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The Assessment of Solar Powered Green Campus *vs* The Conventional Approach: A Case Study at the Main Campus of Universiti Sains Malaysia, Penang, Malaysia

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ABSTRACT

As a guarantee that Malaysia practices sustainable development, this matter is important to be approached in detail and proactively as it guarantees a better future change. The concern of many people including educational institutions is not only to be able to preserve the environment but also to be able to manage the institution's budget expenses and provide satisfactory well-being to the people of Universiti Sains Malaysia. Achieving stability is an important endeavor, encompassing both private and public structures, with a particular focus on educational institutions. This study aims to understand in detail about the effectiveness of solar use in energy saving efforts compared to the use of conventional approaches to meet the term green campus in educational institutions. This objective is in line with the aim of this research which is to evaluate the annual electricity bill in Ringgit Malaysia (RM) main campus of Universiti Sains Malaysia, to analyze the difference in electricity before and after the use of solar energy is practiced on buildings at Universiti Sains Malaysia and the final objective is to give recommendations for productive and efficient electricity saving measures that can be done on campus. This research uses qualitative as a data collection technique to obtain information about electricity and energy consumption at USM. The results of this study will increase the understanding of the effectiveness of solar use in reducing the cost of electricity in a building and give a larger and specific picture of the energy savings that need to be done to maintain the term of green building in the aspect of energy efficiency in educational building.

1. Introduction

Green building has become a topic that has been widely studied. This is because green buildings have led to the advancement of sustainable buildings as well as changing the way the construction sector operates better and innovates. Green buildings are characterized as eco-friendly, sustainable or energy-efficient structures that prioritise human-centered, sustainable development to achieve a peaceful coexistence of environment, architecture and people [1]. To reduce the amount of trash that is dumped in landfills, green construction focuses more on optimizing the design using

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renewable energy, passive building design technology and systematic, scientific waste management approaches [1]. This is also like a design imperative, with the emphasis being on achieving a balance between social, economic and environmental advantages across the asset's life cycle [1]. This green building concept is used as an environmentally friendly and motivated measure to minimize the overall negative impact and to maximize the positive impact of the building on nature and its occupants. This concept not only involves planning, design, construction and operation but also involves maintenance activities. Aspects emphasized in this green building include the efficient use of energy, water and other resources, the quality of the indoor environment and the impact on the environment [1]. This green building concept has been accepted and practiced by various countries globally because of its great benefits, especially for the environment. Although this green building is a popular aspect in the field of construction, there are still a few people who do not know and are exposed to the idea of green building while this knowledge is basic and important knowledge for architects, developers and builders to reduce the negative impact on the environment [1]. This paper describes the performance of the effectiveness of using solar panels on educational buildings as a green building practice initiative and provides an evaluation of solar powered that focuses on the use of electricity in educational institutions.

Energy efficiency is a practiced green building strategy. Energy efficiency means using less energy and eliminating energy waste. This strategy is taken seriously because it can reduce greenhouse gas emissions and reduce demand for energy imports [2]. This strategy can be carried out when renewable energy technologies are used and less use of fossil fuels [2]. Every building need electricity so that every element and asset in the building can operate smoothly. Electricity can be obtained through renewable and non-renewable sources. Green building practices certainly use renewable and inexhaustible resources [2]. On-site renewable energy generation through solar power, wind power, hydropower or biomass can significantly reduce the environmental impact of a building [2]. The most common renewable energy source used on building sites is solar. Malaysia also uses many solar resources to reduce electricity as a substitute for conventional sources. Malaysia, being on the Equator and receiving six hours of sunlight on average every day, has a tremendous deal of potential for solar energy harvesting [2]. This is because of the position of Malaysia which has light rays or suitable rays from the sun for the use of solar panels. Commercial buildings including educational institutions in this country can reduce electricity costs

2. Literature Review

Power and capacity from energy are used to move things or create motion. From an economic point of view, the economic growth of a country is directly related to the consumption of energy in a country. In economic theory, energy demand increases when economic growth increases [3]. The backbone of economic growth is the energy used to produce goods and services for the population [3]. Basically, increasing the rate of energy consumption has a positive effect on stable economic development but has a negative effect on the environment. Conventional energy is a resource that comes from energy sources provided by nature, and it is also known as a non-renewable resource. It includes oil, coal, wood or natural gas [4]. This energy resource is limited and increasingly difficult to obtain. However, the level of exploitation of this resource is getting higher due to its increasing use [4]. In general, this type of conventional energy is also very polluting and can release gases that are harmful to the ozone layer. This situation will affect the ecosystem and living beings including humans. Renewable energy technologies include solar, hydroelectric, biomass and biofuels [4]. With Malaysia's position on the Equator, Malaysia is lucky to get 10 hours of solar energy every day and the time the sun is overhead is when it produces maximum solar energy [4]. Green building is defined as green construction or sustainable building that can help eliminate concerns about building design in terms of economy, utility, durability and comfort for occupants [4]. Green buildings are categorized as buildings that use less water, optimize energy efficiency, conserve natural resources, generate less waste and provide more efficient space for residents than conventional buildings and make it the goal of green building design. However, most studies on green buildings have not yet undergone a systematic review and are considered for the future [5]. Energy efficiency is key to achieving sustainability in green buildings [5]. Energy efficiency in existing and new buildings is a quick solution to limit environmental, economic, social and other impacts in this sector [6]. To achieve sustainability in buildings, high energy efficiency needs to be targeted through energy performance benchmarking methods, energy saving measures, photovoltaic installations, resource efficient building materials and innovative energy concepts [7].

