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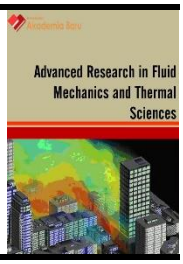

Energy Consumption and Potential Saving in MSI Complex

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ABSTRACT

MSI is a mosque located in Universiti Tun Hussein Onn Malaysia and known as Masjid Sultan Ibrahim. The mosques are considered unique compared to other types of buildings as they exhibit an intermittent operation schedule. This study aims to discover potential saving and provide solutions to achieve cost saving of Masjid Sultan Ibrahim of UTHM. Four potential saving methods were proposed later in this study, which include the installation of sensors, replacement of LED lamp, placement of reminder sign, and human control respectively. Result was found that about 64% of electrical energy was used on ACMV system, 35% on lighting system and the rest were general equipment. From calculation, the monthly electrical energy consumption of Masjid Sultan Ibrahim was near to 36MWh. With the proposed potential saving measures, Masjid Sultan Ibrahim is estimated to reduce the usage of electrical energy for about 13% per month. More potential saving could be found in future study if there is designated system that studies the energy consumption trend of the building.

Keywords:
MSI; achieve cost saving; ACMV system; energy consumption

1. Introduction

Energy is a quantitative property that requires an object or medium in order to perform a work. According to the law of conservation, energy cannot be created nor destroyed [1,2]. Energy can only be converted into one form, or another. The International System of Units (SI) has defined the standard unit of energy as joule. According to Britannica Encyclopedia, energy can be defined as the capacity for doing work, which may exist in potential, kinetic, thermal, electrical, chemical, nuclear, or other various form. Today's trend, electrical energy devices are considered as important as water and air for human being. The electrical energy devices such as air-conditioning system, refrigerators, lighting system, fan, laptops, and television [3-5].

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The use of sustainable supply of energy is important to reduce the consumption of energy generation [6]. Therefore, the increasing of mosque facilities and equipment contributes to increasing of electric energy cost [7,8]. Therefore, the objective of this study is to reduce energy consumption of Masjid Sultan Ibrahim. There are several steps to achieve this objective such as building identification, data collection, data analysis, discussion and conclusion. Several solutions potential to reduce energy consumption, however these studies focus to lighting system. Solution and recommendation were discussed in this study and supported with measurement of approximate saving cost for the mosque. Energy audit has been conducted to identify current energy consumption. There are several potential saving during the audit without compromise users' comfortability. There are many organizations had implemented an energy auditor [9,10]. Then, the organization proceed with measure for energy saving. The energy saving of energy consumption would reduce energy cost of the organization. Finally, this saving action able to save huge number of cash capital and reserve it for future investment [11-15].

1.1 Energy Resources and Consumption

Energy is the main source to all activities. Today, demand for electrical energy had an increasing rate each day. As energy cannot be created nor destroyed, electrical energy requires energy sources to be generated, in order to understand the energy management; a study on energy resources is a must for estimating the energy consumption and proposes ways of energy saving solution [16]. The generation of electricity is using both renewable and non-renewable energy. However, the trend of world energy consumption indicates that 82% is from non-renewable energy, while the remaining 18% is from renewable energy [17,18]. Currently, there are 10 main sources of energy being used to generate electricity worldwide. The sources include solar energy, wind energy, hydrogen energy, tidal energy, wave energy, hydroelectric energy, biomass energy, nuclear power, and fossil fuels. In Malaysia, almost 80% of electricity was generated by natural gas and coal. Fossil fuel such as natural gas and goal are categorized as non-renewable energy, which cannot be replenished. Continuous usage of fossil fuel without control will finish up the resources in no time [19].

