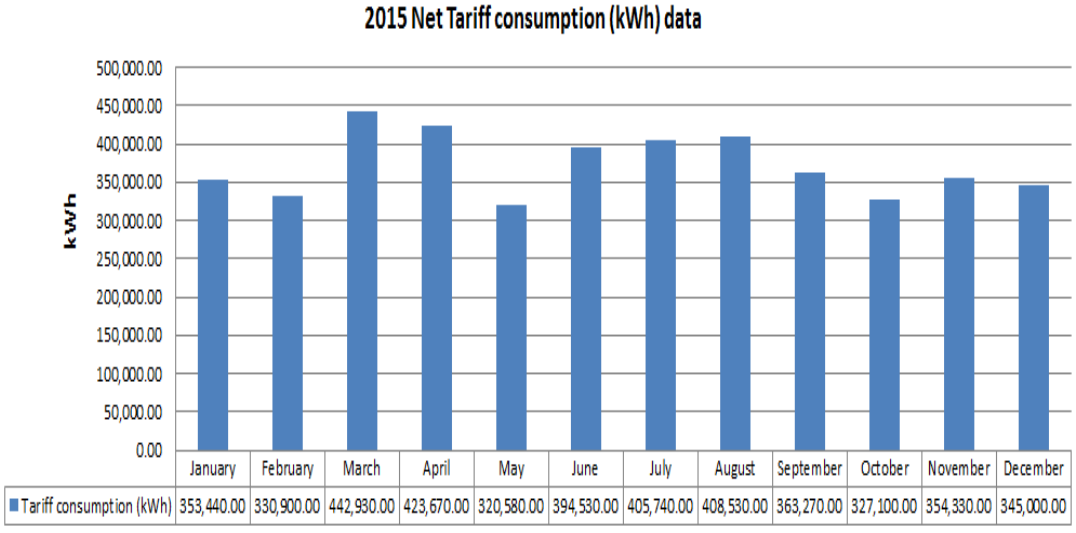

Figure 2: Net tariff consumption (kWh) data from January to December 2015

Inventory Data Analysis

Gathering data through an inventory and measurement is one of the main activities were carried out. The inventory list on load measurement has been performed by all electrical engineering faculty staffs at all designated locations around the campus. The profile of load utilization at each location/buildings has been identified.

Based on inventory list, we concluded that lighting which uses 56% of the total electricity in campus is the major electricity consumer. Air-conditioning with chiller plant follows at 30% which utilized by all the buildings. A total of 8% of the total electricity is consumed by major electrical appliances such as fax machines, photocopy machines, computers, printers and IT servers. Other electrical appliances such as microwave ovens, fans and refrigerators are consumed 6% of the total electricity. Refer to Figure 3 on percentage of energy utilization for Nilai University campus. Energy utilization for lighting and air-conditioning account for a larger proportion of building energy consumption, thus having high potential of energy saving.

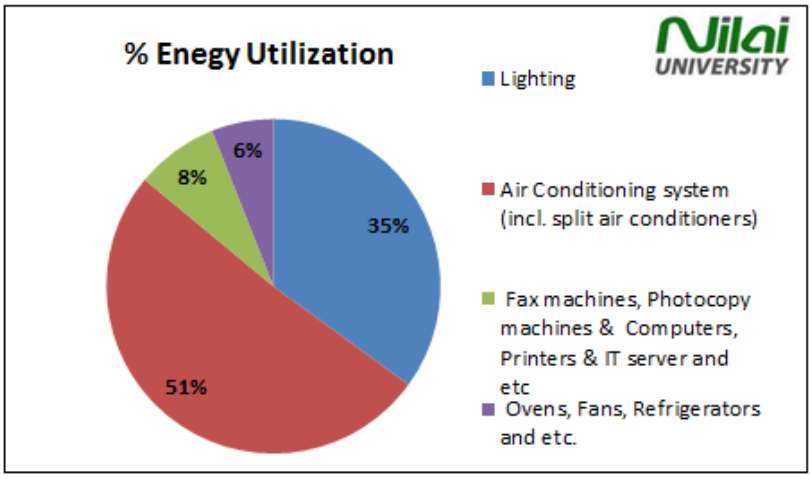

Figure 3: Percentage of energy utilization for Nilai University campus

Load Consumption Analysis

Since energy (kWh) meter installed at important buildings/blocks, energy consumption measurement data collection for 24-hours at one (1) hour interval were carried out. With manpower support from Building, Grounds & Office (BGO) electrical staffs, 24-hours load data measurement were carried out successfully from 14th Sept 2015 at 2.00pm until 15th Sept 2015 at 2.00pm during (long) semester examination period.

Based on 24-hour load pattern data as per Figure 4, it revealed that energy is highly consumed at few locations such as canteen, administration building, lecture hall and hostel block E. This reading merely taken into account as an indication only due to low accuracy factor of energy meters installed for energy data collection purposes.

