Strategic Energy Management Plan and MS ISO 50001:2011 Compliance

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ABSTRACT

Strategic energy management plan is a long-term approach provided for achieving the goals set, determining the level of energy efficiency, detecting, controlling, monitoring and reporting on the performance of energy consumption. Successful strategic energy management plan builds long-term relationships with energy users and can improve the persistence of energy savings. It will also benefit the organization, the country and the world directly and indirectly. However, without the support, these benefits may not be achieved and the implementation of strategic energy management plan will not be successful. The objective of the study is to improve energy performance at ***TH*** *Headquarters building and to reduce electricity energy consumption. The study started with preliminaries study, data collection, data analysis and strategic energy management plan development process. All data and information were sourced from data collection activity that has been processed and analyzed based on the needs such as occupant behavior, trend of energy used and energy performance. Furthermore, wastage factors, target saving baseline, energy performance indicator, and strategic energy management plan were identified and developed. The proposed methods refer to MS ISO 50001:2011 as a guideline.*

Keywords: *Energy Efficiency, Energy Management, Energy Management System*

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Introduction

Tabung Haji (***TH***) Headquarters building was built in July 1982. This building consists of 22 floors of office, 7 floors of parking, 3 floors of Mechanical and Electrical Room, 1 floor of banking area, 1 floor of Café, Multipurpose Hall and Mini Theatre, and 1 floor of main lobby. The total gross area for this building is 28,762m^2 and total occupied area is 24,880m^2. The building is unique in shape. It is cylindrical with minimum radius on Level 21. This building has large window areas.

Based on the electricity bill recorded for the year 2013, the yearly total energy consumption of ***TH*** Headquarters building is 5,595,788kWh. Meanwhile, the Building Energy Index (BEI) for this building is 239kWh/m2/yr. However, the standard value of BEI for commercial building in Malaysia (referring to MS1525) is 135kWh/m2/yr [51]. This value is 77% higher compared to standard. Razidah *et al.* [48] stated the baseline of BEI set by Public Works Department Malaysia (PWD) for their target in energy saving program through the various categories of government building such as office, hospital, clinic, school and residential quarters is 150kWh/m2/yr. Meanwhile, the BEI for normal buildings which do not implement any energy management system or energy saving program is 200kWh/m2/yr to 300kWh/m2/yr.

In addition, based on electricity record from the year 2009 to 2013, the average electricity consumption at ***TH*** Headquarters building for each year was 5.9 million kWh which corresponded to the average cost expense of RM2.7 million. These costs will increase if the tariff fixed by the electricity supplier is increased. The increase in electricity tariffs will indirectly cause impact on the rising cost of building operations. However, these costs can be controlled if the electricity is used efficiently and effectively. All these can be done through implementation of strategic energy management plan or energy efficiency (EE) strategy [35, 41]. Stephen [35] believed formal program of energy management together with full support from the top management can result into an effective energy management plan.

The objective of the study is to develop the strategic energy plan and MS ISO 50001:2011 compliance. The first step is to identify courses of energy wastage. The second step is to identify human habit and behavior that leads to energy wastage. The third is to identify the parameter that affects energy consumption.

Literature Review

Strategic Energy management plan is a key success factor in introducing energy management in any organization. Practice shows that having well developed energy management plan is the only guarantee to initiate and implement sustainable energy saving culture in an organization. Strategic energy management plan can be defined as a systematic planning process that are systematically coordinated, aligned resources and action with mission, vision and strategy through an organization [38]. The process includes accessing, diagnosing and analyzing current position, planning, directing, implementing and controlling the process of energy consumption. Effective energy management will directly and indirectly benefit the organization, the country and the world as well. Hina and Devadas [21], Kwong *et al.* [25] and the United Nations Industrial Development Organization [39] explained that these benefits can be divided into three main categories which are Environment, Economic factor and Social factor. However, without the support from other parties, especially the government, these benefits may not be achieved and the implementation of energy management plan will not be successful.

Support from Malaysia government support

Razidah *et al.* [48] reported during the 15th Conference of Parties (COP15) in Denmark, December 2009, the Prime Minister of Malaysia said that Malaysia pledges to reduce carbon emission of up to 40% in terms of emission intensity of Gross Domestic Product (GDP) by 2020 compared to its 2005 levels. The Malaysian Government has introduced new regulation and energy programs such as Regulation 16 of the Electricity Supply Act 1990 which was effective on 15th December 2008, introduced ASEAN Energy Management Scheme (AEMAS) on 19th July 2011, implemented Sustainable Energy Development Authority Act 2011 (SEDA) on 1st September 2011 and created Energy Service Companies (ESCO) which provided energy management services and creative financing tools to organization that are more towards private initiative than a government policy instrument.

