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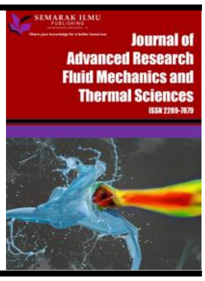

A Case Study on Potential Saving of Energy Consumption at Hospital Putrajaya

Zamri Noranai[1,*], Nurul Farahin Mohd Joharudin[2], Noradila Abdul Latif[2], Nur Liyana' Amirah Mohd Kamil[2], Mohd Azahari Razali[1]

[1] Centre for Energy and Industrial Environment Studies (CEIES), Faculty of Mechanical and Manufacturing Engineering, Universiti Tun Hussein Onn Malaysia, 86400 Parit Raja, Batu Pahat, Johor, Malaysia
[2] Faculty of Mechanical and Manufacturing Engineering, Universiti Tun Hussein Onn Malaysia, 86400 Parit Raja, Batu Pahat, Johor, Malaysia

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ABSTRACT

Efficient electrical energy usage has been recognised as one of the significant factors to reduce the cost of electrical energy consumption. In this world, hospitals are public buildings that use the enormous energy of other buildings. Due to its 24 hours service, the use of hospital building energy is estimated to be among the highest compared to commercial and residential buildings. In this research, the main building of Putrajaya Hospital has been selected. The main building covered by the first floor until the fifth floor will be focused to conduct this research. This research aims to identify energy consumption, cost savings and the provision of solutions to achieve the cost savings target of Putrajaya Hospital. The characteristics and location of the building were recognised at the beginning of the research. Besides, this study was continued by identifying the lighting system presented at Putrajaya Hospital and the electricity tariff published by Tenaga Nasional Bhd. The calculation of energy consumption and cost for each floor of the main building, starting from the first floor to the fifth floor proposed the energy saving method. Four potential savings methods are proposed later in this research which include the switch to LED lighting saving potential, occupancy sensor, regular maintenance, and reduce light operation hour by using the alternate system. The result was found that energy consumption can be reduced up to 73.38% by switching the current lamp to LED lamp.

1. Introduction

Energy is a significant source of power for human in daily activity. Energy can be neither created nor destroyed but only changed from one form to another [1, 2]. Today's trend, electrical energy devices are considered as important as water and air for human being [3]. According to Britannica Encyclopedia, energy can be defined as the capacity for doing work, which may exist in potential, thermal, kinetic, electrical, nuclear, chemical, or other several forms [4]. The increasing energy demand, especially in cities, offers many chances to improve energy efficiency. Management of

* *Corresponding author.*
E-mail address: zamrin@uthm.edu.my

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energy efficiency is crucial, especially in hospitals. It is because they are facilities with high and permanent consumption of energy. There is several potential saving during the audit without compromise users' comfortability. Many organizations had implemented an energy auditor [5, 6]. Then, the organization proceeds with the measure for energy saving. The energy-saving of energy consumption would reduce the energy cost of the organization. Finally, this saving actionable to save a considerable cash capital and reserve it for future investment [7-11]. In hospitals, the lighting, security systems, heating or air conditioning, monitoring, sterilization, cleaning, elevators, and operating rooms work for 24 hours a day, 365 days a year. Improvements in energy consumption will reduce energy costs. Finally, this improvement benefiting in economic.

The purpose of carrying this research is to analyses the current monthly energy consumption for the lighting of the main building Hospital Putrajaya from level one until level five and determine its saving potential. Solutions and recommendation are discussed in the paper.

1.1 Energy Resources and Consumption

As the world's population grows, dynamic economic expansion, particularly in China and India, and the spread of prosperity drive up demand for energy [19]. In dealing with energy resources and energy use, it is often necessary to distinguish between renewable and non-renewable resources [12]. Renewable energies are positioned as an excellent solution to replenished that can be described as a renewable energy resource [13]. Renewable energy sources are more environmentally friendly than non-renewable energy resources because they only emit very few contaminants like carbon dioxide that can harm the environment. Renewable energy resource currently contributes less than 10% of global energy consumption. Non-renewable energy resources are the resources that are found in fixed amounts and cannot be replenished. Non-renewable energy resources are those found inside the earth, and taking million years to form. Fossil fuels, oil, natural gas, coal, and nuclear energy are an example of non-renewable energy resources. Fossil fuels also contributed significantly to global climate change by releasing carbon dioxide into the air when burned. Currently, fossil fuels contribute nearly 84% of the total amount of energy consumed globally [14]. The source of electricity is chemical energy as it is produced from the breakdown of chemical reaction such as oils, organic chemical compounds water and non-organic compounds. Electricity is commonly used in everyday usage as it can be converted into other forms such as water, light, noise and wind. The state of electricity above is a common feature in daily activities. Electrical energy is a secondary source of energy, unlike other sources of energy. To produce electrical energy, another form of energy must be used. A power station is a place where other forms of energy such as coal, natural gas, hydropower and nuclear energy are converted into electrical energy for delivery to electrical energy using locations [15-17].

