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"Sustaining the Resilient, Beautiful and Safe Cities for a Better Quality of Life"

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END-USERS' PERCEPTION OF ENERGY EFFICIENCY AT HEALTHCARE FACILITIES: A CASE STUDY OF BATU GAJAH HOSPITAL, PERAK

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Abstract

The demand for energy efficiency has risen due to the depletion of non-renewable energy sources and greenhouse gas emissions. Energy efficiency aims to reduce energy consumption to perform the same tasks as the conventional method, including building operations. Hospital and healthcare facilities are known to be energy-intensive buildings. The ever-increasing demand for energy efficiency in hospital buildings has been recognised as smart economic management and countermeasure thus will provide better care for the public. High dependence solely on the mechanical system is not sustainable in the long run and various studies have established the optimal corrective measures of hospital design by combining passive and active systems to achieve optimal energy saving. This paper examines the end user's perception of the hospital's energy consumption in the Hospital Batu Gajah, Perak ward area. The study was conducted by using questionnaire administration and due to the nature of the healthcare setting the anonymity of inpatient ward users is preserved. Response by the end-users plays a massive role in addressing the efficiency of energy use in hospital and healthcare settings. The outcome of this paper will benefit the designers for a systematic guideline and consideration for hospital design, ultimately improving the efficiency of energy consumption for hospitals.

Keywords: *User's experience, energy efficiency, passive design; hospital and inpatient ward*

INTRODUCTION

Electricity consumption in Malaysia is increasing every year. Data from the Energy Commission of Malaysia 2020 shows that this energy consumption in 2019 will be 152,865 GW. The industrial sector utilizes a sizeable portion (45.7%), followed by the commercial sector (31.7%) and the residential sector (21.6%). Meanwhile, the agriculture and transport sectors only contributed 0.6% and 0.4%. Power stations mostly supply the use of electrical energy. A report released by the energy commission emphasized only 0.4% of the energy source is renewable. Meanwhile, the remaining 99.6% of non-renewable energy sources consisted of new coal (46.5%) natural gas (40.5%) hydropower (11.2%), diesel (0.7%) and fuel oil (0.7%). The rate of total electricity consumption for the commercial sector, especially buildings, is 32.6% of the energy used (Commission, 2020). Therefore, commercial buildings are one of the main contributors to greenhouse gas emissions, with a projected decrease of 23%

in 2020 and 30% in 2030. Malaysia is concerned with this issue of energy efficiency in buildings and targets a 40% reduction in its carbon emissions by 2020 while saving energy and costs (Ludin et al., 2020).

The energy consumption in hospital and healthcare facilities are increasing significantly over time. It is due to the homogeneous environment that has been created by the designers, which aims to be solved through standard engineering (Azizi et al., 2018). Some may argue that most hospitals and healthcare facilities waste a lot of energy by not responding to climatic conditions and the need for user comfort. A report issued by the Environment and Energy Branch under the auspices of the Public Works Department of Malaysia through the Energy Efficiency Project in the Building Sector (BSEPP) (Ludin et al., 2020) stated that energy consumption had increased 50% more for use in buildings. Therefore, this energy in the building needs to be optimally regulated. The energy consumption in hospitals and healthcare facilities needs to be handled more efficiently and holistically. The passive design utilises natural sources such as daylighting, facilitates natural ventilation for optimal fresh air cycle and proper building orientation to reduce thermal mass, thus increasing thermal comfort for the building occupants. In comparison, the active design system uses or produces energy such as artificial lighting, Heating, Ventilation and Air Conditioning (HVAC), and solar. The active design system is paramount in hospital and healthcare settings because of the various types of medical equipment and machinery. Hybrid optimisation of active and passive design will produce optimal energy-saving measures. This paper explores the end-user's perception of energy efficiency measures taken by the public hospital. The inpatient ward is operating non-stop, therefore the insights from the occupants will be valuable information toward improving users' experience, especially for the patients during their admittance. Their feedback essentially will improve the existing healthcare condition and environments. The outcome of this will be beneficial for the architects and designers by providing a systematic design guideline and input for hospital and healthcare design.