Energy management

In Energy management, there are two terms that should be clearly understood. The first is energy conservation and the second is energy efficiency [2]. Energy conservation means reduction in the amount of energy consumed in a process or system through economy, elimination of waste, and rational use [2]. Meanwhile, energy efficiency is defined as a ratio or other quantitative relationship between an output of performance, service, goods or energy, and input of energy [2]. In simple words, Chung *et al.* [7] defined energy efficiency as using less energy to produce the same amount of useful output. Examples are conversion efficiency, energy required or energy used, output or input, and theoretical energy used to operate. Both input and output have to be clearly specified in quantity and quality, and be measurable. Energy efficiency aims to gain the maximum results of effects from each unit of energy used. In energy management, both of these terms are related to each other. Terms related to energy management are as follows [9, 20, 34]:

a) Electricity, fuel(s), steam, heat, and compressed air are energy. Energy is the ability to do work. The capacity of a system to produce external activity is also called energy. Meanwhile, for the purpose of MS ISO 50001:2011 standard, energy refers to the various forms of primary or secondary energy which can be purchased, stored, treated or used in equipment or in a process, or recovered [9].
b) Energy used is a manner or kind of application of energy. Reckless use of energy will cause energy waste [20, 34].
c) Energy performance is a measurable results related to energy efficiency, energy use and energy consumption. In the context of energy management, results can be measured against the organization's energy policy, objectives, targets and other energy performance requirements. Energy performance is one component of the performance of the energy management [9].

In the process of implementation, energy management can be divided into two levels which are micro level and macro level as explained by Wu [47].

Energy Management System (EnMS)

Energy management system is a systematic process for continually improving energy performance [43]. EnMS, also known as an instrument for the systematic acquisition of energy relevant data, serves as a base for investment to increase energy efficiency [14]. These can be utilized to accomplish seven basic building monitoring and control functions such as heating, ventilating, and air conditioning (HVAC) energy management, lighting energy management, security protection, fire protection, process control, maintenance scheduling and management reports [17].

MS ISO 50001:2011

MS ISO 50001:2011 is a standard guideline for energy management system (EnMS) that has been used in Malaysia since 15 June 2011. The purpose of this standard is to enable organizations to establish the systems and process necessary to improve energy performance, including energy efficiency, use and consumption. The key elements of MS ISO 50001:2011 is energy policy, cross-divisional management team, energy review, baseline(s), energy performance indicators (EnPIs), energy objectives and targets, action plan, operating controls and procedures, measurement, management and documentation, and internal audit of progress [9].

Energy management deal factor

The evaluation of the performance of Malaysian building are based on the six main criteria such as energy efficiency, indoor air quality, sustainable site planning and management, material and resources, water efficiency, and innovation [16]. These criteria can be used for existing and new building. Based on review of the criteria set out, there are several factors that are directly involved in energy management such as follow:

a) Building

   Habib and Akhbar [19] found that the insulation of ceiling, floor and walls and using double layer glasses for windows have significant effect on energy saving. Huang *et al*. [22] and Heravi and Qaemi [26] found that by increasing the thickness of insulation layer is a direct way to improve thermal properties of building external wall in order to decrease heating and air conditioning energy consumption.

b) Energy Type Used

   Some energy services can be achieved by different types of energy. The cost of the energy has to be included into the costs of the equipment.

c) Installed Equipment

   Ma *et al*. [27] reported air-conditioning and lighting are important contributors to total energy consumption. The researcher believed if comprehensive measures are taken to improve air-conditioning and lighting, the power consumption of existing building might be reduced by 30% - 40%.

d) Load Control and Monitor

   BEMS is a tool used for control and monitor energy performance. BEMS consists of monitoring system, metering system, control system and analysis system [27, 30, 49]. In the study done by Yang and Wang [46, 47], BEMS is designed to maintain a comfortable environment and reduce energy consumption. The purpose of BEMS is to improve operation of the equipment, promote the energy efficiency and cut down energy consumption through monitoring and controlling energy demand [23, 49, 52]. By using BEMS the following result can be achieved [3, 27]:

   i. The level of building management can be improved via data acquisition and processing.
   ii. The inefficient equipment can be found through real-time monitoring.
   iii. Identify abnormal energy consumption through alarming system.
   iv. Lower peak electrical demand.

e) Plug Load Management

   Poll and Teubert [31] found that by replacing desktops with laptops computer with similar specifications can achieve estimated yearly energy savings of up to 770kWh/computer, 0.82kWh/week.

f) External Factor

g) Wu [47] explained the first step of reducing energy consumption in buildings in China. One of the methods that has been used is changing the building envelop color in which painting or coating roof with white color can result into a reflection of heat at 90% of thermal heat which saves energy.
h) Human
i) Occupant actions can also result some effects in energy consumption. Investigations on six occupants' actions have been done by Bonte *et al*. [4] which involved blind operations, lighting operations, windows operations, set point temperature, fan operations and clothing adjustments.

Energy management measurement tools

There are four basic tools that can be used to identify and monitor energy management performance as described below:

a) Energy Management Matrix (EMM).
   Quyen and Tan [32] reported the evaluation process focuses on six criteria which are policy and systems, organization, motivation, information system, training and awareness, and investment. It identifies those aspects where some further attention is required to ensure energy management is developed in an effective way [10].
b) Energy Management Assessment (EMA).
   The EMA tool only focuses on five criteria as shown below:
   i. Energy policy, energy strategy and organizational structure.
   ii. Regulatory compliance.
   iii. Procurement policy and investment procedures.
   iv. Energy information system and identifying opportunities including monitoring and analyzing energy use, target setting and opportunities identification.
   v. Culture and communications such as staff engagement and training, operational procedures and communications.
c) Energy Efficiency Index (EEI).
   In building, the definition is tied to the size of the building and is generally considered as energy used per unit of building floor area. The BEI unit for hotel or office building is in kW/m^2, while for hospital is kW/bed. BEI is the basic for setting out the target plan of energy management.
d) Benchmarking.
   Van Gorp [40] coated one key step in the benchmarking process which is to normalize energy consumption into some key metric (such as kWh/m^2 or MWh/ton produced) to allow an "apples-to-apples" comparison between entities. Benchmarking process consists of three steps:

