ENERGY EFFICIENCY STUDY TO REDUCE ENERGY USAGE IN AL-AZIM MOSQUE MELAKA

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APPROVAL

I hereby declare that I have read this dissertation and in my opinion this dissertation is sufficient in terms of scope and quality as a partial fulfilment of Master of Mechanical Engineering (Energy)

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Date : 9/3/2020

DECLARATION

I declare that this dessertation entitled "Energy Efficiency Study to Reduce Energy Usage in Al-Azim Mosque" is the result of my own research except as cited in the references. The dessertation has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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DEDICATION

I would like to dedicate my dissertation to my beloved parents, Noordin Saleem Bin Bashir Ali and Zarinah Abdul Latip and my supervisor Prof. Madya. Dr. Musthafah Bin Mohd Tahir

ABSTRACT

The purpose of this study is to determine the energy usage and energy efficiency in Al-Azim Mosque, Melaka which to determine the electrical appliances that have been used by mosque such as fans, lights and air-conditioner. The mosque only use fans and air-conditioners in office. Its electricity bills is surprisingly high which costs more than RM14, 000 every month where the electricity bills cause burden to the mosque committee. Basically the income of the mosque come from donation of the worshippers. Thus, the saving of electrical bills will be used for others benefits such as increase the number of activities in the mosque. The aim of this study is to determine total power consumption and energy saving measures in Al-Azim Mosque and to identify the current thermal condition and opportunities for improvement of fans power consumption without compromising comfort level. There are two methods used to determine the energy efficiency in this project by measure and verify the actual power consumption in Al-Azim Mosque in order to search for significant energy usage that can be reduced. Thus, the thermal comfort is to focuses on the suggestion of the usage of fans and office air-conditioners in mosque in order to determine the potential energy saving plan. The area for the power consumption has been setup at the electricity main board in Al-Azim Mosque. Then, the thermal comfort methods have select the prayer area which consists of nine points, point A, B, C, D, E, F, G, H and I. The main physical parameters involved in this project are air temperature (Ta), relative humidity (RH) and air velocity (Va). The measurement is taken by using *Three-Phase Electrical Networks Analyser* for the power consumption and *Thermal Micro Climate* for the thermal comfort method. The power consumption research by using Data Viewer Software and the thermal comfort analysis of this study is conducted through Delta Log 10 Software. The power consumption focus on fans which has used about 2% and office air-conditioners usage is about 10% from the total power usage. Hence, the balance from the total percentage is used by lighting. Furthermore, the Coefficient of Performance (COP) for air-conditioners in several rooms has been determine such as air-conditioners in offices, meeting, Imam and Muezzin rooms. Thus, all the sample rooms have met the criteria which have achieved more than 2.7. Based on the COP results obtained, all the air-conditioners in the sample room are in good conditions and the efficiency of them are in satisfactory range. Next, the thermal comfort also included the analysis of Predicted Mean Vote (PMV) and Predicted Percentage Dissatisfied (PPD) index of measurements. According to the obtained results, almost all the air temperature and relative humidity measurement was satisfied the standard and almost 90% air velocity readings were not satisfied the current standard. Furthermore, the questionnaires has been compare with the PMV and PPD results, the results shows the occupant's thermal sensation has met the results for PMV and PPD.