LITERATURE REVIEW

Dilemma in Hospital and Healthcare Building Design

Hospital and Healthcare building design require extensive knowledge of medical planning and elaborate attention to detail, especially when accommodating spatial planning, internal layout, medical equipment and machinery, material, and others. The majority of public hospitals that were built before the independence will require major renovation works. Another solution is by constructing new buildings to accommodate the latest demand for modern equipment and machinery requirements. Barbolini et al. (2017) stated that the architects who designed the hospital building faced considerable challenges in solving the energy consumption problem in the hospital building. Studies conducted in several developed countries showed a sharp increase in active energy use from 20% to 40%. In fact, according to a report released by the Building Sector Energy Efficiency Project (BSEEP) (Tang, 2013), waste also increased by 50%, especially in the health sector. Some of the contributing factors are budget constraints for renovation or new buildings, limitation of knowledge in designing hospitals toward the environment, and incorporation of active and passive design to achieve optimum energy efficiency. It is paramount for the designer to consider the comfort of users in the ward while keeping energy efficiency more optimally (Reddy et al., 2019).

The researchers agreed that proper environmental design for energy use in hospital buildings will affect physical, mental and psychological health outcomes (Kamaluddin, et al., 2016). Furthermore, when designing a hospital, it is not just a project that needs to be completed, but the designer takes into account the energy-saving aspects used in the building. The nature of fast-paced technological advancement is proven to be a challenge to the designer. Hospital and healthcare design specialists are responsible for juggling economic management

from inception until completion, building function and aesthetic and finally user's experience equilibrium. All the resources should be managed carefully especially the public hospital, to achieve energy efficiency (Aydin, et al., 2017). Knowledge of natural elements is crucial because it can help architects explore new dimensions and understand the waste and leakage of active energy use in the space designed, especially the ward space in the hospital. User experience is very important to the design implemented because the design of performance data on energy efficiency will provide a reasonable return in terms of cost, time and material quality (Reddy et al., 2019). In addition, intensive mechanisms for energy efficiency were identified from the dependence on the reduction of mechanical systems. Therefore, the design target for energy efficiency to meet the needs and desires of users is very important to ensure the environment's well-being.

Studies on Energy Efficiency in Hospital Buildings

Various strategies and approaches have been taken to implement energy efficiency in the hospital building as it operates non-stop. Approaches and techniques on strategies implemented include improvements to heating systems, use of mechanical ventilation, air conditioning (HVAC), refrigeration equipment, Thermal Energy Storage (TES), heat recovery and water management (Khakzand, 2018). The Batu Gajah Hospital is selected to be the case study. This resort-inspired hospital is classified as a semi-specialist hospital. The estimated energy consumption in this hospital is more than 2,000,000 kWh per month (Perak, 2020), about half of the energy consumption in a public hospital in Kuala Lumpur. The energy consumption of this hospital is considered enormous for a district hospital status. In comparison, the number would be astronomically higher than a premier or specialist hospital. For example, a public hospital near the city centre of Kuala Lumpur uses 4,000,000 kWh per month, equivalent to RM 1.5 million for its electricity bill (Ahmad Ludin et al., 2020). Lighting, equipment, heating, and cooling contribute significantly to the hospital's energy consumption. Various studies demonstrate the strategies of energy efficient measures, however, there is very little research on the impact of user's experience on energy consumption in hospital wards that can provide useful data and add another dimension of user satisfaction which is valuable information to the designers.

Table 1
Approaches and Strategies for Energy Efficiency in Hospital Buildings

Year	Location	Strategy	Author
2010	Malaysia	The use of high-efficiency mechanical systems The use of drives at variable speeds	Saidur, Hasanuzzaman, Yogeswaran, Mohammed, & Hossain
2016	Egypt	Use for protection from sunlight, using window glass material, airtightness and even insulation on the facade of hospital buildings to save energy	Radwan, Hanafy, Elhelw, & El-Sayed
2016	China	Focused on policymakers for projects, technical procedures as well as operations aimed at improving energy efficiency	Wang, Li, Liao, & Fang
2017	China	The use of web-based lines for control systems for refrigeration plant use	Ma, Zhao, Shen, & Liu
2018	Italy	Simulations conducted can help the use of	Silenzi, Priarone, &

		hydraulic gaskets to produce and install rotating windows, including LED systems aimed at saving energy consumption	Fossa
2019	Spain	Perform a framework for maintenance purposes in addition to proper methods aimed at reducing energy consumption	García-Sanz-Salcedo
2019	India	Application of light use through lots for renovators for hospital building infrastructure	Reddy, Sandbhor, & Dabir
2020	Malaysia	Saving electricity consumption through such types and materials of electricity is intended for energy efficiency	Ahmad Ludin et al.