i. Climate adjustment of energy-use intensities (EUI) (MJ/m2) by degree-day normalization.
ii. Regression model building for discovering the relationship between the climate-adjusted energy-use intensities (EUI) and the significant factors corresponding to building characteristics.
iii. Normalization of the climate-adjusted energy-use intensities (EUI) for the significant factors to form a benchmark table. The factors which may affect the energy-use intensities (EUI) are people, building type, occupancy, climate, age of building, equipment and component, construction, and energy end-use system [7]. Regression model shall be used as an analyzing tool in benchmarking process.

Barrier in energy management

The common barriers that exist in the context of energy management are:

a) No support and commitment from top management.
b) Difficult to change human attitude, behavior and mind set.
c) Lack of strong governance in policies implementation where policy and target is not clear, no comprehensive regulatory and implementation framework provided, and lack of competencies.
d) Not much competency programs provided and implemented to enhance the technical competencies and human resources capacity.
e) Lack of source of fund, lack of understanding risks and mitigating factors in green investments for sustainable financing and business friendly mechanism.
f) Lack of information, awareness and education on energy management practices, business opportunities and impacts to climate change mitigation.

Methodology

The preliminary studies began with the search through academic journals, theoretical article, case studies, government reports and book reviews followed by the process of data collection. This process consists of three activities which are determining energy consumption through electricity bill and on-site measurement data, observation and survey. All data and information sourced from data collection activity have been processed and analyzed based on the needs such as occupant behavior, trend of energy used and energy performance. Data simulation was the first activity involved followed by benchmarking activity. The final stage was strategic energy management plan development. Development process will focus on how to manage the energy by proposing a strategic approach in implementing strategic energy management plan without compromising safety. The proposed methods refer to MS ISO 50001:2011 as a guideline.

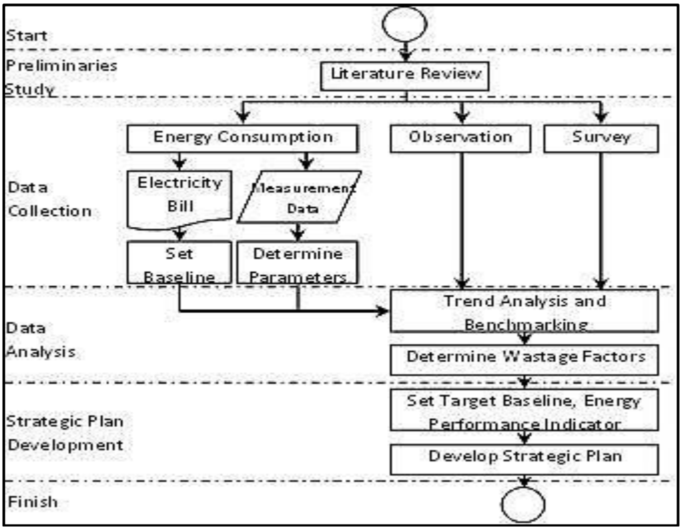

Figure 1: Flow chart of study

Result and Discussion

MS ISO 50001:2011 standard guideline or other relevant International Standard will be referred as guidelines for benchmarking process.

Electricity energy consumption

The energy consumption profile for the previous five years (2009 to 2013) is summarized and shown in Table 1.

Table 1: The summary of electricity energy consumption, maximum demand and electricity cost for year 2009 to 2013.

Year	**Energy Consumption**	**Maximum Demand**	**Total Cost**
	kWh/yr	**kW/yr**	**RM/yr**
2009	6,194,814	20,160	2,342,080.78
2010	5,811,586	23,803	2,452,481.84
2011	5,837,034	22,991	2,205,757.45
2012	6,246,229	19,446	4,393,446.75
2013	5,595,788	17,756	2,205,757.45
Average	**5,937,090**	**20,831**	**2,719,904.85**

The average of electricity energy consumption per year was calculated based on data in Table 1. Average electricity consumption for the year was 5,937,090kWh with the total cost of RM2,719,904.85. This result is used as a baseline.

Determination on the percentage of each parameter is made by taking the size of the current electricity energy consumption data for each parameter (i.e. lighting, plug load and cooling load system) except others system. The percentage of energy use for others system is determined by sub-tracting the average energy consumption (5,937,090kWh) with total sum of lighting, plug load and cooling system consumption. Electricity energy usage is measured by using power meter.

The summary estimates electricity energy consumption for each parameter. The highest percentage comes from the cooling load system with 54% of electricity energy consumption. Lighting system contributes 28% of the electricity energy consumption that makes this parameter the second highest electricity energy consumption followed by others system (13%). Plug load system uses the lowest electricity energy with just 5% out of total electricity energy consumption.

