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Article

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An Economic Feasibility Study on Solar Installation for University Campus: A Case of Universiti Utara Malaysia

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ABSTRACT

Transforming towards renewable energy consumption has become the main agenda for the country due to the drawback of consuming conventional resources. Climate change, energy security, and price fluctuation are the main factors contributing towards the penetration of renewable energy. Solar energy seems to be the most attractive due to unlimited source of energy, and fundamentally, its availability will never run out. This form of energy can also be used as an alternative in producing electricity. Malaysia has potential in developing solar energy for daily usage due to its location in the equatorial area and acquiring approximately 400-600 MJ/m^{-2} of solar radiation every month. Universiti Utara Malaysia (UUM) is a public higher learning institution located in Sintok, Kedah. Sintok is a potential area for the installation of this solar system because the area has a longer peak sun hour rate than other areas. The aims of this study are: (1) to analyse the factors involved in solar installation, and (2) to examine the economic feasibility of solar installation at a university campus. This study used a qualitative approach, whereby the data were taken from interviews with the Development and Maintenance Department of UUM and Detrolic Solar Company. The solar implementation in UUM could reduce the cost of energy usage annually. Furthermore, UUM could gain revenue from the Net Energy Metering (NEM) 3.0 Government Ministries and Entities incentive. Solar installation in the campus could hasten the effort of UUM moving towards a green and eco-friendly university campus. It is best believed that this effort could be a success if UUM is ready to move towards sustainable energy with solar consumption.

Keywords: Solar energy, University campus, Installation, Economic, Universiti Utara Malaysia
JEL Classifications: Q410, Q420

1. INTRODUCTION

Malaysia has potential in developing solar energy for daily usage due to its strategic location situated in the equatorial area and acquiring approximately 400-600 MJ/m^2 of solar radiation every month. Currently, Malaysia has shown an increasing pattern of solar installation. Figure 1 indicates the total of solar installations from 2017 to 2020 (Tenaga, 2022). Figure 2 shows the solar installation for each state in Malaysia for 2020. Meanwhile, Figure 3 presents the solar photovoltaic (PV) total installed cost for the period of 2013-2019 among the residential and commercial sectors in Malaysia (IRENA, 2020). It indicates about 65.24% of installed cost reduction for commercial buildings.

Kedah is one of the most suitable states to develop solar projects since it receives the highest solar energy apart from having the largest solar panel production plant in the country (Mukhriz, 2019). Universiti Utara Malaysia (UUM) is a public higher learning institution located in Sintok, Kedah. Sintok is a potential area for the installation of this solar system. This is because Sintok has a longer peak sun hour rate than other areas (Solargis, 2019). Therefore, implementing solar energy in UUM would be