Through table 1, it is found that various parties are working to reduce energy consumption in hospital buildings. These efforts have a positive impact on the planning implemented. It is because they need to know the energy consumption data in advance, and precise and organized planning must be planned successfully. Then the correct strategy and method will be implemented based on the data obtained. Referring to table 2, the energy consumption used in Hospital Batu Gajah in the ward area. This energy is obtained from the development division of Hospital Batu Gajah by obtaining approval from the Director of the hospital in advance.

Table 2
Energy Consumption in Ward Buildings Is Non-Critical for Adult Patient

Month (mid-2020-mid-2021)	Total usage kWh
July 2020	41,672.00
August 2020	39,848.00
September 2020	43,341.00
October 2020	38,012.00
November 2020	36,516.00
December 2020	37,040.00
January 2021	31,526.00
February 2021	36,812.00
March 2021	44,538.00
April 2021	42,095.00
May 2021	38,528.00
June 2021	43,726.00

In table 2, the data obtained regarding energy consumption in the ward found that energy consumption is between 36,000.00 to 44,000.00 kWh per month. Through the data obtained, strategies need to be carefully planned to ensure that energy consumption is at an optimal level and at the same time, users' comfort and well-being are not neglected.

METHODOLOGY

The Batu Gajah Hospital was built in 1880 by the British Occupation Government. It is built on 55 acres of Bukit Changkat and overlooks the pretty and attractive green landscapes. In the past, the hospital was managed by a medical officer, supervisor, and nurse who were all English. In 1976, the Batu Gajah Hospital was lost as General Hospital after the Ipoh Hospital

was upgraded to the General Hospital, and Batu Gajah Hospital was only called the District Hospital. The hospital is classified as a semi-specialist hospital and has a capacity of 160 beds. Surveys were conducted to collect data on energy efficiency in public hospitals, especially in non-critical ward spaces. The respondents consisted of patients and staff working in the adult patient ward of Batu Gajah Hospital (figure 1). At the same time, the respondents' age is 18 years and above. Fifty-three set of questionnaires were distributed to the respondents in this ward space: 20 males and 33 females (figure 2). This questionnaire summarises the user experience of energy use, frequency of use of electrical equipment, electrical appliances such as lighting are sufficient for the area of the space, lay off the layout of electrical equipment, period of use of electrical equipment, and electrical equipment helps the environment.

This approach is preferred to provide confidentiality and ensure greater trust in the respondents. The quantitative (questionnaire) selection was used to show a significant relationship between users and energy consumption efficiency in the ward space. Their responses were documented, and the Statistical Package for The Social Sciences (SPSS) software program was used to analyse the data. This study highlights the impact of energy consumption in hospital ward space and its potential for its utilization efficiency. The study framework outlines the objectives, data collection, selection criteria, methodology, data analysis and study results shown in figure 3.

Figure 1
Hospital Batu Gajah, Perak

Figure 2
Respondents Gender

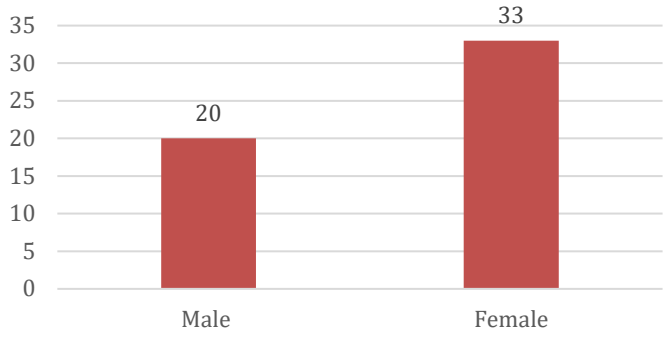
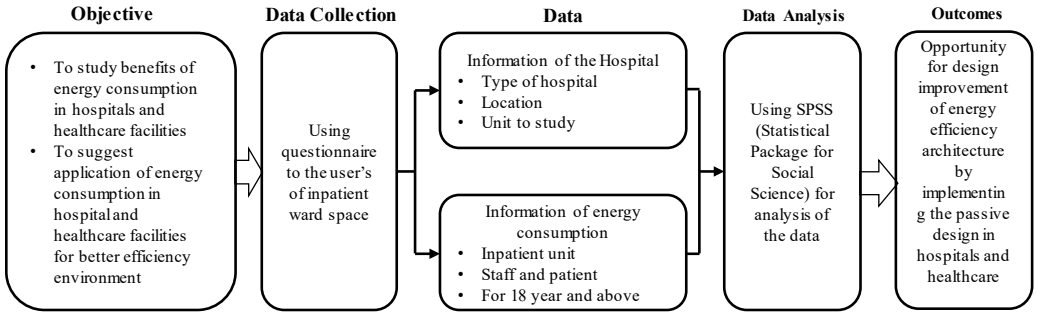


Figure 3
Research Framework Design



RESULTS AND DISCUSSION

The hospital design was built with firmer building codes compared to other buildings. Similarly, the energy consumption in the building increased significantly due to the homogeneous environment created by the designer and finished through standard engineering. Therefore, the use of this energy needs to be managed more holistically to curb the increase in energy. User experience was gauged through the questionnaire that was based on the five dimensions of energy efficiency strategies as listed in Table 3.