Observation

Pilot study process has been done through observation session on 14th April 2014 until 09th May 2014. The purpose of this study is to determine the possible factors that contributed towards energy wastage. The summary of observation results on staff behavior for five consecutive days in terms of percentage showed that 68.93% of staff shutdown the device but did not switch it off, 26.79% of staff shutdown the devices, switched it off but did not unplug the socket. Only 4.29% of the staff shutdown the devices, switched it off and plugged off the socket. Based on the results, most of the staff shutdown their device but did not switch it off.

Survey

The analysis is on the general comfort of occupant in ***TH*** Headquarters building. Most respondents said that they are moderately comfortable with their current desk area which contributes to the total amount of 71% of the respondents. Only 6% respondents feel uncomfortable with the current desk area in which 2% is moderately comfortable and 4% respondents is slightly comfortable.

Most respondents said that the current air movement is acceptable. 7% of them said that it is slightly acceptable, 58% said that it is moderately acceptable while 33% said that it is very acceptable. Only 2% of the respondents indicate that they are slightly unacceptable with the current air movement at their desk area. On the respondent’s preferences upon the current air movement, 67% respondents prefer more air movement on their desk area. 31% said they do not need any changes while only 2% respondents prefer less air movement. The analysis on respondent's estimation on the current temperature at their workspace area found that most respondents believe the current temperature at their workspace is around 23ºC to 26ºC (71%). About 21% of the respondents believe that the current temperature is around 20ºC to 22ºC while 8% respondents believe that the current temperature is around 27ºC to 30ºC.

An overall result of this questionnaire section indicates that 71% occupants generally feel comfortable with the workplace surrounding temperature while 58% respondents state that the air movement around the workplace area is acceptable. However, 67% of the respondents say that they want more air movement around their workplace area. For those reasons, the previous observations showed that many occupants used fan even though the air-conditioning system was operating. The trend shows that the occupants prefer the air movement factor. However, the behavior of occupants who prefer more air movements had been the cause of wastage where air conditioner and fans are used at the same time.

Trend analysis and benchmarking

The trend of electricity energy consumption can be determined by analyzing the data from the electricity bill. In this study, two types of tool have been used. The two tools are cumulative sum (CUSUM) analysis and load factor analysis. The result of the trend for electricity energy consumption is more focused on the performance of energy usage. Meanwhile, the result of load factor analysis will focus on the efficiency of the distribution of energy usage. Besides that, trend analysis and benchmarking process for cooling load, lighting and plug load system have also been studied and described.

Trend of electricity energy consumption

Referring to the scatter graph in Figure 2, the trend line shows that the performance of the electricity energy consumption between each year fluctuates. The green circle with dotted line shows the energy consumption is high during the season of Hajj Operation (in the year 2009, Hajj Operation starts on early September 2009 and at the end of December 2009) and during the account closing process (between December to January). This is because the building is operating for 24 hours during that period. Time period for Hajj Operation is determined through the date of first Hajj flight until the date of last flight return. However, the operations will start a month earlier from the date of the first flight. If the first flight date is in early September, then the exact date of the operation will start on early of August.

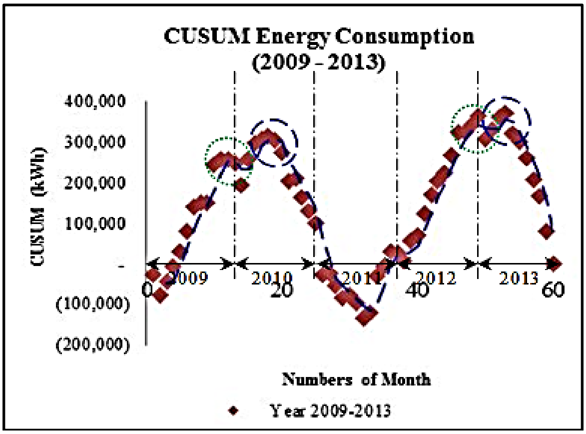

Figure 2: The trend of energy consumption from year 2009 to 2013.

From the Figure 2, it was found that the energy consumption is also high during the period of depositors and staff bonus payment. This season usually starts between March and April each year which is the month after the closing accounts that is made as marked in blue dotted line circle. The energy consumption during this season is higher than the Hajj season due to occupation rate that is higher compared to Hajj season. This shows that there is energy waste in which one unit chiller, one unit cooling tower, two units pump and 6 units AHU (involves three floors) had to be operated to cater a space for just 15 to 20 staff working. The minimum power required to operate centralized air conditioning system is 500kW. If the systems operate lesser from the minimum power required, the system will be tripped.

In proving that during Hajj season, closing account and bonus payment as the period that consumes the highest energy, comparison between baseline and the actual energy consumption for the year 2013 is conducted. Baseline is set based on average rate of energy consumption for the period of previous five years which is between 2009 until 2013. Overall energy consumption is still under control where the actual energy usage is lower than baseline.