ABSTRAK

Tujuan kajian ini adalah untuk menentukan penggunaan tenaga dan kecekapan tenaga di Masjid Al-Azim, Melaka yang menentukan peralatan elektrik yang digunakan oleh masjid seperti penggunaan kipas, lampu dan penghawa dingin. Masjid hanya menggunakan kipas dan penghawa dingin di pejabat. Bil elektriknya telah mencecah lebih daripada RM14, 000 setiap bulan di mana bil elektrik menyebabkan beban kepada jawatankuasa masjid. Pada dasarnya pendapatan masjid berasal dari sumbangan para penyembah. Oleh itu, penjimatan bil elektrik akan digunakan untuk manfaat lain seperti meningkatkan bilangan aktiviti di masjid. Objektif kajian ini adalah untuk menentukan jumlah penggunaan kuasa dan langkah-langkah penjimatan tenaga di Masjid Al-Azim dan untuk mengenal pasti keadaan terma semasa dan peluang untuk meningkatkan penggunaan kuasa pengguna tanpa menjejaskan tahap keselesaan. Terdapat dua kaedah yang digunakan untuk menentukan kecekapan tenaga dalam projek ini dengan mengukur dan mengesahkan penggunaan kuasa sebenar di Masjid Al-Azim dan untuk mencari penggunaan tenaga yang berlebihan yang dapat dikurangkan. Selain itu, keselesaan haba adalah cara untuk memberi tumpuan dan cadangan penggunaan dan penghawa dingin pejabat di masjid untuk menentukan cara penjimatan tenaga yang berpotensi. Kawasan untuk kegunaan kuasa telah disiapkan di papan utama elektrik di Masjid Al-Azim. Kaedah keselesaan termal memilih kawasan solat yang terdiri daripada sembilan titik, titik A, B, C, D, E, F, G, H dan I. Parameter fizikal utama yang terlibat dalam projek ini adalah suhu udara (Ta), kelembapan relatif (RH) dan halaju udara (Va). Pengukuran dilakukan dengan menggunakan Three-Phase Electrical Networks Analyser untuk penggunaan kuasa dan Thermal Micro Climate untuk kaedah keselesaan termal. Penyelidikan penggunaan kuasa dengan menggunakan Perisian Pemapar Data dan analisis keselesaan termal kajian ini dilakukan melalui Delta Log 10 Software. Tumpuan penggunaan kuasa pada yang menggunakan kipas kira-kira 2% dan penggunaan penghawa dingin pejabat adalah kira-kira 10% daripada jumlah penggunaan kuasa. Oleh itu, baki daripada jumlah peratusan digunakan oleh lampu. Selain itu, Coefficient of Performance (COP) untuk penghawa dingin di beberapa bilik telah dikaji ialah seperti penghawa dingin di pejabat, Mesyuarat, Bilik Imam dan Muezzin. Oleh itu, semua bilik contoh dalam eksperimen ini telah memenuhi kriteria yang telah mencapai lebih dari 2.7. Berdasarkan hasil COP yang diperoleh, semua penghawa dingin di dalam bilik contoh berada dalam keadaan yang baik dan kecekapan berada dalam julat yang memuaskan. Seterusnya, keselesaan terma juga termasuk analisis Predicted Mean Vote (PMV) and Predicted Percentage Dissatisfied (PPD) yang telah diukur. Menurut hasil yang diperoleh, hampir semua suhu udara dan kelembapan pengukuran relatif berpuas hati standard dan hampir 90% pembacaan halaju udara tidak memenuhi piawaian semasa. Selain itu, soal selidik telah dibandingkan dengan hasil PMV dan PPD, hasilnya menunjukkan sensasi haba jemaah masjid adalah sama dengan keputusan untuk PMV dan PPD dengan menggunakan Delta Log 10 Software.

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I would like to thank to all those who have helped me to finish this project. First, I would like to thank very much to my beloved supervisor Prof. Madya. Dr. Musthafah Bin Mohd Tahir for guidance and giving brilliant advice to me as well as provision of the valuable time management. There are no other words that would able to express my feeling of gratitude toward you except thanks for kindness and helpfulness. His willingness to spend his time so generously whenever I confront problems is much appreciated.

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LIST OF SYMBOLS & ABBREVIATIONS

TNB	-	Tenaga Nasional Berhad
BEI	-	Building Energy Index
ASHRAE	-	American Society of Heating, Refrigerating and Air-Conditioning Engineers
BMS	-	Building Management System
UTeM	-	Universiti Teknikal Malaysia Melaka
PPD	-	Percentage of Dissatisfied
PMV	-	Predicted Mean Vote
MS 1525	-	Malaysia Standard 1525
COP	-	Coefficient of Performance