Figure 1: Total solar installation

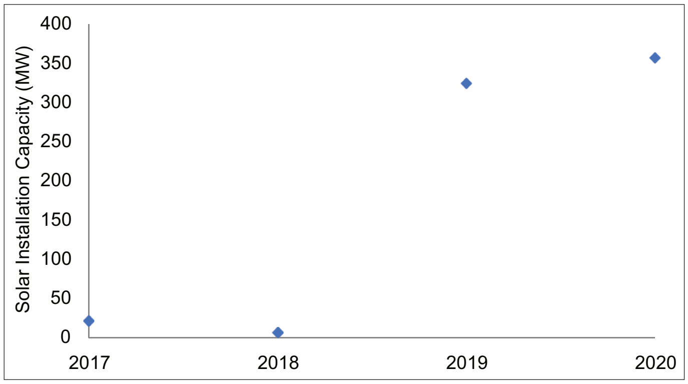


Figure 2: Solar installation in 2020 based on states in Malaysia

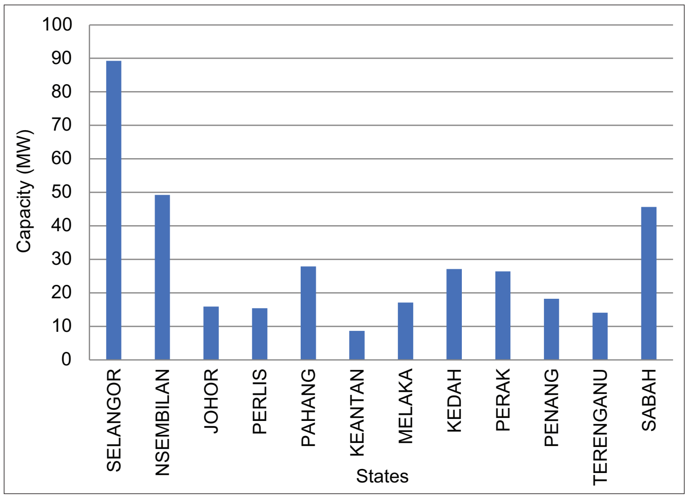
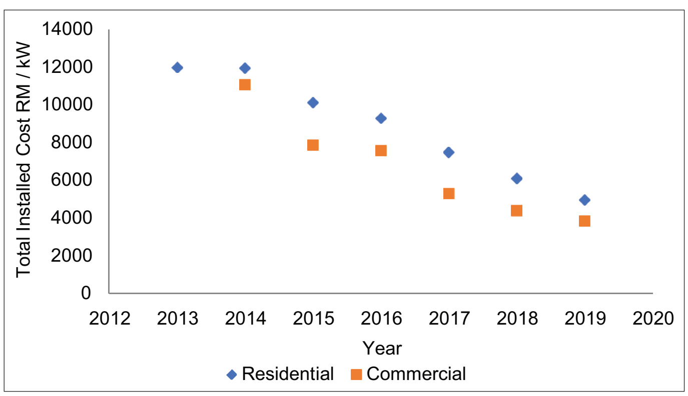


Figure 3: Malaysian residential and commercial sectors' solar PV total installed cost for 2013-2019



beneficial and worth the investment. There are many universities that have implemented solar energy on their campuses such as Universiti Malaysia Pahang (UMP). It was evident from the comparative simulation analysis that the UMP Pekan Campus and UMP Gambang Campus would be effective for PV power station commissioning. The expected high energy efficiency demonstrated the enormous solar energy's potential on campus (Kumar et al., 2017). The most critical step in a feasibility research study is the economic analysis as it determines if the examined resources and technologies are genuinely implementable in the project (Görgen, 2016). Although the area has potential to implement solar energy and develop large-scale solar energy systems, it is still early due to the prohibitively exorbitant cost for the solar cells and the rate of tariffs for solar electricity (Mekhilef et al., 2012). The cost of implementing solar energy in UUM will be the most significant considering that the initial investment in a solar system is relatively expensive. It covers payment for solar panels, inverters, batteries, installation, and wiring (Vourvoulias, 2019). Nevertheless, it is proven that the PV systems could increase the investment's economic profitability (Olivieri et al., 2020). The aims of this study are: (1) to analyse the factors involved in solar installation, and (2) to examine the economic feasibility of solar installation at a university campus. Even though it is proven that solar energy implementation would benefit and give positive outcomes, it is still not widely used in many universities in Malaysia.

2. METHODOLOGY

UUM is a public university that currently has two campuses located in Sintok, Kedah and in Kuala Lumpur. As for this research, the main campus, which is in Sintok, Kedah, was chosen for the solar implementation. The total land area covered by UUM Sintok is 1,061 hectares. Considering that the university now has 1,061 hectares of open space, solar PV panels will have to cover a large part of it. Some parts of this area might be unsuitable for a solar system, and thus buildings such as residential colleges, school buildings, and management buildings are the most considerable areas for this solar panel implementation. As for now, the main area of UUM has not been covered by solar energy yet, but a part of the UUM Mini Golf area has implemented solar panels for lighting purposes at night. Figure 4 shows the overview through an upper angle view of UUM. This study focused on implementing solar panels in several buildings in UUM based on the list provided by the Development and Maintenance Department, UUM. The School of Quantitative Sciences (SQS) and School of Technology Management and Logistics (STML), School of Multimedia Technology and Communication (SMMTC), School of Economics, Finance, and Banking (SEFB), School of Business Management (SBM), and Dewan Kuliah Gugusan (DKG) 1, 2, 3, 4, 5, and 6 were the buildings chosen for the solar implementation. Figures 5 and 6 present the rooftop views of academic buildings in UUM and rooftop views of DKG 1 till DKG 6. Table 1 indicates the electricity consumption and cost for selected buildings in the UUM Sintok Campus. These data were taken from the Development and Maintenance Department of UUM.