Load factor

Load factor is calculated as the ratio between the total electricity used over a period of time and the total electricity that would have been used over the same period the facility operated at that period's peak demand during the whole period. It describes the efficiency of a facility's electrical usage. Load factor is indicative of the consistency of energy usage during a period and is expressed as a number between 0 and 1. Load factor is computed by using the formula as stated in Equation (1) [36].

$$\text{Load Factor} = \frac{\text{Energy Used (kWh)}}{\text{Maximum Demand (kW)}} \times \frac{1}{\text{Time (hour in billing period)}} \qquad (1)$$

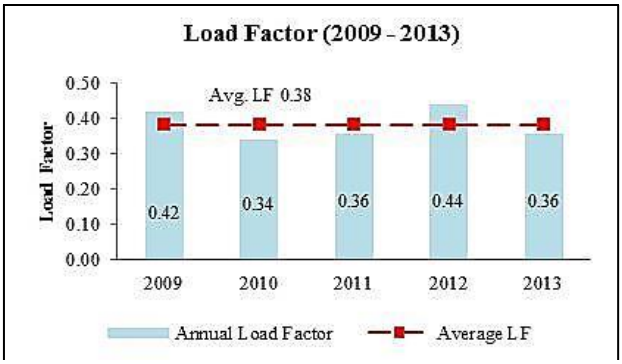

Figure 3: Annual Load Factor versus average.

Figure 3 shows the annual load factor versus average. The load factor value is basically a measure of how efficient the distribution of energy usage is. The closer the load factor value to unity, the better is the efficiency. A higher load factor value means energy usage is more evenly distributed throughout the period. In this case, the load factor value is ≥ 0.6 (considered acceptable) but is at 0.38 (average). This result shows the performance of energy efficiency for ***TH*** Headquarters building is only 38% used and 62% is not efficiently used. This means the distribution of energy usage is not efficient and this provides opportunity to investigate load shifting and peak shaving solutions. Therefore, further investigation must be done to identify the root cause of waste factor and to determine the best solution for the improvement of energy efficiency and performance.

Cooling load system

Based on the study conducted by Ahmadi *et al.* [1] on KTH Royal Institute of Technology Campus, Sweden, it stated that by increasing the set point temperature of only 1°C, 6% to 16% savings could be achieved. It aims to measure the rate of energy consumption for centralized air-conditioning systems and to prove if there any savings can be achieved. Energy consumption data for the period of six months which is three months before the temperature increased and three months after the temperature increased was measured and recorded. From the data, the average energy consumption is calculated to get a more précised data. Results of the study in Table 4 shows that the savings achieved is 9% per month which proved the test conducted by Ahmadi *et al.* [1].

Table 2: Electricity energy consumption before and after temperature set point.

No	Month	Energy Consumption (kWh)				
		kWh		**Electric**	**Cost**	
		Day	**Month**	**Tariff / kWh**	**Day**	**Month**
A	**Before Increase Temperature Set Point**					
1	April 2014	9,858.20	216,880.35	0.43	4,239.02	93,258.55
2	May 2014	10,122.19	202,443.73	0.43	4,352.54	87,050.80
3	June 2014	9,943.98	208,823.48	0.43	4,275.91	89,794.10
	Average (A)	**9,974.79**	**209,382.52**		**4,289.16**	**90,034.48**
B	**After Increase Temperature Set Point**					
1	July 2014	9,344.35	186,886.97	0.43	4,018.07	80,361.40
2	August 2014	9,318.27	195,683.64	0.43	4,006.86	84,143.97
3	September 2014	9,479.78	189,595.68	0.43	4,076.31	81,526.14
	Average (B)	**9,380.80**	**190,722.09**		**4,033.74**	**82,010.50**
Saving (A-B)		**593.99**	**18,660.42**		**255.41**	**8,023.98**
Monthly Saving %				**9%**		

Table 2 and 3 show the approximated annual saving if temperature set point is adjusted. The results show that an increase in temperature will result in greater amount of savings. If the temperature was increased to 24ºC, the estimated savings that could be achieved is 671,775.04 kWh which is RM288,863.28 per year.

Table 3: Approximated annual saving if temperature set point is adjusted.

Adjustment of Temperature Set Point	**Annual Saving**	
	kWh	**Cost (RM)**
21ºC to 22ºC	223,925.04	96,287.76
21ºC to 23ºC	447,850.08	192,575.52
21ºC to 24ºC	**671,775.04**	**288,863.28**
21ºC to 25ºC	895,700.08	385,151.04
21ºC to 26ºC	1,119,625.12	481,438.80

Measurement data on current temperature, which was conducted from 14th October 2014 to 16th October 2014, showed that the average temperature is 22.3°C (after increasing temperature set point) compared with previous record which is 21ºC (before increasing temperature set point). The result in Figure 4 shows that temperature set point at ***TH*** Headquarters building is below MS1525 standard (23ºC to 26ºC). This means temperature setting still does not comply with MS1525 standard and needs to be increased.

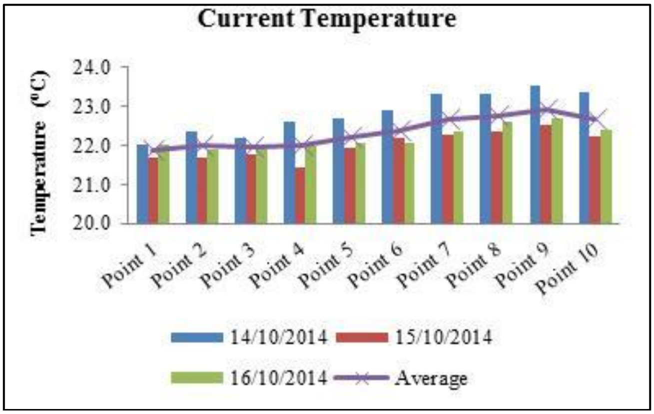

Figure 4: Temperature measurement results.