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CHAPTER 1

INTRODUCTION

1.1 Project Background

The concept of energy efficiency usually to ensures the total energy consumption being reduce in cooling, heating and lighting (Ruparathna *et. al.*, 2016) Therefore, the high energy usage can cause high cost in monthly electrical bills due to the huge usage in cooling system and other electrical appliances. (Gul & Patidar, 2015) There is a way to control the energy wastage where there is a way of increasing energy efficiency is meant to reduce energy consumption but continues to be used in the same level of service. In addition, energy savings or efficiency is also basic effort to make less the impact of Green House Effect into the atmosphere. (NurIzie *et. al.*, 2017)

Religious structures are significant importance for every culture throughout the world. The place for the worshipping is crucial in the comfort to focus on their devotions. Although there are many different methods of worship across many different religions that required various design and structure. Most religious buildings have one or more large gathering areas to accommodate large groups of people, which during specific periods of time. (Al-Homoud *et. al.*, 2009)

Generally, there will also be multiple classrooms or offices in these buildings to accommodate smaller meetings or other use. As buildings consume a large portion of total energy consumption, there exists a significant number of energy studies on various types of commercial buildings. (Budaiwi, 2011)

Religious facilities are thus unique compared to other commercial buildings in that typically characterized with no or minimal occupancy for the majority of the time, with relatively infrequent periods near maximum occupancy. Despite consuming a significant portion of the total floor space and energy use in the commercial sector, religious facilities have received remarkably limited attention in the literature. (Al-Homoud *et. al.*, 2009)

1.2 Problem Statement

The energy usage problems should be an important part of the building because it has huge energy consumers, expensive costs, contributing climate change and the lack of natural resources of non-renewable energy will be easily compromised. (Lo, 2013) Therefore, the high energy usage can cause high cost in monthly electrical bills due to the huge usage in cooling system and other electrical appliances. (Gul & Patidar, 2015) Then, the concept of energy efficiency usually to ensure the total energy consumption being reduced in cooling, heating and lighting (Ruparathna *et. al.*, 2016).

The purpose of this study is to determine the energy usage and energy efficiency in Al-Azim Mosque, Melaka which to determine the electrical appliances that have been used by mosque such as fans, lights and air-conditioner. The mosque only use fans and air-conditioners in office. Its electricity bills is surprisingly high which costs more than RM14, 000 every month where the electricity bills cause burden to the mosque committee. Basically the income of the mosque come from donation of the worshippers. Thus, the saving of electrical bills will be used for others benefits such as increase the number of activities in the mosque.

1.3 *Objectives*

The objectives of this project are as follow:

- To determine total power consumption and energy saving measures in Al-Azim Mosque
- To identify the current thermal condition and opportunities for improvement of fans and air-conditioners power consumption without compromising comfort level

1.4 Scopes

The scopes of this project are:

- Measure and verify the actual power consumption in Al-Azim Mosque and search for significant energy usage that can be reduced.
- Focuses on the suggestion of the usage of fans and office air-conditioners in mosque in order to determine the potential energy saving plan by using ASHRAE and MS 1525.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In Muslim communities, mosques symbolize a place of huge influences to the Muslim. The mosque become the important place where people gather for their daily as well as weekly prayers such as Friday prayers. Worshippers in mosques need to feel relaxed and calm in order to attain a feeling of stillness, harmony and peace. Then, mosques are represent by having a different activity programmes as compared to other types of buildings. Generally, the worshippers occupied five times intermittently throughout the day all year round with each occupancy averaging a fraction of an hour to an hour. (Abdou *et. al.*, 2015)

Mosques has been characterized as unique structure in context of energy analysis point of view. Muslims perform their prayer five times in a day on schedule that is connect the position of the sun. The time of prayers are from a fraction of an hour. Friday noon prayers approximately one hour forms a weekly peak since the activity is compulsory only for men to be performed prayer in mosque. Thus, mosques usually sized to accommodate a very large number of occupants for just one hour or so per week. The rest of the week other than Friday noon prayers typically has significantly lower occupancy. (Mokhtar, 2015)

There is an annual peak that occurs in the month of Ramadan. Based on the Islamic calendar, Muslims fasting is obligatory during day and a night the time prayer (Taraweeh) approximately two hours is popular. (Lamiaa and Tarek, 2017) (Mokhtar, 2015)

There are has a sentimental value to reduce the energy usage in mosque because the mosque is the central location and visibility in the community where the most of the cities in Malaysia has a large of Muslims population. Thus, the mosques are significant to make a campaign in buildings through the society (Mokhtar, 2011a). Furthermore, mosques are perfect shelters in cases of disasters. The effort to make the mosque as low energy usage can significantly enhance such a potential role (Mokhtar, 2011b).