Table 3
Questionnaire construction from previous literature reviews

No	Questions	Source
1	Frequency of use of electrical equipment	Sahamir, Zakaria, Alqaifi, Abidin, & Raja Muhd Rooshdi, (2017)
2	Electrical appliances such as lighting are sufficient for the area of the space	Franco, Shaker, Kalubi, & Hostettler, (2017)
3	Layout of electrical equipment	Naamandadin et al., (2019)
4	Period of use of electrical equipment	Lindh, (2016)
5	Electrical equipment helps the environment	Nirit & E, (2017)

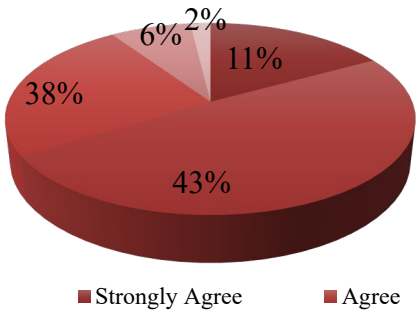
To meet the energy efficiency of this hospital, then at the initial stage of design should be taken into account and emphasized so that the objectives will be achieved. Therefore, feedback from users is very important to know about the energy consumption used in a Batu Gajah Hospital building space. This hospital uses five strategies to determine energy consumption, especially electricity.

Frequency of use of electrical equipment

According to the analysis obtained from the questionnaire, the frequency of use of electrical equipment for energy in the hospital ward is illustrated in figure 4. Most users are satisfied with the frequency of use of electrical equipment. Of the 53 respondents who followed the questionnaire, it was found that 23 (43%) people strongly agreed with the frequency of use of electrical equipment, followed by 20 (38%) who chose a neutral stance and 6 (11%) people strongly agreed with this statement. On the other hand, 3 (6%) and 1 (2%) disagreed with the

given statement. Therefore, most respondents, 54%, are satisfied with the frequency of use of electrical equipment in the hospital ward.

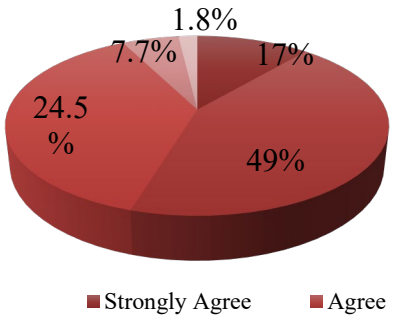
Figure 4
Frequency of use of electrical equipment



Electrical appliances such as lighting are sufficient for the area of the space

Next is respect to adequate electrical equipment for the space area because it is a factor in carrying out activities, as shown in figure 5. Feedback received from respondents saw that 49% of 26 agreed that electrical equipment is sufficient for the space. On the other hand, 24.5% of the 13 respondents chose neutral while 17% strongly agreed with this electrical equipment to increase the activities carried out. 7.7% (4 respondents) and 1.8% (one respondent) disagreed and strongly disagreed with the statement.

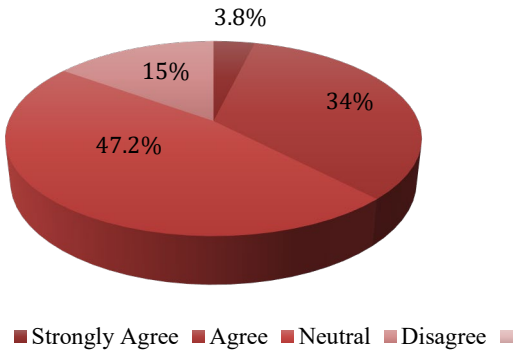
Figure 5
Electrical appliances such as lighting are sufficient for the area of the space



Layout of electrical equipment

The benefits of this efficient layout of electrical equipment according to the designed space benefit consumers in using energy more efficiently. This approach to using electrical layouts should benefit the user mentally and physically. As shown in figure 6, the electrical equipment's layout benefits the users, i.e. the patients and the staff. 47.2% agreed with this layout, and 34% chose neutral. While 15% strongly agree with the statement. In addition, 3.8% did not agree with the statement given. The analysis concerning the layout of this electrical equipment is beneficial and agreed upon by Maassen (2017).