Energy consumption refers to all the energy used to perform an action, produce something or simply inhabit a building [3]. It means that every production process must be evaluated because it is related to the use of electricity. Energy plays an important role in human life and in economic activity, both as a scale of economic and social development and as a basic human need. The per capita energy consumption performance of a country is considered an important indicator of economic development [8]. Nevertheless, the world's energy demand has a negative effect on global warming [9]. Although sustainable development is emphasized, energy is an important need for every country because it continues to be used in various sectors for the sake of the country's progress, especially the transport sector and the energy industry [9]. Energy is a key factor in meeting the global sustainable agenda and should be a major challenge for the development of developed countries. The global demand for energy has increased the demand for fossil fuels instead of coal [9].

The annual World Energy and Climate Statistics show energy consumption trends at the global level. America, China and India are the top three countries with the highest total energy consumption (Figure 1) [10]. This is because America and China are developed countries with rapid economies from various sectors. Its economic development which carries out various types of activities makes the country have a high amount of energy consumption. India is in the top three because the growing population and economic activities causes energy consumption to increase [11]. This proves that the population or number of people affects the energy consumption of a country. Malaysia's energy consumption is the smallest and has a very long distance with developed countries because Malaysia is one of the developing countries and has a small population.

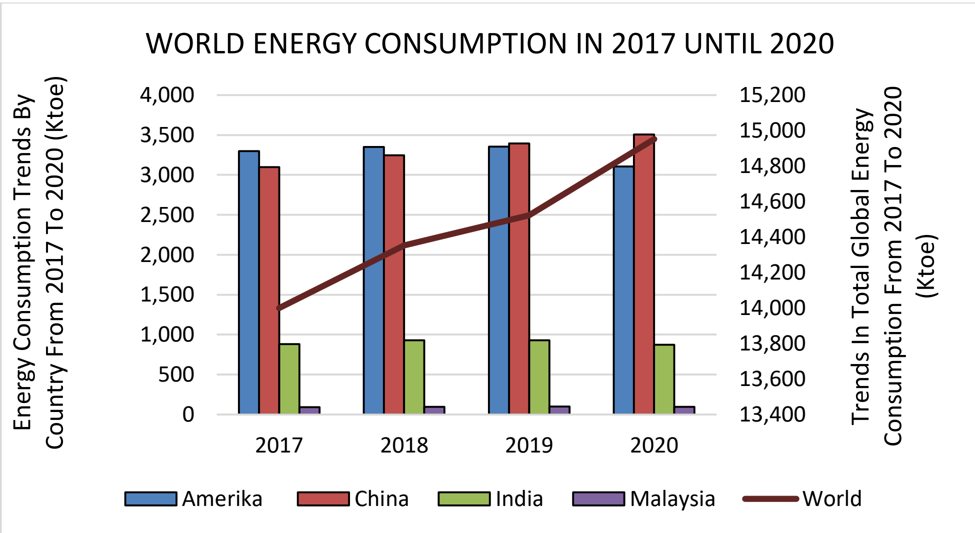

Fig. 1. Global energy consumption
Source: World energy and climate statistics (Enerdata, [22])

Energy is considered one of the most important resources needed by modern human society for the development and progress of life. In fact, energy consumption is closely related to rapid urbanization, population and economic growth. In addition, several other factors have influenced the energy consumption of a country apart from the population, namely the season, geographical position and location of the country [11].

In fact, energy consumption increases from year to year, but due to the spread of Covid-19 that has hit the whole world, this trend of energy consumption has changed, which is decreased. In 2020, energy consumption was at its lowest level due to the constraints of the Covid-19 Pandemic which restricted most sectors in Malaysia due to the Movement Control Order (MCO) (Figure 2). Industrial sectors such as factories were blocked from operating, educational institutions, administration, etc. were limited in their operations, resulting in reduced energy consumption. This was because most of them worked from home (WFH). This increase in demand for energy consumption proves that the economy in Malaysia is back in operation and free from the issue of economic regression. Estimated electricity demand per capita will continue to increase in 2040 due to population growth and the importance of electricity in daily activities [12]. The pattern shows that electricity demand and generation in Malaysia will grow massively from year to year.