1.2 Building

Masjid Sultan Ibrahim is located in UTHM, Parit Raja, which is one of a town of Batu Pahat district. With the coordinates of 1.8553° N, 103.0811° E, it is approximately 4.8 kilometers or six minutes drives from Parit Raja town. In UTHM area, Masjid Sultan Ibrahim is clustered in an area along with Dewan Sultan Ismail (DSI), Perpustakaan Tunku Tun Aminah (PTTA), and Padang Kawad UTHM. As described earlier, Masjid Sultan Ibrahim can hold up to 3000 occupants during its peak time, for instance during Eid's prayer and Friday's prayer. However, the number of occupants during off-peak time is varying throughout the day. As a Muslim, we are obliged to perform five times prayers daily, which are Fajr at dawn, Zuhr during midday, Asr during afternoon, Maghrib during sunset, and Isha during the night. Hence, Masjid Sultan Ibrahim daily usage is focused on these five times daily prayers. Masjid Sultan Ibrahim also being used for other religious activity such as religious ceremony, seminar, and others. However, the usage of Masjid Sultan Ibrahim for these purposes is not permanent, meaning the activities are done at intermittent time without fixed schedule.

2. Methodology

The process flow of this study is divided into 3 phases, namely Phase 1, Phase 2, and Phase 3 respectively. Firstly, it consists of a selection of study area. Next, following sequences is data collection. This data collection will divide into two method, desktop collection and field collection. After that, the sequence moves to data calculation. In this section, total energy consumption and energy efficiency will be calculated. Last but not least, the hierarchy is recommendation solution and expected result for the research. It will be discussed briefly and conclusion will be made.

During Phase 1, literature review has been done on several sources in order to grasp a clear conception of this study. A study on building identification, location, the usage trend, electrical equipment presented, and the published electrical tariff by TNB were done to familiarize with the building of study. Next, Phase 2 is where data being collected and the calculation of estimated energy consumption of Masjid Sultan Ibrahim were done. Meanwhile in Phase 3, the analysis on potential energy saving method has been discussed, followed by the process of thesis writing. During data collection of building, the building has been studied thoroughly, so that the researcher grasps a clear understanding on the type of the building, its characteristics, and the user trend. During data collection of electrical equipment facilities, quantity of lighting and ACMV device were recorded according to their types, together with their rated power consumptions. Besides, the quantity of electrical device such as computers was taken in as well. Next, the calculation of the estimated energy consumption of Masjid Sultan Ibrahim was done and the energy cost was obtained. Solution and recommendation based on the potential saving is listed afterwards, supported with simple measurement of potential saving. Some general solution includes replacement of device and increase users' awareness towards electricity usage.

3. Results and Discussion

The data collected during Phase 1 was tabulated as shown in Table 1. Section no 5 show lobby, walkway and others are the highest operation hours due to this section operate 12 hours per day. This section operation from 6am until 6pm daily while section no 2 shows prayer hall are the lowest operation hours due to this section operate approximately 4 hours per day. This section operates at intermittent time. The other sections operation such as normal office operation hour. From the study result, it is identified that air conditioning system consumes the highest electrical energy. The air conditioning system consumes electrical energy 10,598.40 kWh per month. It is consuming more than 60% of total energy percentage. Even though air conditioning is the highest energy consumption, it is costly to implement any energy saving action. Table 2 shows list of electrical equipment of Masjid Sultan Ibrahim and Table 3 shows list of energy consumption of Masjid Sultan Ibrahim.

Table 1
Masjid Sultan Ibrahim's operation hour per month

No.	Section	Operation hour per month (hours)
1.	Offices	160
2.	Prayer Hall	125
3.	Al-Farabi seminar room	194
4.	Al-Khawarizmi computer room	182
5.	Lobby, walkway, etc	360

Table 2
List of electrical equipment of Masjid Sultan Ibrahim

No.	Equipment	Power (Watt)	Quantity (pcs)
1.	T12, 36W Fluorescent Lamp (Lobby and etc)	36	582
2.	T12, 18W Fluorescent Lamp (Prayer hall)	18	80
3.	T12, 36W Fluorescent Lamp (Offices)	36	74
4.	T12, 36W Fluorescent Lamp (Al-Khawarizmi)	36	8
5.	T12, 36W Fluorescent Lamp (Al-Farabi)	36	56
6.	T12, 36W Fluorescent Lamp (wall mounted)	36	4
7.	CLF downlight (Lobby and etc)	18	538
8.	CLF downlight (Offices)	18	101
9.	CLF downlight (Al-Farabi)	18	54
10.	Spotlight 1	400	12
11.	Spotlight 2	200	7
12.	Exit signboard	18	31
13.	Emergency light	18	71
14.	16” standing fan	58	14
15.	Ceiling fan	82.5	39
16.	HVLS fan	1500	3
17.	Air Conditioning	4140	28
18.	Desktop computer	105	30
19.	LCD television unit	200	1