The UUM Sintok Campus, with a size of 1061 ha, consists of 1,191 academic staff and 1,736 administration staff. In this study, surveys and interviews were conducted to gain information and data in relation with the implementation of solar energy in UUM. Moreover, a government agency, i.e., the Sustainable Energy Development Authority Malaysia, was also partially involved in the process of gathering necessary information for this study. The electricity consumption data and information for UUM were obtained from the Development and Maintenance Department of UUM (JPP). A series of interviews was carried out with JPP regarding the implementation of solar energy in UUM. The data on the cost of solar installation were acquired through an interview session with Detrolic Solar Company. A flow chart describing the study outline is shown in

Figure 7. The PV Watts Calculator website was used, whereby the system generated the total energy produced by the solar panels. The system calculated the solar energy produced by including the calculation of the roof area in the system and assuming that the average sunlight received daily would be 4.71 h. Based on the data generated from the website, the researcher could identify the total excess energy produced by the solar PV system.

Figure 4: Universiti Utara Malaysia

2.1. Solar Energy Calculation

Table 2 shows the suggested PV system specifications that are suitable for solar energy implementation in UUM based on the system generated by the PV Watts Calculator website. The PV module type that had been chosen was the crystalline silicon with the approximate nominal efficiency of 19% with anti-reflective coating. This type of module would be the most suitable to be implemented as it had the highest efficiency rate. Moreover, the array type is fixed with an open rack, making it appropriate for ground-mounted systems. It assists the air to flow freely around the array, helping to cool the modules and reduce the cell operating temperatures. The system losses for the solar PV panel would be around 14% as factors such as shading, mismatch, wiring, connections, and light-induced degradation were considered in this calculation. The tilt angle refers to the horizontal angle of the PV modules in the array. For a fixed array to be implemented in School of International Studies buildings, the tilt angle would be around 14°. This is to ensure that the system would maximise the total electrical output over the year. The azimuth, on the other hand, is the angle clockwise from true north, describing the direction that the array is facing. For this system, it would be 180°. The direct

