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Case Study of Solar PV Comparison Cost Saving at Student Accommodation

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Abstract: Malaysia is located at strategical location which is in the equatorial region which offers it an advantage in the solar energy production. Bistari Hostel at Parit Raja, Johor contains 168 houses and located near the main campus of University Tun Hussein Onn Malaysia (UTHM), which is one of the best accommodations for students along their university life at UTHM. This study focuses on solar energy harvesting at Bistari Hostel which is to identify the cost electricity can be reduce if solar PV are installed at the building roof of blocks B1, B2, B3, B4 and the parking area of Bistari Hostel. The solar PV modules that will be study in this paper are produced by Jinko Solar. The energy consumption at Bistari Hostel was taken from Uten Holdings Sdn. Bhd. (the property owner) and estimation of energy usage if all the houses are rent out were made. The potential application of the five types of solar PV from Jinko Solar was determine and in this study, the most efficient solar PV are chosen from their ability to generate electricity. The energy saving if the solar PV is installed at Bistari Hostel are expected to reduce the cost of electricity for more than 25% and the results shows that there will be excess electricity generate by the solar PVs. More factors can be included to determine the effectiveness of the solar panels in future study such as the degradation rate and the installation and maintenance cost and payback period.

Keywords: Solar PV, Electricity Usage, Efficiency

1. Introduction

Energy is one of the most important items in a country for economic development and social growth. Because of technological advances and the growing importance of the world's population, energy demand is continuously rising [1]. As electricity has become a demand in our daily lives, this rises in demand for power has resulted in continuous emissions of CO_2, creating more environmental hazards [2]. Renewable energy has been excavated in order to minimize the use of fossil fuels and preserve the green atmosphere, in order to reduce the potential instability of energy supply [3].

In the transition of world energy from fossil fuels to zero-carbon energy production by 2050, solar energy has been discussed as one of the renewable energy resources [4]. Solar energy is the radiant

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energy generated by the sun and the sun's radiation sends out a tremendous amount of energy every day. The conversion phase of solar energy is highly affected by environmental conditions. The conversion process of solar energy is greatly influenced by environmental factors. There is a lot of equipment being used as solar thermal energy, ocean thermal energy conversion, solar dams, solar towers and photovoltaic systems to harness the energy from the sun [5].

Malaysia is a country with a wide variety of energy resources, including fossil fuels, as well as numerous renewable energy sources such as hydro, wind, solar, geothermal and tidal waves, but most of these renewable energy resources are not completely exploited. More development of these resources would need to be focused on different points of view and a major challenge. Malaysia is still very much supported by fossil fuels as its main energy source [6]. At the same time Malaysia has advantageous values in the production of its solar energy due to its position in the equatorial region. Moreover, Malaysia is blessed with a natural tropical climate with an average daily solar radiation of $4500 kWh/m^2$ and an ample sunshine of around 12 hours per day [7].

Many developed countries face the same issue of rising population and pollution. This has led to a rise in energy consumption, which causes them to explore renewable energy sources other than the depletion of fossil fuels such as solar energy [7]. Electric power supply using non-traditional energy resources such as solar PV technology has thus become a significant alternative to conventional fossil fuel resources. Solar cell or PV cell is a system that transforms solar energy into photovoltaic energy [8]. Sufficient and sustainable energy supply is at the center of economic growth. This study focuses on solar energy harvesting at the Bistari Hostel to assess if it is beneficial to reduce the cost of electricity in the hostel. The objective of the study is to identify the electricity consumption at Bistari Hostel, Parit Raja and to study the potential application of solar PV manufacturer by Jinko Solar by identifying the energy saving if solar PV is installed at Bistari Hostel. The study was expected that the energy consumption at Bistari Hostel will be determine and the potential application of solar PV will be identified by comparing the amount of power generated will be identified if solar PV is installed at Bistari Hostel. This study also expected that the percentage of reducing in the electricity usage in Bistari Hostel is more than 25% if the solar PV is installed.