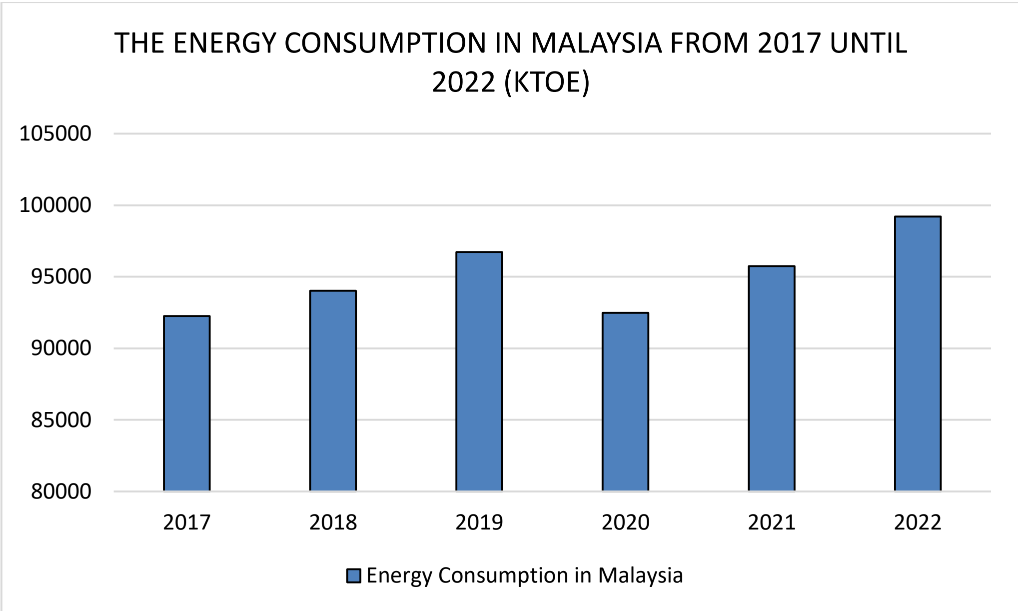

Fig. 2. Energy consumption in Malaysia
Source: Malaysian energy information (Enerdata [22])

The transport and industrial sectors are sectors that use a lot of energy as operations compared to other sectors (Figure 3). This is because rail transport can contribute 40 to 50 % of the energy consumption obtained from transport activities [13] and it will be affecting the carbon emission [14]. Educational institutions come under the category of residential and commercial sectors. This category involves housing found in Malaysia, office buildings, shopping centres and others. Among the systems found in a building are lighting systems, air conditioning systems, motor equipment systems and communication systems.

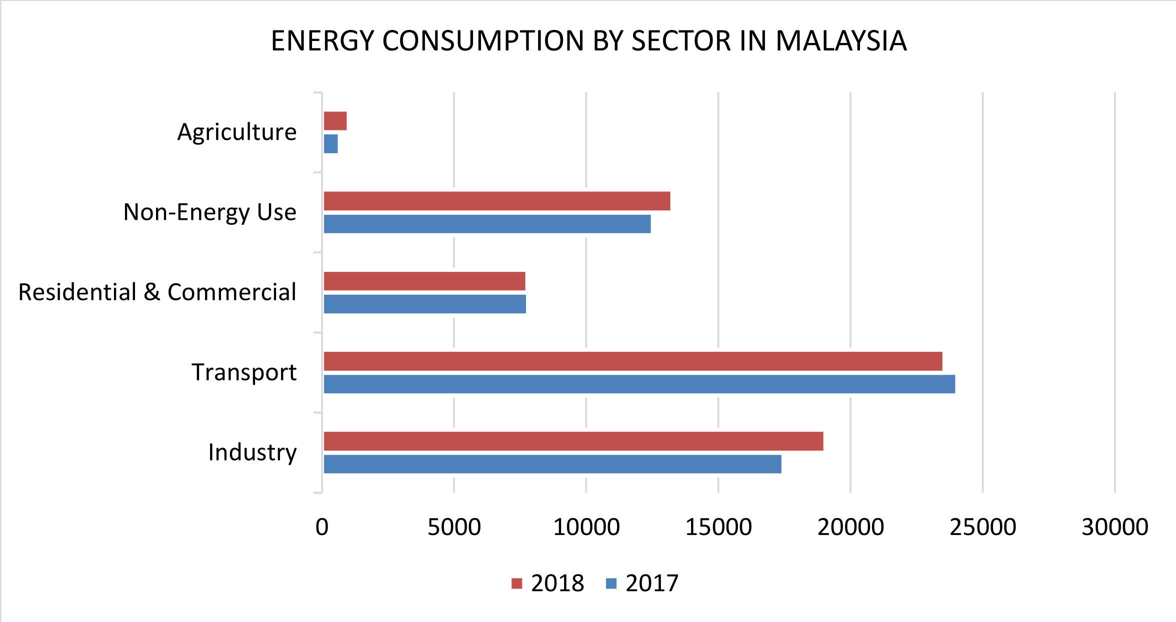

Fig. 3. Energy sonsumption by Sector in Malaysia
Source: Suruhanjaya Tenaga [23]

Conventional energy directly means permanent energy sources such as oil, gas and coal or more accurately referred to as non-renewable energy sources [15]. Malaysia has only one energy supplier for all states in Malaysia. It is known as Tenaga Nasional Berhad (TNB) which is a company that is fully responsible for power generation and power plants.