Lighting system

For the total amount of light available in the ***TH*** Headquarters building, the type of lights mostly used here is the conventional fluorescent type ranging from 2' to 5' size. The highest quantity is from conventional fluorescent 4' type that carries 34.99% (3,844 bulbs) of overall lights used. The second in ranking is the conventional fluorescent 2' which carries 23% of total lights in the building with approximately 2,527 number of lights. Table 6 shows that for the conventional fluorescent 4', it used 36W (bulb only) that is slightly higher as compared to the PLCE865 types which only uses 18W. The results show that the type of conventional fluorescent lamp is the largest contributor to energy consumption for lighting system.

Comparison analysis was done on electricity energy consumption between conventional fluorescent lighting and LED fluorescent lighting for operating hours between 6.00 A.M to 12.00 P.M (18 hours). With the same operating hour, electric tariff and quantity, the results show that conventional fluorescent light consumption uses higher energy compared to LED fluorescent light. For conventional fluorescent 4' type, it costs RM264,559.76 per year to operate it as compared to LED fluorescent 4' light that has the cost of RM117,582.12 per year. With the use of conventional fluorescent light 4', 2' and 5', the total of energy consumption is 1,277,265kWh/yr with total cost of RM549,223.81 per year. However, with the use of LED fluorescent light 4', 2', and 5', the total energy consumption is 583,978kWh/yr with the total cost of RM251,110.39 per year. This resulted in total saving of RM298,113.41 per year if the conventional fluorescent light is changed to LED fluorescent light.

The return of investment analysis was done when the LED fluorescent light is being used for 18 hours. With a total of 8,154 quantities of LED fluorescent required, average cost per unit at RM120.00 each will make a total investment cost of RM978,480.00. This will result in annual saving cost of RM298,113.41 per year which is a total of 54% savings. The payback period is at 3.28 years. The payback period value was determined by dividing estimated investment cost and annual savings [26].

Comparison analysis was also done for electricity energy consumption between conventional fluorescent lighting and LED fluorescent lighting for operating hours between 6:00 A.M to 8:00 P.M (14 hours). With new operating hour (for LED fluorescent light only), the same electric tariff and quantity, the results show that conventional fluorescent light consumption produces higher energy compared to LED fluorescent light. For conventional fluorescent 4' type, it costs RM264,559.76 per year to operate it as compared to LED fluorescent 4' light that costs only RM91,452.76 per year. With the use of conventional fluorescent light 4', 2' and 5', the total of energy consumption is 1,277,265kWh/yr with total cost of RM549,223.81 per year. However, with the use of LED fluorescent light 4', 2', and 5', the total energy consumption is 454,205kWh/yr with total cost of RM195,308.08 per year. This resulted in total saving of RM353,915.72 per year if the conventional fluorescent light is changed to LED fluorescent light.

Table 4: Payback period calculation result.

Analysis Result	
Total Quantities of LED Fluorescent Required	8,154
Average Cost per Unit	RM120.00
Estimated Investment Cost	RM978,480.00
Annual Savings	RM353,915.72
Saving Percentage	64%
Payback Period (years)	**2.76**

The return of investment analysis was done when the LED fluorescent light is being used for 14 hours. With a total of 8,154 quantities of LED fluorescent required, average cost per unit at RM120.00 each will produce a total investment cost of RM978,480.00. This will result in annual saving cost of RM353,915.72 per year which is a total of 64% savings. The payback period was at 2.76 years. It means, changing conventional fluorescent to LED fluorescent and shortening the operating hour, the energy consumption provides more savings and the payback period is shorter.

Plug load system

Desktop PC is the largest contributor in the plug load equipment at a rate of 45% or 749 units. Among the highest contributors in the plug load equipment are laptop, individual printer, fan or air cooler with the percentage of 10.92% (180 units), 8.79% (145 units) and 10.86% (179 units) respectively.

Table 5: Total annual energy consumption for Desktop PC base on power mode.

	Annual Desktop PC Energy Consumption			
Energy Consumption	**Power managed, Turned OFF**	**Not power managed, Turned OFF**	**Power managed, Left ON**	**Not power managed, Left ON**
Annual idle	42,943.32	101,930.21	42,943.32	468,472.54
Annual sleep	2,629.53	0.00	18,952.14	0.00
Annual off	10,626.65	10,626.65	0.00	0.00
TOTAL (kWh)	**56,199.49**	**112,556.86**	**61,895.46**	**468,472.54**
TOTAL (Cost)	**RM24,165.78**	**RM48,399.45**	**RM26,615.05**	**RM201,443.19**

Table 5 shows the total annual energy consumption for desktop PC based on power mode. Power managed means desktop PC or laptop is in power saving mode. With power managed and desktop PC turned off, the total energy consumption is 56,199.49kWh/yr and the total cost is RM24,165.78 per year. However, with desktop PC not power managed and being left on every day, the total energy consumption is 468,472.54kWh/yr and the total cost is RM201,443.19. Overall, if the desktop PC is in power manage mode, it will contribute in more savings that not power managed. More savings will be achieved if the desktop PC is power managed and turned off upon leaving the office. Annual laptop energy consumption is shown in Table 6. The highest consumption of energy comes from laptop that is poor power managed and being left on upon the end of office hour which is at the consumption of 92,513.48kWh/yr and requires a total cost of RM39,780.80 per year. However, with laptop being power managed and turned off upon leaving the office, it shows the highest energy consumption annually which is at 13,880.72kWh/yr and a total cost of RM5,968.71 per year. Laptop that is power managed costs lower to operate compared to laptop not power managed.