Figure 5: Rooftop of academic buildings in UUM Sintok Campus

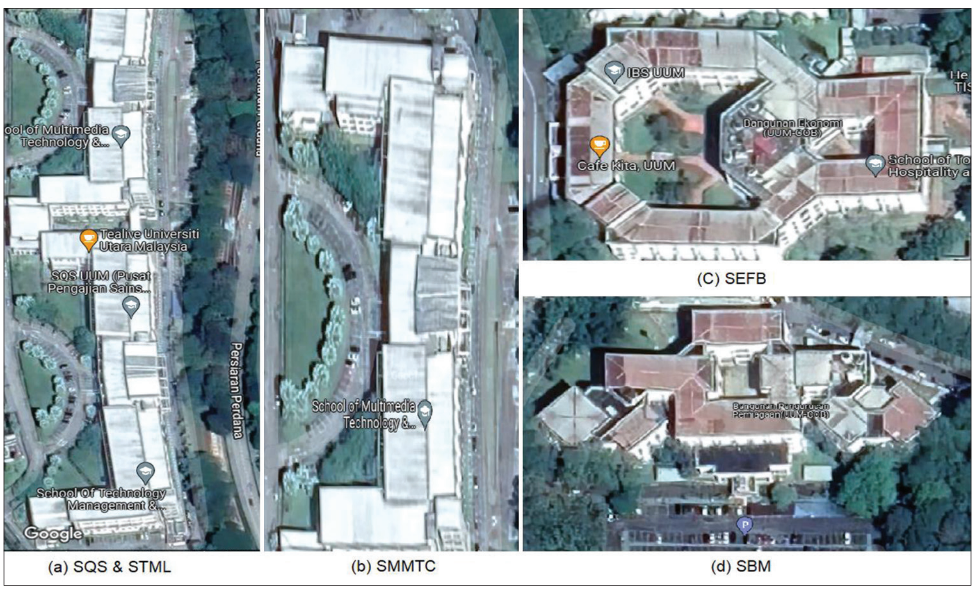


Figure 6: Rooftop of DKG 1-6

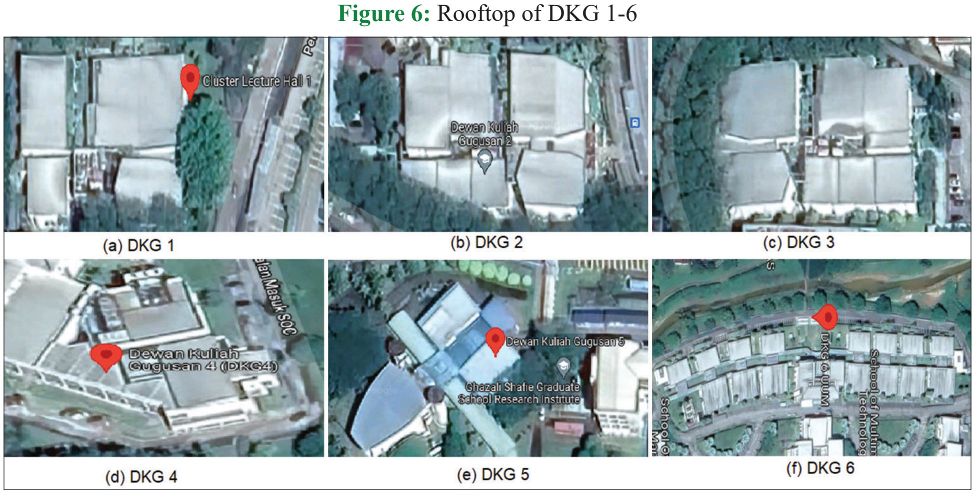


Table 1: Electricity consumption and cost for selected buildings in UUM Sintok Campus

Building Name	Rooftop Area (m^2)	Total Average Annual Consumption (kWh)	Total Cost (RM)
School of Quantitative Sciences and School of Technology Management and Logistics	4,523	226,000	RM103,000
School of Multimedia Technology and Communication	5,053	210,000	RM95,000
School of Economics, Finance and Banking	7,358	310,000	RM141,000
School of Business Management	13,386	560,000	RM255,000
Dewan Kuliah Gugusan 1-6	24,596	1,900,000	RM860,000

current (DC) to alternating current (AC) size ratio is the ratio of the array's DC rated size to the inverter's AC rated size. For the default value of 1.2, a 4-kW system size would be for a 4 DC kW array at standard test conditions and 4 DC kW/1.2 = 3.33 AC kW inverter. The inverter efficiency rate has been set at a default value, which would be 96%. The ground coverage ratio for the system would be 0.4, whereby it is the ratio of module surface area to the area of the ground or roof occupied by the array.

2.2. Solar Component Cost

The solar installation cost depends on the usage and location. There are also other factors that need to be considered, such as roof type, irradiance, and most importantly, the implementation cost. Nevertheless, all these costs for each component are subject to the current market price. Prices may change due to the market demand. Table 3 shows the price for solar components provided by Ditrolic Energy in 2022. Based on the interview with Ditrolic Energy, in determining the solar panel installation cost, there were many aspects that needed to be included in the calculation. This is because the solar panel installation cost could not be calculated based on the physical area itself. There are several other things to be considered prior to the installation, such as the Tenaga Nasional Berhad (TNB) incoming reading and the physical area of the roof. A solar panel needs at least 9 m^2 to be implemented on the rooftop. However, for the grid connected system, the cost for each Wp would be around RM1.30, while the cost for the grid connected system per 1 kWh would be RM1,300. The expected project lifetime would be around 20 years.