Maximum demand (MD) is the highest level of electricity demand monitored in each period for a period of one month (Table 1) [15]. MD is measured in Kilowatts (kW). Electricity cannot be stored, so sufficient generation, transmission and distribution capacity must be kept to meet peak demand at that time [15]. MD tariffs are structured to reflect the time of day they are used. Because of that, the tariff for MD is high because it wants to encourage customers to control electricity demand during the peak hours of the day.

Table 1
The tariff of electricity in Malaysia
Source: Pricing and tariffs [15]

Tariff Category	Unit	Existing Rates (1 June 2011)	New Rates (1 January 2014)
Tariff C1 – Medium Voltage General Commercial Tariff			
For each kilowatt of maximum demand per month			
For all kWh	RM/kWh	25.90	30.30
The minimum monthly charge is	Sen/kWh	31.20	36.60
	RM	*600.00*	*600.00*

Imbalance cost pass-through (ICPT) is a charge applied to all TNB customers. This charge is applied to each energy consumption (kW/h) used. A mechanism under the Incentive Based Regulation (IBR) framework that allows TNB to make ICPT a utility to reflect changes in fuel and other generation-related costs in electricity tariffs [15].

The Renewable Energy Fund (RE Fund) is a fund collected by the Government through the use of electricity by consumers [15]. This fund will be used to promote the growth of electricity generation from renewable energy sources. TNB acts as a fund-collecting agent for the Government because the collected funds will be channeled to the government, Sustainable Energy Development Authority (SEDA) a body formed by the government under the Renewable Energy Act 2011 to manage and administer the Feed-in Tariff (FiT) system.

i. Off Peak Tariff Rider (OPTR)

OPTR is one of the special schemes offered by TNB to all medium voltage commercial and industrial customers. The scheme applies during off-peak hours, starting at 10.00 p.m. to 8.00 a.m. [15].

ii. Discount for institutions

In addition, TNB also offers a 10 % discount to several commercial sectors including learning institutions. All government and private educational institutions that are fully or partially funded by the government and administered by the Ministry of Education are eligible for a 10 % discount on their monthly bill [15]. Provided that the institution has a relationship with a government body (gets help from the government) and the institution is not a training institution such as a police academy, fire academy, nursing college and bank training center [15].

A formula to calculate the electricity bill is shown in Table 2, comprising of the parameters discussed above.

Table 2
Formula for electricity bill

No.	Item	Formula
1.	OPTR	Energy Consumption X Current Rates
2.	OFF OPTR	Energy Consumption X Current Rates
3.	MAXIMUM DEMAND	Energy Consumption X Current Rates
4.	ICPT	Total Energy Consumption OPTR + Off OPTR X Current Rates
5.	DISCOUNT TNB	(Total Energy Consumption in RM+Max Demand+ICPT) X 10 %
6.	RE FUND (KWTBB)	(Total Energy Consumption in Rm + Max Demand) X 1.6%
7.	THE ELECTRICITY BILL (CURRENT BILL)	OPTR + OFF OPTR + MAX DEMAND + ICPT – DISCOUNT TNB + KWTBB - Excess Energy Generated (if any)

Solar energy is the portion of the sun's energy available at the earth's surface for useful applications [16]. This energy is free, clean and abundant in most places all year round. Solar energy can be used as an electricity generator [17]. Malaysia receives an average of 4.21-5.56 kWh/m^2 of daily solar radiation, with around 12 hours of sunlight per day. Peninsular Malaysia has higher solar radiation compared to eastern Malaysia. The best sites identified for solar power generation are Kota Kinabalu, Penang, Kota Bharu, Kuching, Johor Bahru, Kuantan, Melaka and Kuala Lumpur [17].