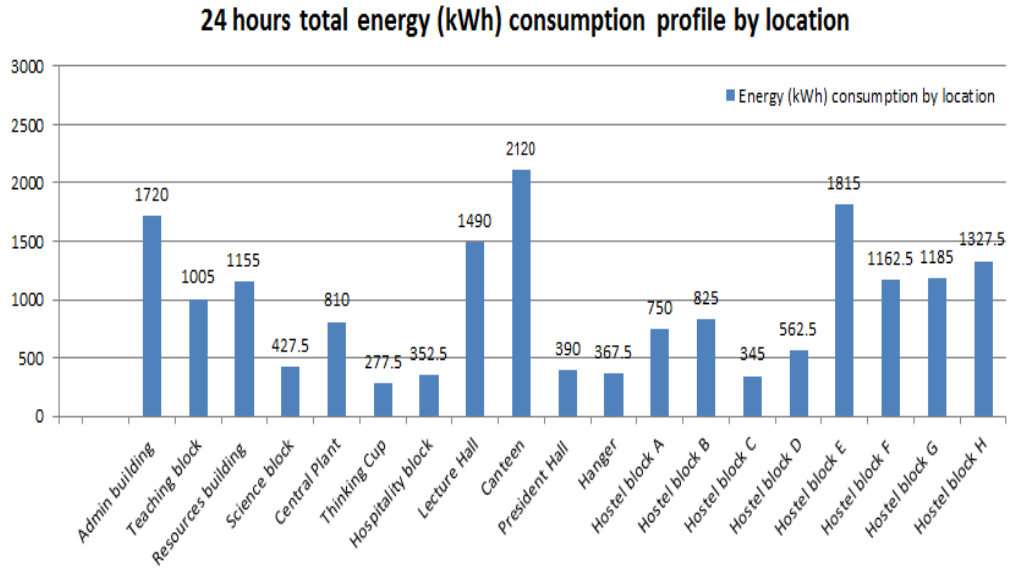

Figure 4: 24-hour total energy (kWh) consumption profile by location (on 14th Sept 2015, 2.00pm until 15th Sept 2015, 2.00pm)

Nevertheless, energy consumption at canteen, administration building, lecture halls and hostel block E is consistently at high-end compared to other locations. Further investigation can be carried out based on inventory list of electrical appliances at each location.

Load pattern analysis

Based on load pattern data, we observed that energy utilization is varies where the peak hour of Nilai University is from 8.00 a.m to 5.00 p.m consumes higher amount of energy compared with the off-peak hour (5.00 p.m. to 8.00 a.m.). Refer to Figure 5 on daily energy consumption pattern during working days at Nilai University campus.

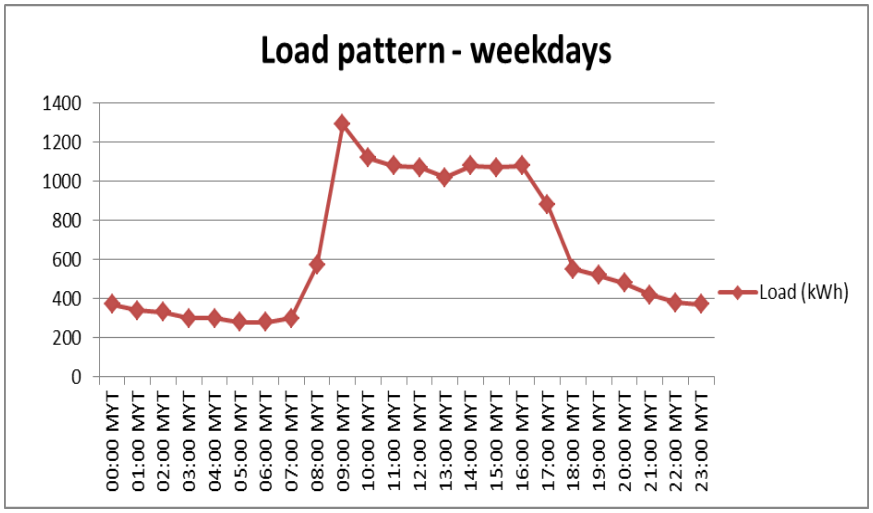

Figure 5: Daily energy consumption pattern during working days

Normally, centralized air conditioning systems from chiller plant will be in service from 8.00a.m. and stopped manually at 5.00 p.m. every day except during public holiday. However, split Air Conditioner Units will operate to cater for extended hours at few

buildings mainly at administration building, library area, IT communication & telephone room.