The subjective assessment or as know as questionnaires of thermal comfort in mosques has been related the subject of a number of studies to prove the comfort of worshippers. The investigation gave the results of a survey conducted on people performing prayer which indicated that people comfort on certain points of location (Saeed, 1996).

2.2 Building Information and Description

Al-Azim Mosque is a mosque located about three kilometres from Melaka town in Melaka Tengah district, Melaka. The mosque is capable of accommodating a congregation of 10,400 people. The upper floor is reserved for 700 women while the ground floor can accommodate up to 9,700 male males. The mosque is spacious and comfortable because it is not disturbed by small pillars.

The Al-Azim Mosque was built on March 14, 1984 and fully completed on January 12, 1990. Its construction project costing RM19.5 million was officially opened by His Majesty the Sultan of the Sultanate of Azlan Shah on July 13, 1990 equivalent to 20 Zulhijjah 1410 H.

The Al-Azim Mosque also has an Administrative Office, Mini Auditorium, Lecture Rooms, Imam Room, VIP Room and other rooms. Based on the computation of the area of Al-Azim Mosque in a gross floor area, the Gross Floor Area (GFA) is 5,415,107 m^2. The main energy source for this building is electricity from Tenaga Nasional Berhad (TNB). The diesel fuel input to the generator set is not considered a source of energy.

The architectural style of the Al-Azim Mosque is provided by a Design Committee which takes into account the unique aspects of the Malay tradition of architecture and Islamic art. In accordance with its uniqueness, it can be seen from both external and internal angles.

This mosque is rectangular in shape with a three-tiered roof that is also the same. This inspiration is based on the first mosque form built by Prophet Muhammad S.A.W. and in accordance with the essence of Islam itself which consists of four main elements, namely:

(i) the site symbolizes the *shari'a* (Islamic law)

(ii) the first level symbolizes *tariqat* (the way to approach Allah)

(iii) the second level symbolizes *haqiqat* (seeking the truth of Allah)

(iv) third level symbolizes *makrifat* (knowing God)

(v) The engraved vertex is replaced by *Dom*.

Some pieces of Quranic verses have been selected and carved with khat writing. The selection of the verse is adapted to the concept and philosophy of building this mosque. At each end of the mosque roof there is a *sulur bayung* which symbolizes a distinctive feature of the Malay architectural beauty. The idea of creation of the design of *sulur bayung* is taken from a wild plant by the river. It illustrates the grasp of the hand while being blessed.

Al-Azim Mosque is the biggest mosque in Malacca. In Malaysia, there are 19.5 Million Muslims and there are more than 5,000 mosques has builds in Malaysia which depend on the electricity. Generally, the mosque is design in a rectangular, wall enclosure with a roofed prayer hall. In addition, people use electricity through fan, lighting and speakers. Total up of the electricity used became higher when performing prayers everyday on five times. The Islam prayer time and associated rakaat has shown in table 2.1. (Abdou, 2015)