Table 3
List of MSI Office energy consumption

No.	Equipment	Power (W)	Quantity (pcs)	Total Power (W)
1.	Recessed fluorescent 2 light fitting (1200mm)	36	166	5,976
2.	Bare channel reflector 2 light fitting (1200mm)	36	74	2,664
3.	Recessed compact fluorescent downlight	18	22	396
4.	Exit sign C/W 3 hours battery backup	18	8	144
5.	Emergency light C/W 3 hours battery backup	18	9	162
6.	VRV indoor unit	4,140	16	66,240
7.	Desktop computer	105	15	1,575
8.	LCD television unit	176	1	176

Based on Table 1 and Table 2, the energy consumption calculated from Eq. (1) and summarize in Table 4.

$$\text{Energy consumption (kWh)} = \text{Total Operation (h)} \times \text{Total Power (W)} \quad (1)$$

Energy consumption for lighting system (kWh) = Total Operation Hours (h) x Total Power (W)
= [8(hrs/day) x 20 (days/month)] x 9,342 W
= 1,494.72 kWh per month

Energy consumption for ACMV system (kWh) = Total Operation Hours (hrs) x Total Power (W)
= [8(hrs/day) x 20 (days/month)] x 66,240 W
= 10,598.40 kWh per month

Energy consumption for general equipment (kWh) = Total Operation Hours (hrs) x Total Power (W)
= [8(hrs/day) x 20 (days/month)] x 1,751 W
= 280.16 kWh per month

Total estimated energy consumption (kWh) = Lighting system energy consumption + ACMV system energy consumption
= 648.41 + 839.97
= 1,488.39 kWh per month

Table 4 shows the summary of energy consumption and cost analysis. From this table, ACMV system is highest 62%, lighting system 37% while general equipment 1%.

Table 4
Summary of energy consumption and cost analysis

Criterion	Power Consumption (kWh)	Estimated Cost (RM)	Percentage (%)
Lighting System	13,312.75	4,859.15	37
ACMV System	22,772.97	8,312.15	62
General Equipment	324.26	118.35	1
Total	36,409.98	13,289.65	100

Table 5 shows potential saving suggested in this study. The saving potential is focusing to relamp activity, where the activity is replacing the current lamp with high energy efficient lamp. The suggested potential saving is by replacement of current T12 36W Fluorescent Lamp with LED lamp. Current T12 36W Fluorescent Lamp consume energy for 13,312.75kWh and the energy cost is RM4,859.15, while LED lamp consume energy for 8,589.70kWh and the energy cost is RM3,135.25. There are significant energy saving by 4,723.05kWh and manage to save RM1,723.90. Finally, the result achievement of energy saving contribution from relamp activity is 35.5%.

Table 5
Comparison between current usage vs after replacement of LED lamp

Criteria	Power Consumption (kWh)	Estimated Cost (RM)
T12 36W Fluorescent Lamp	13,312.75	4,859.15
LED lamp	8,589.70	3,135.25
Saving value	4,723.05	1,723.90
Saving percentage	35.5%	

4. Conclusions and Recommendations

This study investigated potential energy saving in Masjid Sultan Ibrahim, Universiti Tun Hussein Onn Malaysia. The available potential energy saving can be achieved when the action is taken as listed.

i. Identify the building location and building orientation.
ii. Identify user trend such as the uses of lamp and air conditioner that consume in daily life.

As a conclusion, this study found the relamp energy saving action able to reduce 35.5% of total lamp energy consumption. However, there are three recommendation suggested in this study. Firstly, all the access to MSI complex needs to be controlled and monitored. Create awareness among MSI complex user. Secondly, all the history of information such as electrical bill, event schedule, activity is kept record properly. All the information must be freely accessed by energy auditor. Thirdly, it is suggested to install MSI complex with separate electrical meter. Let the electrical bill separated from main campus bill and lastly action is to proceed any other energy saving activity.

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