Energy Efficiency Measures (EEM) program

Based on load consumption analysis report, we opted to perform detailed research studies on energy consumption at administration building since this is one of highest load consumed location. Based on detailed inventory data measurement and survey, we identified that energy utilization for lighting and air-conditioning account for a larger proportion of building energy consumption, thus having high potential of energy saving. Refer to Figure 6 on inventory data survey for administration building.

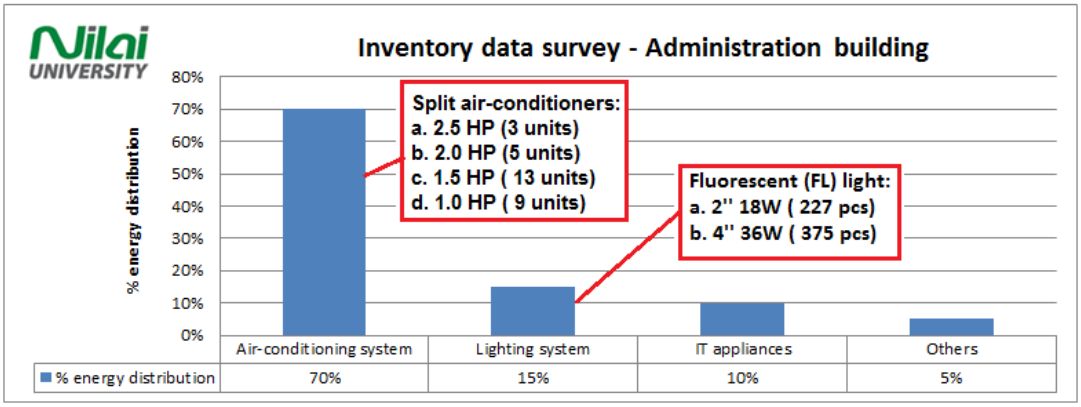

Figure 6: Inventory data survey for administration building

A good lighting system provides the necessary intensity, color and degree of economical, safe and durable lighting in the right place. Studies on the influence of both artificial and natural lighting have shown that people are more energetic and productive when they work in a well-lit environment and when exposed to daylight. Artificial lighting consumption can be reduced by simply installing fewer electric lights because daylight is present, or by dimming/switching electric lights automatically in response to the presence of daylight a process known as daylight harvesting. Artificial lighting should be regarded as a complement to daylight, occasionally or permanently. Table 7 and figures 8 below illustrates the use of natural light comparison with artificial light based on load consumption during weekdays at administration building using FLUKE power data logger tool.

Table 7
Energy Savings on Lighting System

Administration building	FLUKE data logger measurement for 24-hours (1 day only)		TNB Electricity bill (MYR)*
	Meter - A (kWh)	Meter - B (kWh)	
Use of Artificial light *(normal)*	338.14	289.79	45838.89
Embrace of natural light	327.13	290.05	45054.14
Cost saving/ load reduction	11	N/A	804.00

Remarks:

ADMIN Meter - A for lighting and office-based electrical appliances

ADMIN Meter - B for essential lighting, server panels, MDF panels & air-conditioning

*Calculation is based on TNB meter factor of 10X and multiply MYR 0.365/kWh for 20 weekdays of the month

[Note: this is applicable for sunny weather condition throughout 20 days except for weekends]

Figure 8: Concept of natural light and artificial light (HR block @ Admin building)

Upgrading to LED lighting is a smart move financially since these lamps use 50% less energy than traditional fluorescent 36W T8 systems, shrinking our electricity bill substantially. LED lamp usage will reduce energy consumption and investment is paid back over a relatively short period of time.

As fluorescent tubes expire, their light levels decrease significantly and eventually they start to flicker. In comparison, LED tubes do not flicker or decrease the amount of light coming from the bulb. The average lumens (amount of light produced by the tube) for 36W T8 Fluorescent is 1,800 lumens compared to 1,600 lumens for 16W T8 LED Tube. Therefore, to improve the lighting system efficiency, the Energy Efficiency measures (EEMs) have been achieved by retrofitting the T8 fluorescent tube (36W) with T8 equivalent LED tube (16W) with 55% of energy savings. LED lamp usage will reduce energy consumption and investment is paid back over a relatively short period of time. Cost saving on lighting efficiency explained in Table 9 and Figure 10 below.