This study case does not include the cost of installation and the maintenance and there are a few factors that can be consider in future study such as the roof type of the buildings and its support. Moreover, the types of warranties such as solar panels warranty, installation warranty, inverter warranty and energy storage system warranty (based on types of solar power system install).

2. Materials and Methods

The materials and methods section, otherwise known as methodology. Methodology can be defined as systematic and standardized procedure or process which can be applied in a field of study. In this chapter, the method/process to conduct this case study will be discusses. A research must have a clear methodology which can provide a clear mind-set to help in achieve the objective of research.

2.1 Materials

Bistari Hostel is the biggest private hostel located at Parit Raja, which is about 3-4km away from UTHM. As Bistari Hostel is highly energy consumption compared to Kolej Kediaman Bestari because of the increasing of usage of electrical applications such as refrigerator, rice cooker and others. This will aggravate the burden of the Bistari Hostel for paying high cost of the electrical usage in order to maintain the affordable rental fee for students.

The study means to focus on proposing solar energy harvesting at the Bistari Hostel to assess if it is beneficial to reduce the monthly cost of the hostel. The data collected from Uten Holdings Sdn Bhd

(the owner of Bistari Hostel) are the car park area, the building plan which contain roof area of Bistari Hostel, also the most importantly, the electric consumption at Bistari Hostel from March 2019 to February 2020.

Based on the car parking area value and the area of building roof block B1, B2, B3 and B4 collected from Uten Holdings, the area of solar panels produced by Jinko Solar Technology Sdn Bhd can be determine. In this study case, five types of solar PV panels will be compared, and the energy generated based on these five types of solar panels will be calculate.

Table 1: The selected module series of solar PV manufactured by Jinko Solar with their cell type and dimensions.

No.	Module Series	Cell Type	Dimension ($m \times m$)
1	Tiger	N-type Mono-crystalline	1.692×1.029
2	Tiger Pro	P -type Mono-crystalline	1.903×1.134
3	Cheetah	Half Cell Mono PERC	1.684×1.002
4	Swan	Bifacial Mono PERC	2.031×1.008
5	Eagle	Poly-crystalline	1.956×0.992

2.2 Methods

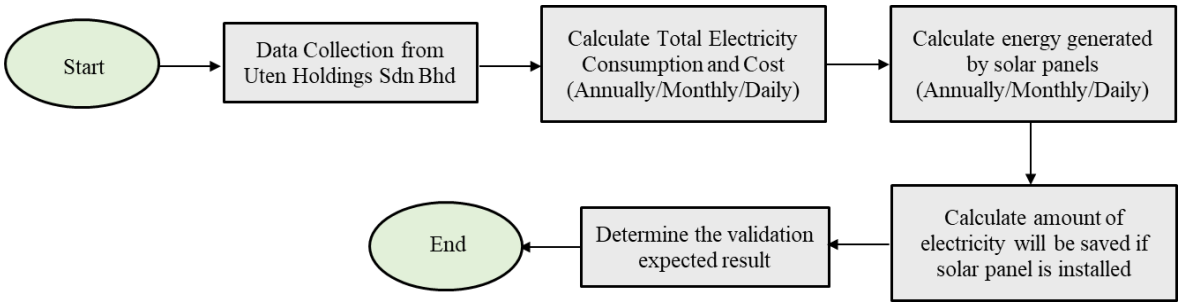

Figure 1: Flow Chart of Methodology.