1.2 Building

The buildings selected were the main building of Hospital Putrajaya, located in Presint 7, Wilayah Persekutuan Putrajaya at 2.9292° toward North and 101.6742° toward East built on a piece of land of 25.74 acres. The main building of Hospital Putrajaya consists of eight stories which lower ground, ground, level one, level two, level three, level four, level five and level six respectively. The total floor area of the building is 40,575 m^2. Hospital Putrajaya provides a range of service to the public, including specialist clinics, maternity, and paediatrics. In general, Hospital Putrajaya opens at approximately 8 a.m. and closes at around 5 p.m. with sometimes extended hours of operation beyond 6 p.m. and weekends or public holidays based on specific requirements. However, there are few departments and wards are exceptions due to 24 hours services.

2. Methodology

The Figure 1 shows the flow chart of this research that consists of three phases, i.e., phase one, phase two, and phase three, respectively. Through phase one, the research building was selected, problem statement, objectives and research scope was identified. Besides, a literature review was also conducted on several sources to gain a clear understanding of this research. Research on building identification, location, operation hour and lighting system presented were done to familiarize with the research building. Next, phase two is where data is collected, and the calculation of estimated energy consumption of level one until level five for the main building Hospital Putrajaya was done.

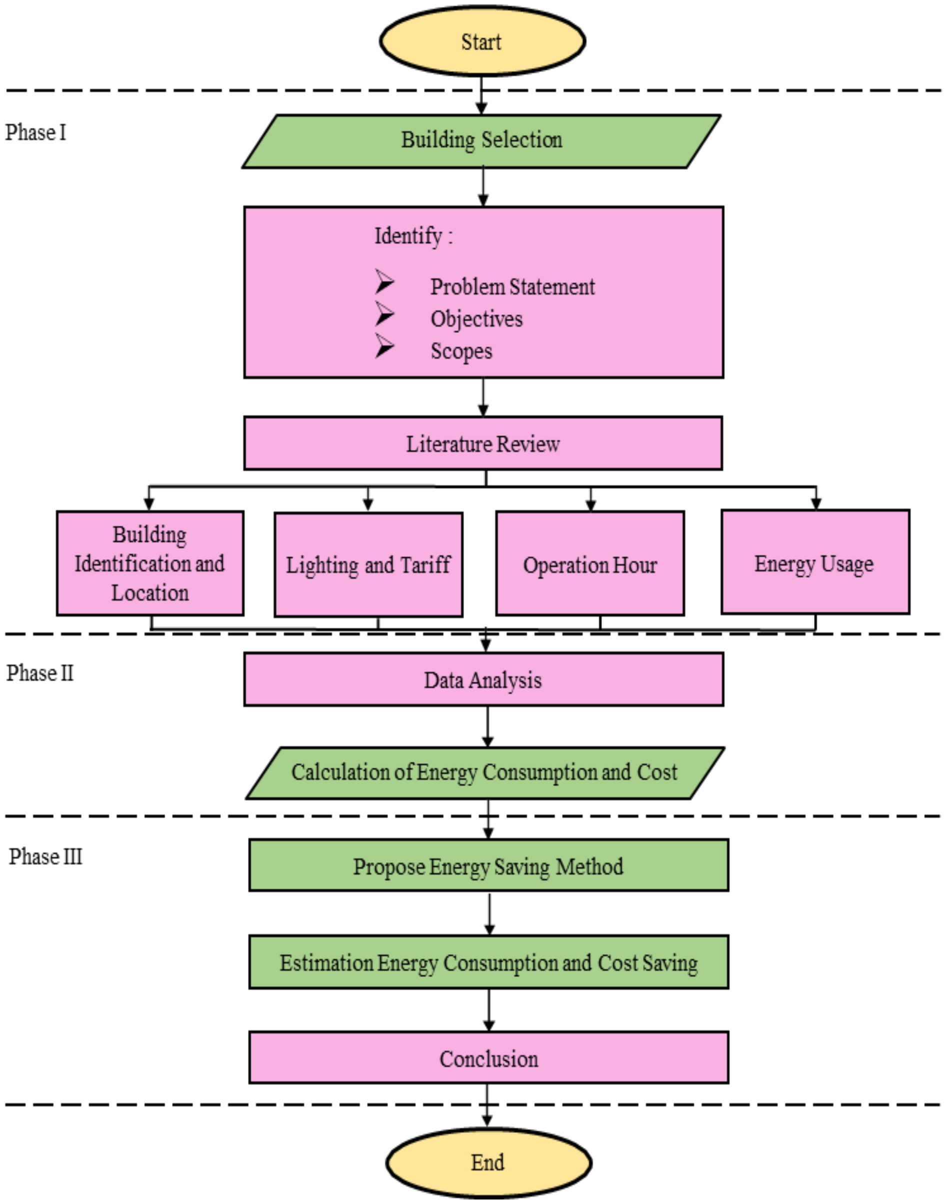

Fig. 1. Flow chart of research methodology

Meanwhile, in phase three, the analysis of potential energy-saving method has been discussed and documented. During the data collection of the building, the building was thoroughly studied so that the researcher had a clear understanding of the type of the building, its characteristics, and the time of operation. The quantity of lighting was recorded according to their types, together with their rate power consumptions. Next, the calculation of the estimated energy consumption of the main building has been carried out, and potential energy-savings have been obtained. Solution and recommendation based on the potential saving are listed afterwards, and one of the solutions is switching to LED lamp.

3. Results and Discussion