Solar panel technology has grown as it is a great initiative to achieve higher efficiency, lower cost, aesthetics and durability [18]. The choice of solar type depends on the type of system installed. Renewable technology and the best choice in utilizing rooftop systems, solar photovoltaic (PV) is believed to have the greatest potential [19]. However, the use of solar PV is still low due to the cost of PV systems. The price drop from RM 31,410 per kilo peak watt (kWp) in 2005, to RM 20,439 kWp in 2009 still did not increase the demand for solar photovoltaics [18]. There are three types of solar panels and have their own privileges that can serve as a benchmark for users to choose the appropriate solar panel in their place [18]. Monocrystalline, polycrystalline and thin film are different types of solar panels. Different in terms of appearance, performance, cost and method of manufacturing solar panels. The Technology Master Plan 2017-2030 is one of the Malaysian government's strategies to continue to fight for sustainability. One of its main goals is to improve sustainable construction with great collaboration with higher institutions in building capacity through the university's Centre of Excellence [20]. The Malaysian Ministry of Higher Education through the Public Sector Conducive Ecosystem urges efforts to be taken by Malaysian public universities towards green campus initiatives [20]. The implementation of sustainability or green campuses in higher education institutions can provide many benefits to campus residents by living a harmonious environment and a green lifestyle [20]. Most of the institutions use solar panels, water recycling, rain barrels and material recycling practices. Gray water systems and passive lighting should be used. The government encourages educational institutions to use solar alternatives as an energy source in educational buildings, regardless of whether they are private institutions or public educational institutions [20]. The government places more emphasis on university-level institutions because the number of students is larger than primary and secondary school-level institutions. And it is also because it involves high costs, not only in installation but also in maintenance costs [20]. The government will also support educational institutions in maintaining a sustainable environment.

3. Methodology

This study applied qualitative research methodology to achieve the objective whereby it examines people's opinions, behaviours and experiences. It collects and analyzes words and text data. In this research, the type of sampling design in the research methodology used was non-probability sampling which involves feedback based on the researcher's sample selection ability. In this type, the researcher used the Quota technique. It means, while undergoing the form of research, the researcher determines the number of people who have the characteristics that need to be included as participants. The characteristics of the people selected were related, knowledgeable and experts about this study. The data collection method used was qualitative research where the researcher used one-on-one interview techniques. The researcher interviewed the person in charge who manages the facilities of Universiti Sains Malaysia. He is the person who fully knows about the facilities, utilities and solar projects carried out at USM. In this session and this interview technique, the researcher focused on objective three which was to give recommendations for productive and efficient electricity saving measures that can be done on the campus. Using the interview data for objective 3, which is to give suggestions for productive and efficient electricity saving measures that could be done on campus as referred to Table 5. In addition, this qualitative methodology was conducted using document review (electricity bill 2023 and annual report for energy consumption 2017-2023). The researcher reviewed USM's annual electricity bill report to conduct a study to complete the research objective. The researcher obtained all the details about the use of electricity in USM from 2017 to 2023. The total energy consumption was valid and indeed a source from USM, meaning that this data was taken with the consent of the university. This source is to achieve the first objective (to evaluate the annual electricity bill in Ringgit Malaysia (RM) of Universiti Sains Malaysia main campus) and the second objective (to analyze the differences in electricity bill before and after the use of solar energy is practiced on buildings at Universiti Sains Malaysia). Table 3 lists the demography of the respondents.

Table 3
Demographics of interviewed respondents

Respondent/ Information	Mr S	Mr I	Mr H
Gender	Male	Male	Male
Position	Engineer (Deputy Director, Project Management Section)	Engineer (Electrical)	Engineer (Repair & Maintenance)
Department	Facilities and Development Department, Universiti Sains Malaysia	Facilities and Development Department, Universiti Sains Malaysia	Tenaga Nasional Berhad, Selangor
Years of service	10 years and above	3 years	7 years

There are several techniques for analyzing data in qualitative research.

i. Content analysis

The researcher used content analysis techniques. Information and data were documented from texts and reports found to answer all the objectives set. The contents of the energy consumption report and electricity bill were clearly seen and examined.

ii. Narrative analysis

This method was used to analyze content collected from various sources namely personal interviews. This analysis gathers about the opinions shared by the public focused according to the questions asked by the researcher.

4. Results and Discussion

4.1 To Evaluate the Annual Electricity Bill in Ringgit Malaysia (RM) of Universiti Sains Malaysia Main Campus

Figure 4 shows the annual electricity bill trend RM of the main campus of Universiti Sains Malaysia, Penang from 2017 to 2023. Due to the world being hit by the spread of the Covid-19 virus in 2019, the researcher chose to study electricity bills before, during and after Covid-19. Based on Figure 4, the trend of increase and decrease for all years is the same except for 2020 because that year is in the relatively strict MCO phase. Based on the USM academic calendar [21], February was a semester break for four weeks followed by August, September until the beginning of October which is a semester break for students. This means less electricity supply during those months due to the lack of population in USM. In 2017, 2018 and 2019, the trend of their total annual electricity bills each month was the same. There is a difference in the increase in electricity bills due to events held in heavily used hall areas. Total electricity bills did not increase much even though student enrolment increased.