Table 3 explains the cost of solar panels by inserting all the required information such as the rooftop area, size per panel, number of panels, and system size to obtain the results, which is the cost of panels. Since a normal-sized panel produces 250 watts/h, the researcher calculated the system size in kWh by multiplying the number of panels by 0.25 kWh/h (Aggarwal et al., 2014). Table 4 lists the installation cost for the UUM Sintok Campus. Equation (1) is used to calculate the return on investment (ROI).

$$\textit{Payback Period} = \frac{\textit{Initial investment}}{\textit{Cost of the system}\ (kWh) \times \textit{Annual production of energy}\ (CF)} \quad (1)$$

3. RESULTS AND DISCUSSION

3.1. Factors That Need to Be Considered Before Installation

There are many factors that need to be considered first before performing the installation of solar panels, such as the type of roof. The orientation and tilt angle of PV modules are significant aspects to recognise when installing solar PV systems (Aboagye et al., 2022). The perfect and most suitable type of roof for solar implementation for rooftops would be a flat roof or a roof that is at least around 15 until 40°. Roofing arrangements affect the PV panel yield (Cavadini and Cook, 2021). If there is an obstruction that interferes with sunlight to reach directly to the rooftop surface such as trees, it will reduce the energy production and make it harder for the solar panel installation process. Moreover, solar radiation would be one of the most important factors that need to be considered before installing solar panels. Therefore, Sintok,

Table 2: PV system specifications

Parameters	Results
Module Type	Crystalline Silicon (Glass with Anti-Reflective Coating)
Array Type	Fixed (Open Rack)
System Losses (%)	14
Tilt (degree)	20
Azimuth (degree)	180
DC to AC Size Ratio	1.2
Inverter Efficiency (%)	96
Ground Coverage Ratio	0.4

Table 3: Solar component price

Solar Component	Price (RM)
Solar Panel	RM1.30/Watt
Inverter	3,000
Grid Connected System per 1 Wp	RM1.30
Grid Connected System per 1 kWh	RM1,300 Unit
Rooftop Area Per Panel	Solar Panel = 6 m^2 Walkway = 3 m^2 Total = 9 m^2

Figure 7: Flow chart process of the study

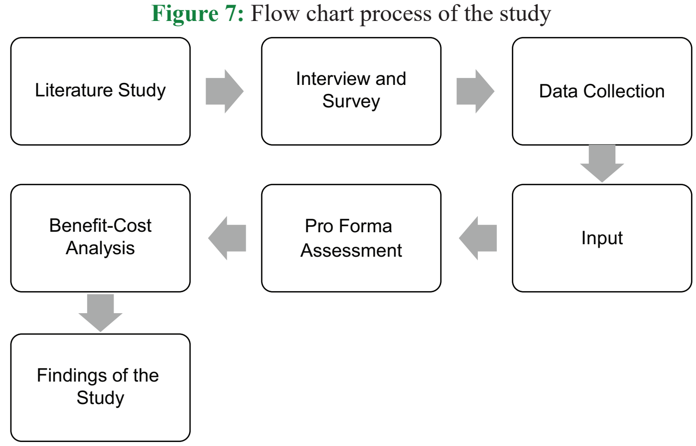


Table 4: Installation cost for UUM Sintok Campus

Building Name	Rooftop Area (m^2)	Size per Panel (m^2)	Number of Panels	System Size (kWh)	Cost of Panels
School of Quantitative Sciences School of Technology Management and Logistics	4,523	9	503	125.75	RM163,475
School of Multimedia Technology and Communication	5,053	9	561	140.25	RM182,325
School of Economics, Finance and Banking	7,358	9	818	204.50	RM265,850
School of Business Management	13,386	9	1,487	371.75	RM483,275
Dewan Kuliah Gugusan 1, 2, 3, 4, 5, 6	24,596	9	2,733	683.25	RM888,225

Kedah is among the most suitable areas for solar implementation as this northern region of Malaysia receives a total amount of sunlight that is higher than other regions.

3.2. Specific Incentives Offered by the Company

As for now, there are many incentives provided by the government to support solar energy usage, such as the Net Energy Metering (NEM) Government Ministries and Entities incentive under the NEM 3.0 programme, whereby it is a programme that is specifically for government buildings including public university buildings. Under this programme, any excess energy produced will be supplied to the utility grid and compensated on a 1:1 basis. Apart from this, there is also the incentive provided by Ditrolic Energy. Ditrolic Energy could offer free solar installation in UUM with 0 CAPEX (capital expenditure). Therefore, UUM will not issue any capital cost from the start until the end of the installation process including the operation and maintenance (O&M) cost, which will be fully borne by the company.