The formula for the calculations will be show as below:

$$\text{Annual power produce, } E_{ann} = A \times r \times H \times PR \quad \text{Eq.1}$$

$$\text{Monthly power produce} = E_{ann}/12 \text{ months} \quad \text{Eq.2}$$

$$\text{Daily power produce} = E_{ann}/365 \text{ days} \quad \text{Eq.3}$$

$$\text{Cost of electricity per house per year= cost of electricity per house} \times 365 \text{ days} \quad \text{Eq.4}$$

$$\text{Annual electricity saving} = \text{Annual electricity used} - E_{ann} \quad \text{Eq.5}$$

Eq.1 is the universal formula for estimating the annual power produced by a photovoltaic panel, where E is energy (kWh), A refer to the total solar panel area (m^2) and r is solar panel yield or efficiency (%). PR is the performance ratio, in this study default value of 0.75 is used. Performance Ratio (PR) acts as a very significant value for determining photovoltaic system quality because it offers installation performance regardless of the angle and orientation of the panel. All losses are included.

3. Results and Discussion

3.1 Electricity usage and cost

The usage of electricity in each house by taking the difference of electricity unit at certain month and the previous month. For example, the usage of electricity in April 2019 is the difference of the meter reading in March 2019 and April 2019. The electricity usage is minimum in August 2019, which is only $2454kWh$, this is because according to the academic schedule 2019/2020 UTHM, 07th July 2019 until 07th September 2019 was a 9-week semester break.

The electricity usage had increased after August 2019 until December 2019, the electricity usage on September 2019 is almost 4 times compare to August 2019, which is $9223kWh$ because starting from 08th September 2019 was Semester I of 2019/2020.

The electricity usage in November 2019 was slightly decrease to $7968kWh$ as 27th October 2019 to 02nd November 2019 was a one-week Mid-Semester Bread. As for January 2020, the electricity usage started to decrease to $5393kWh$ because 29th December 2019 to 18th January 2020 was three-week Semester Final Examination week, students will go back home after their final examination.

Until February 2020, the electricity usage decreased until $3329kWh$ because Semester II 2019/2020 started from 16th February 2020, students just came back from their hometown from semester break maybe few days before Semester II started so the electricity usage is not much.

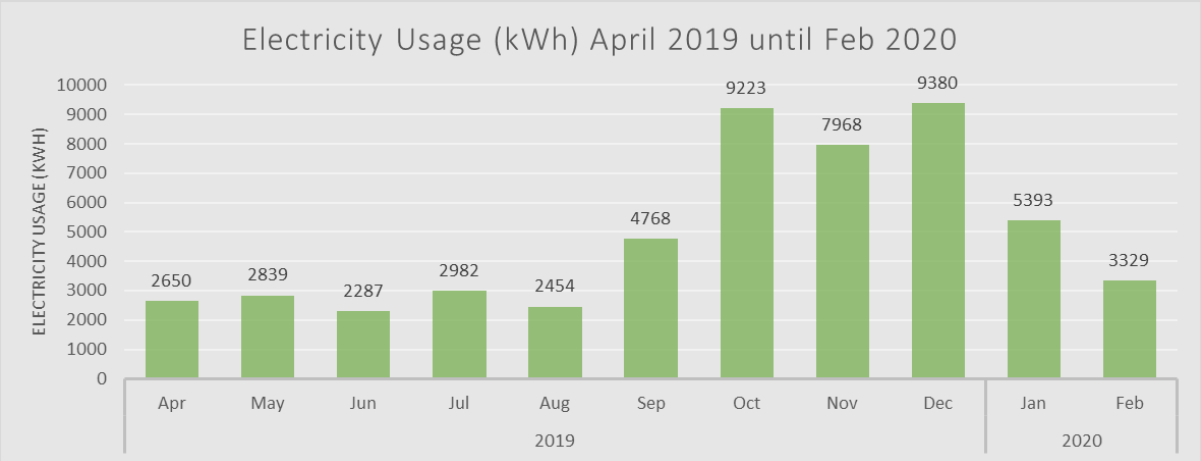

Figure 2: The electricity usage from April 2019 until February 2020 at Block B4 Bistari Hostel.