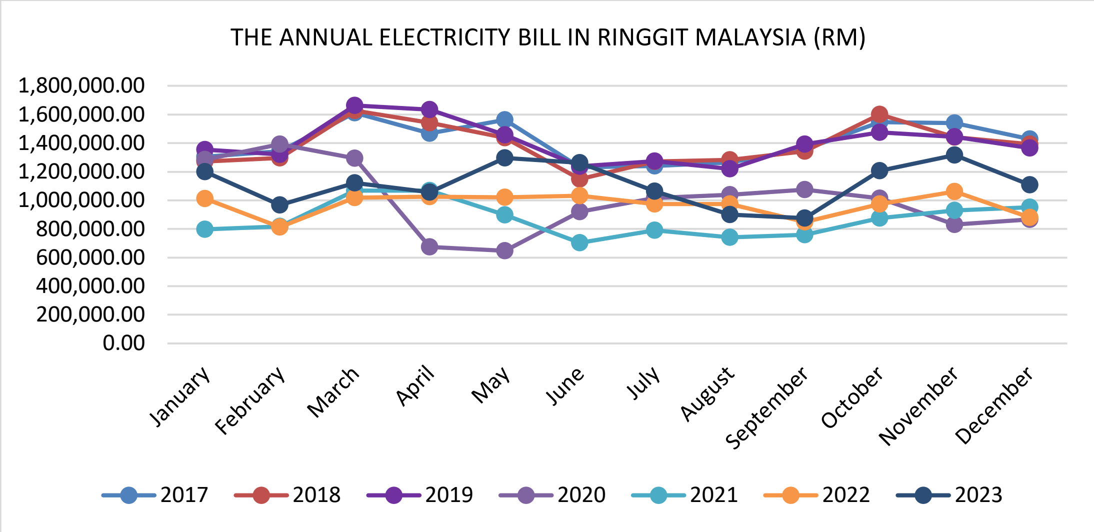

Fig. 4. The annual electricity bill in Ringgit Malaysia (RM)

The electricity bill trend at USM in 2020 was the most significant difference because the Phase 1 MCO came into force then (March). A 47.88 % decrease from RM 1,294,587.02 to RM 674,683.71 in April. The electricity bill in May is still significant because there are no learning activities due to the MCO. The implementation of the MCO in six states (Penang, Selangor, Federal Territories (Kuala Lumpur, Putrajaya and Labuan), Melaka, Johor and Sabah) was announced by Prime Minister Tan Sri Muhyiddin Yassin in 2020 for the chain of transmission of the COVID-19. This implementation took place in April and May. The education sector was closed and students undergo online and home learning sessions. Students who were on campus were directed to return to their respective villages.

Figure 4 shows that in June 2020, there was an increase of RM 279,309 from the total electricity bill for May 2020. This is because most economic and social activities were allowed for Conditional Movement Control Movement status until June. The WFH session was still ongoing. So, there was still an education sector that took the initiative to do learning sessions from home. In June 2020, Muhyiddin announced that the PKPB was replaced by the PKPP which saw more relaxation given from June 10 to August 31. The planning of learning operations was discussed by the university. The office building was used to manage administrative matters at the university. This caused the electricity bill that year to continue to rise until November.

Figure 4 also showed that electricity consumption in 2021 was the least electricity bill flow for a year compared to other years. The increase in electricity bills took place in October as the government allowed students to enter universities in stages. Only faculty with training, laboratories and studios were directed to return to campus to undergo practical learning while management faculty were still not allowed to return to campus. However, student movement was still limited and controlled where most courses were still conducted online in their respective dormitories or residences. Buildings at USM have also been limited in their usage time where the building was not used at night and no events were held because it involves the public. This causes energy consumption on campus to remain low.

Electricity bills at USM will return to normal in 2022 because the education sector has been fully opened by the government. The government has allowed full admission to study in their respective institutions. Activities and events have also been actively carried out to restore the normalization of the world of university institutions. In January 2022, the electricity bill was as much as RM 1,012,119.74 because it was the second to last month for the 2021/2022 session. Many activities at the end of the session are carried out and February 2022 is exam week for students and slowly students return home for a month-long semester break. This resulted in reduced energy consumption and certainly reduced the university's electricity bill that month (RM 813,315.04). The electricity bill increased again the following month because the students had finished their semester break and returned to the study session. The increase occurred in March and April 2021 following student activity. Major activities and events at USM are factors in increasing electricity at USM. In May 2021, there is a decrease of RM 6,311.93 because there are many holidays in that month. For example, workers' day, Eid al-Fitr and Wesak day [21]. Most students and lecturers have planned to hold online learning sessions to make it easier for students to manage their journey back to their respective villages. So, it becomes a factor in reducing the electricity bill.

Electricity bills at USM were back to normal as usual from June to August. In September 2022, the electricity bill decreased from RM 928,618.06 to RM 848,504.32 because students were on semester vacation or doing practical for two months and increased again in October. The same situation occurred in 2023 where the electricity bill increases during the study session and decreases during the semester break. Nevertheless, the activities and events at USM in 2023 were more lively and more numerous than in other years. No more online curriculum, online meetings and online learning. Most co-curricular activities such as webinars were conducted in the hall found at USM. This has affected the amount of electricity bills at USM where most electricity bills reach RM 1 million and above. The increase in student enrolment in 2023 also affected the increase in electricity bills at USM. Also in 2023, there will be an increase in ICPT from RM0.02 per kWh to RM0.20 per kWh. It is a high value for an educational institution that uses hundreds of thousands of kilowatts of electricity.