3.3. Duration for Solar Energy Implementation

The standard practice for solar energy implementation especially for universities buildings would be around 20 until 25 years based on the Power Purchase Agreement (PPA). This information is based on the solar installations that have been done by Detrolic for other universities such as Universiti Tunku Abdul Rahman (UTAR) in Kampar, Perak, Universiti Sains Malaysia (USM) in Penang, and Southern University College in Skudai, Johor. As for this study, the recommended solar system duration would be around 20 years.

3.4. Type of Solar Panel

The type of solar panel that is suitable to be implemented in UUM would be the Tier 1 type panel, it has the most effective sunlight absorption. The Tier 1 solar type panel lasts long, and its effectiveness has been proven, such as solar panels by Panasonic, LG, and First Solar. However, in deciding how many PV panels to be used, many studies and investigations need to be done such as the TNB incoming readings as well as the current transformer (CT) ratio of each building. The accurate number of panels can only be ascertained after conducting some research and performing the HelioScope software report. Moreover, as recommended by Ditrolic Energy, crystalline silicon would be the most suitable solar module type to be implemented in UUM as it has the highest effectiveness rate.

3.5. Economic Analysis

The pro forma calculation was made to thoroughly explain the costs involved in the solar implementation cost calculation. The solar rate usage was given by Ditrolic Energy to be around RM0.36 per kWh for the energy produced by the solar system. The NEM incentive offers a 10-year period for excess solar energy produced to be sold to the TNB grid with the rate offered at 1:1, which for now is RM0.36 kWh as per the agreement. The solar system would take around 20 years as per the PPA agreement. However, after the NEM 10-year offset period ends, UUM only needs to pay the electricity usage as per usage only. This incentive will indeed help UUM to gain revenue in the short term.

The result of the outline costs and savings is presented in Table 5. Each analysis used the buildings' average annual electricity consumption and average annual electricity bill that were calculated based on Table 1. Based on the pro forma for the SQS and STML buildings explained in Table 4, the estimated solar size is 125.75 kWh. The total energy produced by the solar power would be 876,846 kWh and the excess power to be returned to TNB for the NEM programme would be around 650,845 kWh. From this calculation, the energy bill for the SQS and STML buildings could save around RM21,640 as the new solar energy bill would be RM81,360 annually. The excess solar power sold to TNB would be RM234,304/year. This sums up the net revenue for excess solar energy at RM234,304 annually as well. Nevertheless, if this value is carried through the life cycle of the solar system that is expected to be 20 years, then UUM would save and earn revenue approximately around RM2,395,965 in 20 years just for the SQS and STML buildings. From the table, it could be seen that the estimated solar size for the SMMTC building that has been calculated is 140.25 kWh and UUM could save and earn revenue of at least RM2,779,355 for the total of 20 years' solar usage. Subsequently, the table also shows the pro forma model for the SEFB building. The current electricity usage for SEFB before is 310,000 kWh/year. The solar size of the solar system is 204.50 kWh based on the area of the rooftop that is suitable for solar implementation. The solar energy could produce a total of 1,425,664 kWh/year, making the excess energy after consuming be around 1,115,664 kWh/year. The total annual bill before the solar implementation is RM141,000, and by implementing solar energy, the current electricity bill would be RM111,600. This shows that solar energy could reduce the annual bill by RM29,400. Moreover, the excess energy could be sold to TNB under the NEM incentive, resulting in UUM to receive a total net revenue of RM401,640 annually. Therefore, the total annual savings and revenue would be RM431,040. For the total of 20 years, UUM could possibly save around RM4,044,550 for the SEFB building only.