As the number of houses rented was not fixed until September 2019, so the average daily electricity usage of Block B4 at Bistari Hostel will be taken from September 2019 until February 2020. Since the meter reading operation was held on every 21st of the month, the number of days to calculate the average daily usage of electricity will start from 21st September 2019 to 21st February 2020. There are 153 days from 21st September 2019 to 21st February 2020, and the number of houses rented was 47 houses, with the data given, average electricity usage per house per day can be calculated.

Table 2: The electricity usage and the cost of electricity consumption at Bistari Hostel, Parit Raja, Johor from April 2019 to February 2020.

Parameters	Electricity Usage (kWh)	Cost
Daily	5.571	RM 1.26
Annually	40,061	RM 9,066.14

For the cost of electricity used, the cost of the electricity is calculated based on the domestic tariff rates (Category A) for every house and the average is taken. There are 4 blocks in Bistari Hostel, B1, B2, B3 and B4, with total 168 houses, therefore the electricity usage and the cost can be calculated.

Table 3: The electricity usage and the cost of electricity consumption if all the houses at Bistari Hostel, Parit Raja, Johor were rent out.

Parameters	Electricity Usage (kWh)	Cost
Daily	935.923	RM 211.81
Annually	341,611.982	RM 77,309.96

3.2 Solar PV output

In this project, there are 5 types of solar PV chosen from Jinko Solar. As solar PV comes in standard size based on manufacturer, the total area the total area needed for each type of solar PV module were calculated by divide the total area of parking area and building roof area to the standard area solar PV. The annual power produced by solar PV were calculated using Eq. 1, with performance ratio, 0.75 and the annual average radiation at Malaysia,$1643\ \mathrm{kWh/m^2}$.

Table 4: The total solar panel area needed, solar PV efficiency and the energy generated annually by the 5 types of solar PV.

Cell Type	Total solar panel area	Solar PV yield	Energy generated annually
N-type Mono-crystalline	$5174.45m^2$	21.54%	137,343,801.6 kWh
P -type Mono-crystalline	$5442.48m^2$	21.32%	142,982,521.7 kWh
Half Cell Mono PERC	$5271.34m^2$	20.45%	132,835,138.5 kWh
Bifacial Mono PERC	$5013.71m^2$	19.78%	122,203,699.8 kWh
Poly-crystalline	$5679.41m^2$	17.26%	120,793,304.8 kWh

3.3 Summary of the energy saving.

The energy generated annually was calculated using equation Eq.1, to know the energy generated monthly and daily by the solar PV, the energy generated annually by the solar PV was divided by 12 months and 365 days.

Table 5: Energy generate monthly and daily if the solar PV is installed at Bistari Hostel, Parit Raja, Johor.

Cell Type	Energy generated monthly	Energy generated daily
N-type Mono-crystalline	11,445 MWh	376.3 MWh
P -type Mono-crystalline	11,915 MWh	391.7 MWh
Half Cell Mono PERC	11,070 MWh	363.9 MWh
Bifacial Mono PERC	10,184 MWh	334.8 MWh
Poly-crystalline	10,066 MWh	330.9 MWh

All the 5 types of solar module are efficient solar PV in terms of saving the cost of electricity if they were installed at Bistari Hostel. As the estimated annual usage of electricity at Bistari Hostel are

around 0.24-0.28% of the electricity generate by the 5 types of solar PV. From Table 4, the P-type Mono crystalline solar PV module is most efficient as it can generate 142,982,521.7kWh of energy to Bistari Hostel if the solar PV is installed on the roof and the parking area of Bistari Hostel. Based on the calculation, the annual electricity usage if all the houses (168 houses) at Bistari Hostel are rent out were only 341,611.9816kWh, which is only 0.24% of the energy that can be generate annually from the P-type Mono crystalline solar module.