4.2 To Analyze the Difference in Electricity Before and After the Use of Solar Energy is Practiced on Buildings at Universiti Sains Malaysia

Figure 5 shows the difference in electricity bills before and after solar application (January-June) from 2017 to 2023 and electricity bill (Table 4). Energy consumption is common for large educational institutions. The decrease in energy demand from USM in 2020 until 2022 is due to the spread of the Covid-19 epidemic which affected activities at the institution. However, energy consumption returned to normal when the country's recovery was implemented starting in 2022. In a period of 3 consecutive years, the total energy consumption was around twenty thousand kWh and the electricity bill was around RM8.5 million. The large consumption of energy caused the university to take the initiative to install solar and use solar energy as an initiative to practice green buildings. In 2023, as much as 20.85 % of the total energy consumption (19,786,129 kWh) for half of the year 2023 (January-June) can be covered by solar energy. This caused the electricity bill at USM in 2023 to be reported as RM 6,904,128.22 for the months of January to June 2023. The increasing use of energy will inevitably increase the electricity bill. If the university does not use solar, the researcher estimates the electricity bill at USM to be higher than the price of solar application which is RM 9,022,465.56. A difference of RM 2,118,337.34. A profit of RM2 million or more within 6 months allows USM to earn double its income within a year. The average electricity bill savings that can be made after the application of solar panels is as much as RM 300,000 per month. The maintenance cost is as much as 10 % of the initial cost of the solar panel. However, thanks to the environment and weather in Malaysia, solar panels are not given attention in terms of periodic maintenance because there is rain that can clean the surface of the solar panels to absorb sunlight. The cost estimated by the USM facility is around RM 100,000. So, USM can get a lot of profit after using solar energy as an alternative to reduce electricity bills.

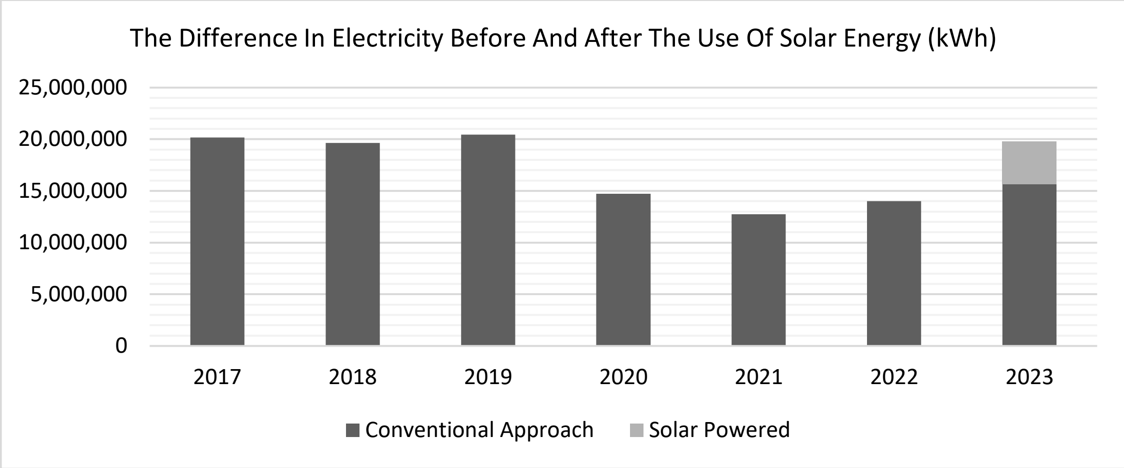

Fig. 5. The difference in electricity before and after the use of solar energy (kWh)

Table 4
The electricity bills before and after the use of solar energy

Year	Energy Consumption (KWH)	Electricity Bill (RM)
2017	20,151,237	8,522,859.06
2018	19,643,539	8,323,295.81
2019	20,426,490	8,667,001.80
2020	14,713,543	6,215,169.65
2021	12,735,043	5,353,096.43
2022	13,994,779	5,922,422.42
2023	15,660,324	6,904,128.22 (with solar) 9,022,465.56 (without solar-estimation)

4.3 To Give Recommendations for Productive and Efficient Electricity Saving Measures that can be Done on Campus

To ensure that Universiti Sains Malaysia is still within the green building practice standards, various productive and efficient electricity saving measures that can be done on campus were suggested. This can fulfil the green building component which is energy efficiency for building sustainability. Some suggestions have been listed (Table 5) for the university residents to excel.