Table 6: Total annual energy consumption for laptop base on power mode.

	Annual Laptop Energy Consumption			
Energy Consumption	**Power managed, Turned OFF**	**Not power managed, Turned OFF**	**Power managed, Left ON**	**Not power managed, Left ON**
Annual idle	8,480.40	20,129.08	8,480.40	92,513.48
Annual sleep	1,190.73	0.00	8,582.10	0.00
Annual off	4,209.59	4,209.59	0.00	0.00
TOTAL (kWh)	**13,880.72**	**24,338.67**	**17,062.50**	**92,513.48**
TOTAL (Cost)	**RM5,968.71**	**RM10,465.63**	**RM7,336.88**	**RM39,780.80**

Analysis of total annual saving based on power mode if all desktop PCs are changed to laptop is summarized in Table 7. The investment cost is estimated at RM 2,621,500.00, if the cost of laptop is at RM 3,500 each. However, the payback period is too long (between 16 to 144 years). Even though the saving is high, it is not practical to implement.

Table 7: Total annual saving based on power mode if all Desktop PCs change to laptop.

	Annual Savings			
Energy Consumption	**Power managed, Turned OFF**	**Not power managed, Turned OFF**	**Power managed, Left ON**	**Not power managed, Left ON**
Annual idle	34,462.91	81,801.14	34,462.91	375,959.05
Annual sleep	1,438.80	0.00	10,370.04	0.00
Annual off	6,417.06	6,417.06	0.00	0.00
TOTAL (kWh)	**42,318.77**	**88,218.19**	**44,832.95**	**375,959.05**
TOTAL (Cost)	**RM18,197.07**	**RM37,933.82**	**RM19,278.17**	**RM161,662.39**
Saving Percentage	**75%**	**78%**	**72%**	**80%**
Pay Back Period (Years)	**144**	**69**	**136**	**16**
Investment Cost	RM2,621,500.00	@ RM3,500.00 / unit		

The data survey on the staff behavior of switching off Desktop PC or laptop after office hour shows that only 4.29% of the staff shutdown the devices, switch it off and plug off the socket but the rest only shutdown the device but do not switch it off (68.93%), and shutdown the devices, switch it off but do not unplug the socket (26.79%). Based on the results, most of the staff shutdown their device but did not switch it off.

Wastage factor

Referring to the results that have been produced in section 4.1 to 4.7, a few wastage factors which contributed towards energy wastage can be determined and concluded as follow:

Building

This contributes to energy waste, especially during after office hours where the number of staffs who are still working is small but the lighting for the unoccupied area needs to be turned on to cater the entire area. In addition, the use of conventional fluorescent lamp type also contributes to energy waste. The existing lighting circuit design is shown in Figure 5. Therefore, if the lighting circuit is zoned according to each Unit and uses an efficient lamp type such as LED fluorescent lamp, it can overcome this problem. These issues need to be considered and taken into account during the design of new layout concept or during renovation works.

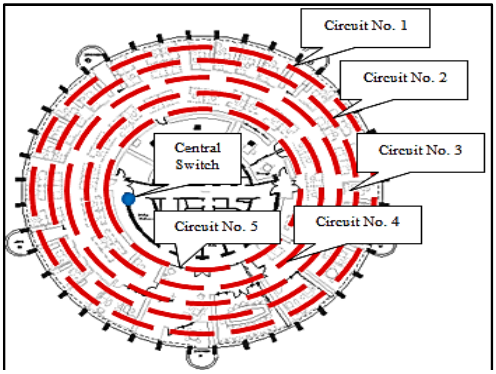

Figure 5: Existing layout of lighting circuit system.

Installation equipment

In order to chill a space for just 15 to 20 staffs working, the centralized air conditioning system needs to operate at temperature that exceeds the actual necessity temperature. This has indirectly contributed to increasing electrical energy consumption. To overcome the problem, current policies and working procedure or regulations should be reviewed and amended.

Human behaviour

Use of fan even when air conditioning system is operating, use of kettle at some work area even though the dry pantry is provided with kettle by management, curtains are not closed properly resulting environment at work area to be warm due to the solar heat gain, not switching off the lights when leaving the toilet and wet pantry, using a lift to the nearest floor, windows open when air conditioning system is operating and not switching off the power point and unplugging the socket after usage are among of the issues related to human behavior. It contributes to energy waste. To overcome the problem, current policies and working procedure or regulations should be reviewed and amended.