The current electricity usage for the SBM building is 560,000 kWh. The estimated solar size is 371.75 kWh for the SBM building that has a total rooftop area of 13,385 m^2. The total energy produced by solar power would be 2,593,843 kWh, whereas the

Table 5: Outline costs and savings

	SQS and STML		SMMTC		SEFB		SBM		DKG 6	
Electricity Demand										
Electricity usage (kWh)	226000		210000		310000		560000		1900000	
Rooftop area (m^2)	4523		5053		7358		13386		24596	
Annual Bill (RM)		103000		95000		141000		255000		860000
Solar Energy Usage										
Solar size (kWh)	125.75		140.25		204.50		371.75		683.25	
Potential Annual Production (kWh)	876846		978799		1425664		2593843		4766382	
Extra Electricity Produced (kWh)	650845		768799		1115664		2033843		2866382	
Annual Consumption Cost Before Solar (RM)		103000		95000		141000		255000		860000
Solar Annual Consumption Cost (RM)		−81360		−75600		−111600		−201600		−684000
Total Annual Savings (RM)		21640		19400		29400		53400		176000
NEM Incentive										
NEM Tariff (1:1) (sen/kWh)		0.36		0.36		0.36		0.36		0.36
NEM Offset Period (Years)	10		10		10		10		10	
NEM Revenue (RM)		234304		276768		401640		732183		1031898
Total Annual Savings/Revenue (RM)		255944		296168		431040		785583		1207898
Term of Solar (Years)	20		20		20		20		20	
Savings with NEM Incentive (RM)	10 Years	2343040	10 Years	276768	10 Years	401640	10 Years	7855830	10 Years	12078980
Saving after NEM Offset (RM)	10 Years	216400	10 Years	194000	10 Years	294000	10 Years	534000	10 Years	1760000
Initial Cost (RM)		−163475		−182325		−265850		−483275		−888225
Total Overall Savings/Revenue (20 years) (RM)		2395965		2779355		4044550		7906555		12950755

excess energy power would be around 2,033,843 kWh. The total electricity bill before the solar implementation is RM255,000 and the total electricity bill after the solar implementation would be RM201,600/year. This indicates that the annual savings would be around RM53,400. However, the excess energy produced could gain revenue as well by selling it to the TNB grid under the NEM incentive. The total NEM revenue would be RM732,183 and the total annual savings and revenue of the solar energy annually would be RM785,583. This solar energy is expected to last for 20 years, whereby the total overall savings and revenue could reach around RM7,906,555 during this period. The DKG buildings that were involved with the solar implementation were DKG 1, DKG 2, DKG 3, DKG 4, DKG 5, and DKG 6. The total rooftop area of all these areas is 24,596 m^2 accumulatively, whereby the electricity usage is at 1,900,000 kWh annually. The solar size of these buildings would be 683.25 kWh. The total energy produced by the solar power system would be 4,766,382, whereas there would be a total of 2,866,382 excess energy produced by the solar power system. The annual bill before the solar implementation is RM860,000 and the annual bill after the solar implementation would be RM684,000, making the total annual savings for these buildings around RM176,000. The total NEM revenue would be RM1,031,898. Meanwhile, the total annual savings and revenue would be RM1,207,898. This solar power is expected to last for 20 years, making the total overall savings and revenue for 20 years at RM12,950,755.

The SQS and STML buildings received an ROI of 155.56%, while the SMMTC building received an ROI of 162.14%. SMMTC, on the other hand, gained an ROI percentage of 162.14%, while SBM received 162.55% for ROI. For the DKG buildings, the ROI was 136%, which was the lowest ROI rate among other buildings.

3.6. Solar Maintenance Cost

Typically, the cost for maintenance will be calculated by kWp, whereby the standard practice of Detrolic Energy Company depends on the amount of solar capacity installed. Ditrolic Energy also has its own O&M team who will be in charge of performing the service and maintenance of the solar PV panels. However, as discussed with the Detrolic Energy Company, the solar maintenance cost will be borne as an incentive from the company for UUM in the effort of moving towards solar energy.

4. CONCLUSION

The implementation of solar energy in UUM could be beneficial in many aspects and not only in terms of cost. As per the efforts implemented by UUM to reduce the usage and cost of electricity in the campus, solar implementation could be a great effort to ensure UUM's intention in reducing costs. Moreover, for UUM to be a green and eco-friendly campus, this solar energy implementation is one of the great foundations to ensuring the success of it. This will help UUM to achieve higher ranks as a sustainable university in the UI GreenMetric World University Rankings in future years. Moreover, the benefit of solar implementation in UUM could reduce the greenhouse effects as the solar energy only produces and releases quality energy for a better quality of life.

5. ACKNOWLEDGMENTS

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