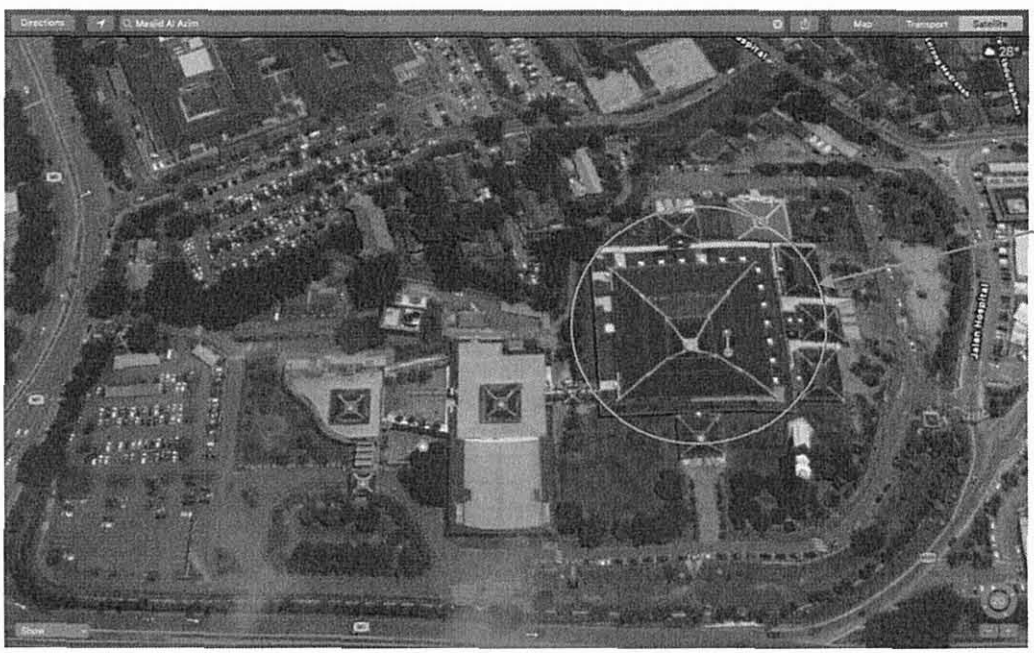

Figure 2.1: Location Al-Azim Mosque, Melaka

Table 2.1: The Islam Prayer Time and Associated Rakaat

Time (Based on 29/3/2019 – 5/4/2019)		Rakaat
Fajr	5.45 A.M	2
Dhuhr	1.15 P.M	4
Asr	4.40 P.M	4
Maghrib	7.15 P.M	3
Isha	8.25 P.M	4

Usually most of the mosque has followed the design of the Makkah city. The area of the mosque is mostly determined by the floor area divided by the area required for a worshipper to perform the prayer which approximately $0.80 \times 1.2 = 0.96\ m^2$. (Abdou, 2015). The figure 2.2 has shown the general layout for mosque.

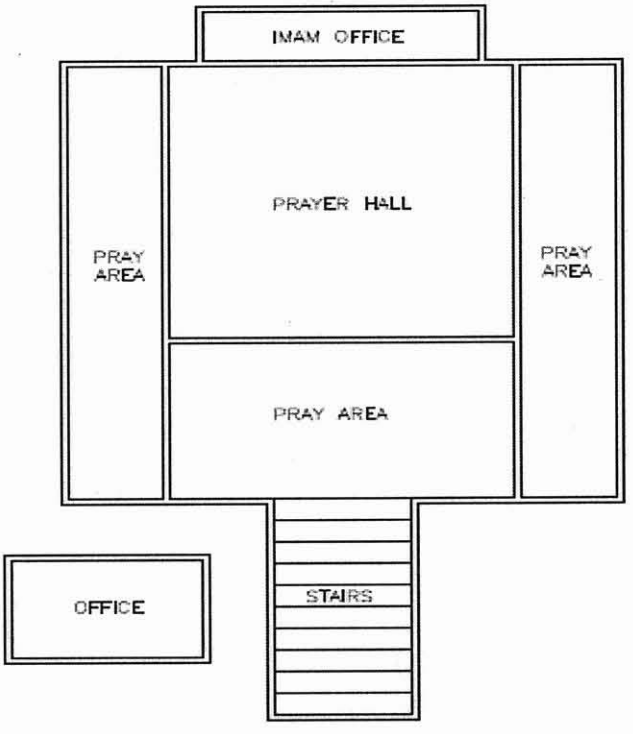

Figure 2.2: General layout for Mosque

(Source: Adel Abdou, 2003)