The data are presented in the table form after the data collection phase for ease of reading and calculation step. Table 1 shows the types and quantity of lamp focused on the main building of Hospital Putrajaya. Table 2 shows the energy consumption on the main building for current lighting system and Table 3 shows the energy consumption on the main building for future lighting system.

Table 1
Types and quantity of lamp focused on the main building of Hospital Putrajaya

No.	Floor	Quantity of Lamp (pcs)		
		Fluorescent (36 W)	Compact Fluorescent (26 W)	Compact Fluorescent (18 W)
1.	Level 1	1,429	77	-
2.	Level 2	624	71	443
3.	Level 3	588	57	378
4.	Level 4	269	135	172
5.	Level 5	241	204	181

Table 2
Energy consumption on the main building for current lighting system

No.	Type of Lamp	Power (W)	Quantity (pcs)	Total Power (W)
1.	Fluorescent	36	3,151	113,436.0
2.	Compact Fluorescent	26	544	14,144.0
3.	Compact Fluorescent	18	1,174	21,132.0

Table 3
Energy consumption on the main building for proposed lighting system

No.	Type of Lamp	Power (W)	Quantity (pcs)	Total Power (W)
1.	QEOS LED T8 tube	9.50	3,151	29,934.5
2.	QEOS LED T8 tube	7.50	544	4,080.0
3.	QEOS LED T8 tube	4.75	1,174	5,576.5

3.1 Calculation of Energy Consumption for Current Lighting System

The energy consumption was calculated from Eq. (1) according to the operating of the hospital with daily use which is 24 hours/day and 30 days/month as shown below

Energy consumption = Total operation (h) × Total Power (W) (1)

Energy consumption for a fluorescent lamp (36 W)

$$= \left[24\frac{hrs}{days} \times 30\frac{days}{month}\right] \times 113{,}436\ W$$

= 81,673,920 Wh

= 81,673.92 kWh per month

Energy consumption for Compact fluorescent (26 W)

$$= \left[24\frac{hrs}{days} \times 30\frac{days}{month}\right] \times 14{,}144\ W$$

= 10,183,680 Wh

= 10,183.68 kWh per month

Energy consumption for Compact fluorescent (18 W)

$$= \left[24\frac{hrs}{days} \times 30\frac{days}{month}\right] \times 21{,}132\ W$$

= 15,215,040 Wh

= 15,215.04 kWh per month

Total estimated energy consumption = Energy consumption for a fluorescent lamp (36 W) + Energy consumption for Compact fluorescent (26 W) + Energy consumption for Compact fluorescent (18 W) (2)

= 81,673.92 + 10,183.68 + 15,215.04

= 107,072.64 kWh per month

3.2 Calculation of Energy Consumption for Proposed Lighting System

The energy consumption for proposed lighting system was calculated from Eq. (1) according to the operating of the hospital with daily use which is 24 hours/day and 30 days/month as shown below.