Table 5
Recommendations from interview session

What are the suggestions for productive and efficient electricity saving measures that can be done on campus?		
1. Organize an awareness campaign every session. 2. Perform space audit 3. Replacement of energy saving products (4 stars and above) 4. Reduce activity in air-conditioned rooms 5. Encourage activities and events to be done at night	1. Periodic room inspection 2. Encourage outdoor activities 3. Set the scheduling of air-conditioned halls more strictly	1. Install meters in every building and room 2. Campaign awareness for the occupants 3. Preventive wiring inspection 4. Carry out maintenance on all facilities that use electricity

4.3.1 Conduct a university-level awareness campaign

Among the recommended measures is that the university should hold a university-level awareness campaign. This awareness campaign can be done in stages and involve all USM students and staff. Through the campaign, the influencing facility can reveal the total electricity bill per month to make USM residents aware that electricity at USM is a large amount. The USM can also reveal factors that can contribute to the increase in electricity to prevent increased energy consumption.

4.3.2 Hold a competition between hostels

In addition, the university can also hold a competition between Desasiswa at the university level to encourage students to save electricity. This can help avoid wastage of electricity. For example, the Facilities Department can organize a special program for Desasiswa residents. This is because the hostel building at USM also contributes to the consumption of large amounts of electricity. Although there is a Desasiswa that has a small capacity, its use is still high because there are exclusive rooms that use air-cond. This competition can be by evaluating the lowest energy consumption or by deciding which Desasiswa can reach the limited quota. Through competitions like this, USM can reward the winners who successfully reach the target. This matter can be discussed with the hostel manager and the Majlis Perwakilan Desasiswa (MPD) to work together to implement the program. With this, there is healthy competition, and it is a challenge for them to win the competition.

4.3.3 A regular room inspection

The next step is a regular room inspection. This can be called a space audit and can also be implemented by managers, student representatives and staff in their respective faculties. This is because there are some individuals who use appliances in the room. Residents should use the equipment provided by USM completely without adding any other equipment. This is because the quota that has been provided by the university must be in accordance with the needs of USM residents. Most residents have brought additional electrical items in their rooms for their own comfort and satisfaction. For example, bring fans from home, decorative lamps, bedside lamps and mini aquariums as room decorations. Equipment that can lead to an increase in electricity are those involving heat and cool systems such as portable air conditioners, water heaters, irons and so on. Not only that, the use of wire extension is also a factor in increasing electricity, especially if the item does not have the SIRIM approval mark.

4.3.4 Replace old equipment with energy saving equipment

In addition, replace old equipment with energy saving equipment with three stars and above. This is because, energy saving can be done when using equipment like this. Although the price is higher than the old model, it can be profitable in the long run. It is also of higher quality. For example, the use of LED lights, efficient refrigerators and 4-star energy air conditioners and above. USM can also collaborate with branded electrical equipment suppliers to facilitate energy management.

4.3.5 Encourage activities and events to be done at night

The next suggestion is to encourage activities and events to be done at night (10 p.m. until 8 a.m.). This is because the university can fully optimize the use of electricity during off-peak hours.

Although it was an inconvenient time to conduct but most associations used to hold discussions until late at night. So, the management can suggest to the association to use the USM facility starting at 8 p.m. At least, the high tariff applies to 2 hours (8 p.m. until 10 p.m.). Planning like this can save electricity bills brilliantly.

4.3.6 Encourage outdoor activities

Another suggestion is to encourage activities to be done in open areas. Students or association managers should be aware of energy saving. They should take the initiative to get involved in this energy saving plan. Students can do meetings or co-curricular activities outside the hall. Using nature as an air conditioner. This is not a trivial matter.

4.3.7 Installation of meters for each building and space

Another suggestion is to install a meter in each building. This installation can help managers identify buildings that use a lot of electricity. This is because USM only has one meter (main) that connects to the entire campus. This creates constraints for facility managers to manage campus utilities more intelligently. If the university has a larger allocation, the university is encouraged to install a submeter in each room. In this modern age, technology is becoming more and more sophisticated. The campus can install a submeter for each room in Desasiswa, lecturer's room, lab, studio, class, hall, library, mini surau, etc. to evaluate kilowatts of energy consumption in more detail. Installation in every hostel room and lecturer's room is the most worthwhile because it definitely causes residents to be more vigilant in energy use because they want to avoid being notified by the management.

4.3.8 Carry out the maintenance of all facilities that use electricity

The last suggestion is to carry out the maintenance of all facilities that use electricity. Mostly the maintenance side focuses more on large facilities such as large HVAC equipment (chiller, air-conditioning, cooling tower), lighting system and so on. The university must regularly check the wiring for all equipment involving electricity and carry out immediate maintenance on those elements. Residents at USM who are provided with appliance facilities by the university should be alert to the environmental facilities provided in terms of wiring, function and installation to avoid the occurrence of uncontrolled electricity flow without realizing it. All parties must be responsible for every facility provided.

5. Conclusions

This study was conducted to see the effectiveness of solar energy when applied to educational institution buildings. This study was successfully analyzed after calculating the electricity bill through the use of energy used and the results of interviews to obtain recommendations for energy saving measures on campus. As a result, this analysis achieved all the objectives set in this study in detail.

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