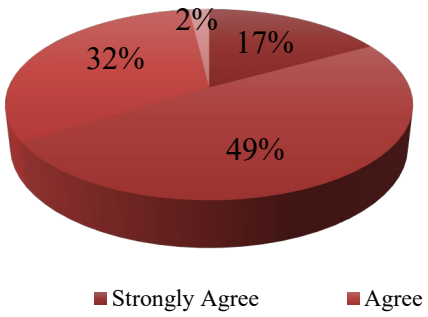
Figure 6
Lay out the layout of electrical equipment



Period of use of electrical equipment

According to Reddy et al., (2019), the period of use of these electrical appliances impacts energy consumption efficiency. It is because the correct way and period of use of the equipment can affect the comfort of the occupants in the space. Following the questions in the questionnaire, does using this equipment (light) help your comfort. The findings of the respondents illustrated in figure 7 have shown that 49% agree with the given statement while 32% chose neutral. Followed by 17% of respondents who strongly agree. On the other hand, only 2% disagreed with the statement.

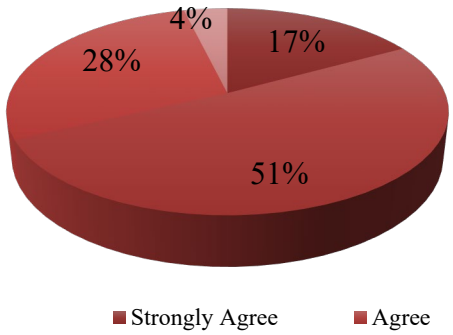
Figure 7
Period of use of electrical equipment



Electrical equipment helps the environment

Electrical equipment, especially for this lighting, helps the environment in the hospital ward space. Surveys conducted related to electrical equipment for lighting the environment faced by the respondents are shown in figure 8. The study's findings showed that 17% strongly agreed and 51% agreed with the statements. At the same time, 28% chose neutral electrical appliances for this lighting. In addition, it was found that 4% or two respondents did not agree with the statements that have been raised. It shows that the importance of electrical appliances for lighting greatly helps the environment and gives more stable emotional control to the occupants.

Figure 8
Electrical equipment helps the environment



Several strategies are in place to optimize energy use more efficiently. Among them is designing wider openings in the space so natural light can penetrate directly. If designed more efficiently, it will increase the emotions of the occupants. In addition, it can also increase the amount of input for a wider and clearer external display. Then it will have psychological and physiological benefits for the users of the space. Therefore, future research may find a more efficient design of openings against this natural light. In turn, energy efficiency will be able to be improved.

CONCLUSION

Based on the potential for energy efficiency is recommended five strategies through user feedback are used as a guide in public hospitals in Malaysia. The data that has been obtained shows the importance of user feedback or experience, and at the same time, the energy consumption in this hospital ward space will be more efficient and optimal. Therefore, public hospitals need to get feedback from the user experience that can help comfort and universal harmony. In turn, the improvement of health will be more assured. The results showed that most of the respondents agreed that the use of electricity is easily accessible and user-friendly and, in turn, helps to improve energy use efficiency in hospitals and healthcare facilities. Then based on these five strategies, the user experience can be proven technically beneficial and beneficial to the designers. Assessment of real situations in the field is particularly useful than simulation-oriented research. Therefore, it will be a very important tool to enhance the experience. However, some of the technologies for new energy savings may not be compatible with existing buildings and will require high additional costs. Consumer aspirations and evaluations are very important in making the design more environmentally friendly, and energy efficiency will be easily achieved.

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2. Adalah dimaklumkan bahawa pihak kami ingin memohon kelulusan tuan untuk mengimbas (*digitize*) dan memuat naik semua jenis penerbitan di bawah UiTM Cawangan Perak melalui Repositori Institusi UiTM, PTAR.

3. Tujuan permohonan ini adalah bagi membolehkan akses yang lebih meluas oleh pengguna perpustakaan terhadap semua maklumat yang terkandung di dalam penerbitan melalui laman Web PTAR UiTM Cawangan Perak.

Kelulusan daripada pihak tuan dalam perkara ini amat dihargai.

Sekian, terima kasih.

"BERKHIDMAT UNTUK NEGARA"

Saya yang menjalankan amanah,

SITI BASRIYAH SHAIK BAHARUDIN
Timbalan Ketua Pustakawan

nar

Setuju.

27.1.2023

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