Energy consumption for a LED lamp (9.5W)

$$= \left[24\frac{hrs}{days} \times 30\frac{days}{month}\right] \times 29{,}934.5\ W$$

= 21,552,840 Wh

= 21,552.84 kWh per month

Energy consumption for a LED lamp (7.5W)

$$= \left[24\frac{hrs}{days} \times 30\frac{days}{month}\right] \times 4{,}080\ W$$

= 2,937,600 Wh

= 2,937.6 kWh per month

Energy consumption for a LED lamp (4.75W)

$$= \left[24\frac{hrs}{days} \times 30\frac{days}{month}\right] \times 5{,}576.5\ W$$

= 4,015,080 Wh

= 4,015.08 kWh per month

Total estimated energy consumption = Energy consumption for a LED lamp (9.5W) + Energy consumption for a LED lamp (7.5W) + Energy consumption for a LED lamp (4.75W) (3)

= 21,552.84 + 2,937.6 + 4,015.08

= 28,505.52 kWh per month

3.3 Summary of Data Analysis

Table 4 shows the comparison of current usage by using the current lighting system and proposed lighting system, which is after switching of the LED lamp, by using Tariff C1 with RM 0.365 for each kilowatt [18]. The saving potential is focusing on relamping activity, where the activity is replacing the current lamp with high energy efficient lamp. Current Fluorescent Lamp consumes energy for 107,072.64 kWh, and the energy cost is RM 39,081.51, while LED lamp consumes energy for 28,505.52 kWh, and the energy cost is RM 10,1404.51. There are significant energy saving by 78,567.12 kWh and manage to save RM 28,677.00. Finally, the result achievement of energy-saving contribution from relamp activity is 73.38%.

Table 4
Comparison between current usage and after the switch to LED lamp

No.	Criteria	Power consumption (kWh)	Estimated Cost (RM)
1.	Current lighting system	107,072.64	39,081.51
2.	Proposed lighting system	28,505.52	10,404.51
3.	Saving value	78,567.12	28,677.00
	Saving percentage	73.38%	

3.4 Suggestion and Recommendation

There are a few ways of solution and recommendations that were proposed in this research. Some equipment or components switching were included in this research to achieve energy-saving objectives. The potential saving measures was proposed, which is technical saving measures include: Switching of an LED lamp in the lighting system. Table 3 above shows the comparison between current usage and after switching to the LED lamp.

Occupancy sensor. Occupancy sensor ensures light only run when there is somebody there need lighting while at those places. In general, a sensor is a tool or system that works by detecting an approaching object or changes in the environment surrounding. These are particularly useful in places such as toilet and lighting zone area. An occupancy sensor can also be used to lower light levels in the corridor at night time which can be a cost-effective measure. However, it is imperative to maintain the lowest light level in order not to compromise safety and health standards. Besides, an occupancy sensor may not be appropriate at wards and for patient rooms where people may not be moving regularly enough to be detected.

Regular Maintenance. Retain clean spaces, skylight, light fixtures, replace the old, dim or flickering lamp and ensure that any occupancy sensors are clean in good working order. Other than that, encourage workers to report a problem with maintenance. It will help to maintain the optimal light output. Also, it provides both staff and patients with a clean and more desirable environment.

Reduce Light Operation Hour using Alternate System. In these cases, reduce the operation hour of lamp can be one of the solutions in reducing the light energy consumption at the hospital. This reduction of operation hour for the lamp can be implemented at a particular area of the hospital, such as a corridor. The reduction can be made by using an alternate system. Each lamp at the hospital operates for 24 hours per day. By using this method, the operation hour can be reduced into 12 hours for each lamp. For example, 24 hours of operation where 12 hours in the beginning, the number of lamp operation will be odd while 12 hours next, the number of lamp operation will be even number.

4. Conclusions

This research purposed to identify building characteristic and analyse the estimation of monthly energy consumption of level one until level five for the main building of Hospital Putrajaya. This research also discovers the saving potential that can be applied in main building hospital based on the data collected. Lighting consumption at main building consists of labour room lighting, intensive care unit lighting, main lobby lighting, neonatal intensive care unit lighting, surgical day care lighting, ward lighting, corridor lighting, toilet lighting, on-call accommodation lighting and VIP executive ward lighting. However, no record or system can monitor the power consumption for lighting at a certain location of the main building, as the electricity bill comes in bulk with several other buildings in Hospital Putrajaya. Hence, it is important to have an estimation on the monthly electrical energy consumption for lighting to visualise energy usage. Level one until level five of the main building monthly lighting energy consumption was estimated at nearly 107 MWh. From these figures, the lighting system was identified as a high contributor to energy consumption. With these proposed potential saving measures, it is estimated that the lighting energy consumption will be around 28MWh per month, which can be translated into 73.93 % saving on monthly lighting energy consumption.

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