Discussion

Target saving baselines

Based on the results in Table 8 of the analysis that has been made, it can be concluded that the estimated rate of savings that can be achieved is 26% if the proposals being set out in the analysis are implemented. This rate is equivalent to 1,537,154kWh/yr or RM660,976.22 per year. Details are shown in Table 12 and the graph of baseline versus target baseline is shown in Figure 6.

Table 8: Saving target baseline base on yearly saving assumption.

Parameter	Baseline	Saving Assumption		Saving Target Baseline
	kWh/yr	kWh/yr	%	kWh/yr
Lighting System	1,635,621	823,060	50	821,561
Plug Load System	311,620	42,319	14	269,301
Cooling Load Sys	3,187,730	671,775	21	2,515,955
Others	802,119	-	0	802,119
Average (2009 – 2013)	**5,937,090**	**1,537,154**	**26**	**4,399,936**

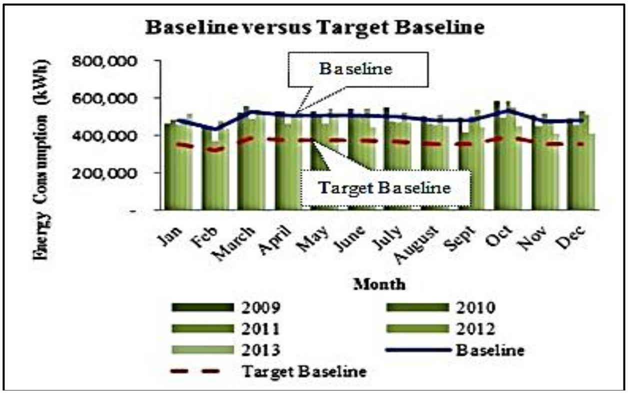

Figure 6: Baseline versus target baseline.

The new BEI value is 177kWh/m2/yr compared to current BEI which is 239kWh/m2/yr. This value is 31% higher compared to standard and 18% higher than PWD target baseline. However, it is believed with proper implementation of energy management plan and continuous control and monitoring process, this value can be reduced further to comply with MS1525.

Energy performance indicator

To control and monitor the energy consumption, control chart was developed as shown in Figure 7. The purpose is to assist in achieving the target savings and monitor the performance of energy usage. An investigation would then be conducted into the causes of change if the actual energy consumption data is far from the target baselines or if unexpected trend is revealed (above U_{CL} line). Then, the corrective action shall be taken to resolve the problems.

However, if the actual energy consumption is below L_{CL} line, then it is important to find out why that high performance of energy usage can be maintained.

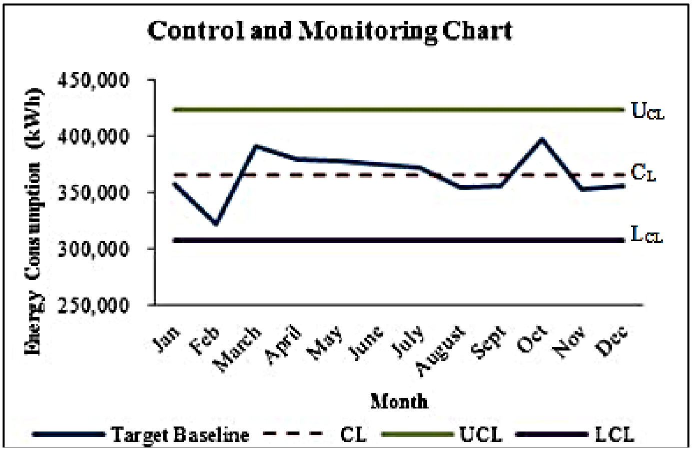

Figure 7. Control and monitoring chart.

Strategy energy management plan

For the purpose of implementing a more effective and systematic energy management, MS ISO 50001: 2011 is highly recommended as a reference standard guideline. By following the EnMS standard requirements, ***TH*** can develop and implement an energy policy, and establish objectives, targets, and action plans which take into account legal requirements and information related to significant energy use. ***TH*** can choose to use it alone or integrate this EnMS standard with other current existing or new managements systems, including those related to quality and occupational health and safety.

The proposal for a strategy approach in energy management plan in ***TH*** is as described below:

a) Commitment from top management.
b) Organize management resources.
c) Appoint a Champion or an Energy Manager.
d) Appoint an Energy Management Team.
e) Energy management strategy to maintain a high level of awareness among staff.
f) Assess performance and set goals.
g) Develop action plan.
h) Implement action plan.
i) Evaluate progress.
j) Annual review.

Conclusion

The energy consumption profile for the previous five years (2009 to 2013) shows the average electricity consumption for the year was 5,937,090kWh with the total cost of RM 2,719,904.85 where 54% was contributed for mechanical and electrical system. However, to overcome this problem, the schedule of the operating mechanical system should be reviewed and adjusted to prevent the system from operating in peak time and to reduce maximum demand charges. Indirectly, this method can help to improve the performance of energy efficiency. The total estimated rate of savings that can be achieved is 26% or 1,537,154kWh/yr with the cost of RM 660, 976.22 per year if the proposals set out in this study are implemented. The current BEI value which is 239kWh/m^2/yr can also be reduced to 177kWh/m^2/yr.

Additionally, the level of awareness among staffs and other parties either they are involved directly or indirectly also need to be nurtured and enhanced through the energy campaign or energy programmes.

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