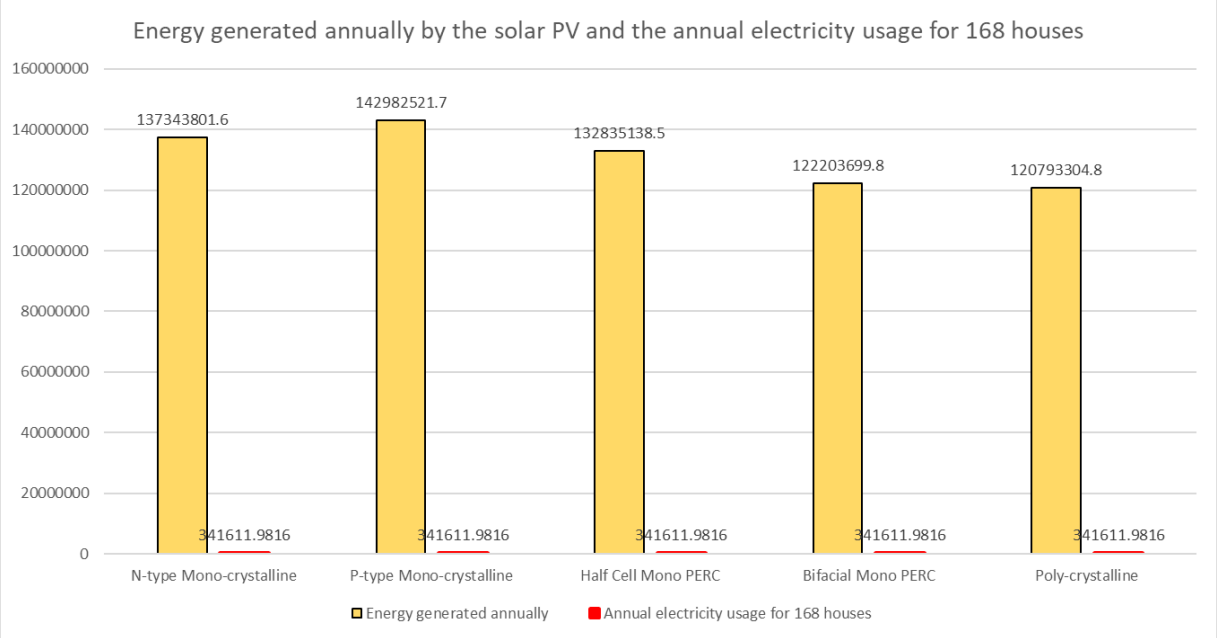

Figure 3: Comparison between the energy generated annually by the solar PV and the annual electricity usage for 168 houses at Bistari Hostel, Parit Raja, Johor.

4. Conclusion

The results of energy consumption at Bistari Hostel since April 2019 to February 2020 were taken and from the findings, the energy consumption if all the 168 houses at Bistari Hostel were rent out to students can be estimate. The results of estimated annual electricity usage for 168 houses was 341,611.9816 kWh/year which will cost about RM 77,309.96/year.

For the study of potential application of solar PV in saving the electricity usage and the cost of electricity, all the five types of solar PV manufacturer by Jinko Solar do fulfil the objective. The most effective solar cell type is P-type Mono-crystalline as this module can generate 142,982,521.7 kWh of electricity if solar panels is installed at the roof of Block B1, B2, B3, B4 and the parking area of Bistari Hostel. This will give an excess of 142,640,909.7 kWh electricity that can be sell back to the utility company or store in the energy storage system (batteries) depends on the type of solar power system as mentioned at Chapter 4.5.2.

It was expected that the installation of solar panels will reduce more than 25% of the electricity usage at Bistari Hostel, but the results shows that there will be more than 99% excess electricity generate if the solar PV are installed at Bistari Hostel. All the 5 types of solar PV in this study shows there will be excess electricity generate, and P-type Mono-crystalline solar cell can generate more electricity than others type of solar cell, which means it is the most effective solar cell type than the others.

This study shows that installation at Bistari Hostel can reduce the electricity usage and its cost fully, however there are some factors are not considered in the study which if further study is made later,

these factors such as the degradation rate and the installation and maintenance cost and payback period can be add to the study to make the study more complete.

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