Table 9: Payback period on LED lighting at administration building

Energy Efficiency Measure (EEM) - Retrotting Fluorescent tubes to LED tubes								
Retrofitting of lights	Admin building			Average loading hours (weekdays)	Energy calculation (kWh)	Total electricity bill per month (MYR)	Total Investment (MYR)	Actual data
	Size	Load (Watt)	Quantity					
Fluorescent	2''	18	217	3.0	11.7	3662.1		
	4''	36	356	3.0	38.4			
LED	2''	8	217	3.0	5.2	1627.6	15020	
	4''	16	356	3.0	17.1			
Cost saving per month (MYR)							2035	1680
Annual cost savings (MYR)							24414	20160
Payback period (ROI)							8 months	9 months

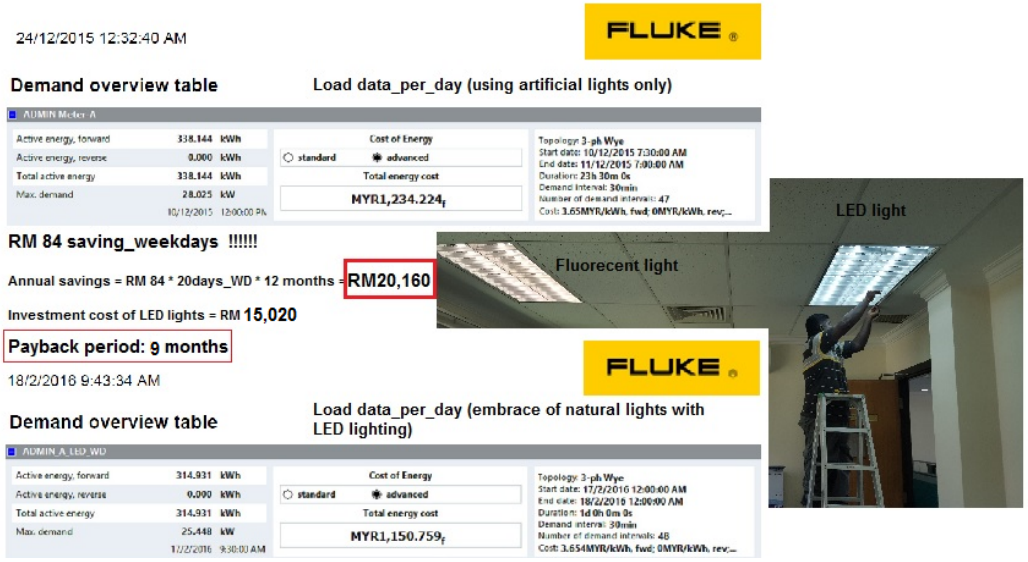

Figure 10: Energy efficiency measures for lighting system at admin building

Refer to Figure 11 below, the load (kWh) data on meter-A shows 6% reduction in electricity bill after few improvement plans. In addition, we have identified several energy saving measures which can be undertaken within the building mainly on air-conditioning system to reduce energy utilization by reducing wastes and improving energy efficiency in future.

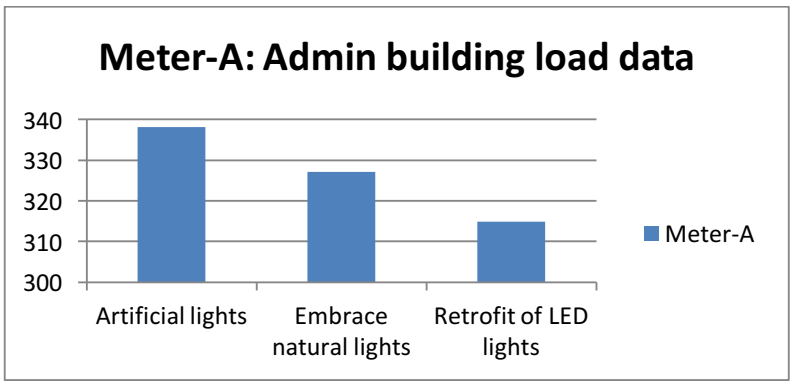

Figure 11: Load data based various on few improvement plans

Limitation

Ideally energy awareness and cultural change should complement other elements of good practice as part of an integrated approach to energy management in an organization. Significant savings can be realized through the effective engagement of staff and the management in resource efficiency and carbon reduction. Firstly, the university staffs able to engage in energy efficiency at their respective offices by few actions which can reduce the electricity cost such as embrace of natural light instead of artificial lights, reduce the energy wastes by switch off lights and air-conditioners before leaves the room and so on. Secondly, the management engagement to invest on LED lightings retrofit projects and approved energy efficiency products and purchase of monitoring tools such as infrared thermography camera and flow meter for heat loss performance studies at chiller plant which will benefit the undergraduate students to take part in the energy efficiency program at campus buildings with few years of payback period.

Conclusion

Electrical energy utilizing in buildings is continuously increasing and will continue to grow in the foreseeable future as more high power electrical equipment are installed. Energy audit identifies several energy saving measures which can be undertaken within an organization to reduce electrical energy utilization by reducing wastes and improving energy efficiency. To achieve optimal energy performance in buildings, energy audit is able to reduce energy wastes and improve the energy efficiency of the lighting and air conditioning equipment. Finally, energy audit has created the awareness on energy efficiency and encourages an educational-based energy saving studies for student who registered for energy management module at the institution.

Acknowledgement

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