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The installation of solar photovoltaics for charity homes in rural Malaysia: A community-based approach

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Abstract

The adoption of solar panels installation in Malaysia, especially for rural areas are still at the preliminary stage, due to the high cost of the system and the limited access to this technology in the remote region. The availability of this green electricity for public buildings are still limited since the current dissemination of this green energy technology is still funded by the government, resulting in slow progress in the area. In addition, Malaysians also received subsidized power supply which has led to high dependency on this conventional supply from the national electricity provider, Tenaga Nasional Berhad (TNB) which is slowing the progress of solar energy usage. However, since 2014, there has been a gradual increase in electricity tariff that has led to the increasing cost of monthly electricity bills. This has affected many sectors in paying off the utility bill, especially charitable organizations owned by private Non-Governmental Organizations (NGOs). The significant impact may occur to private charity homes in rural areas which usually depended on donations from the public. The worst scenario may arise, for instance the power may be cut-off if the electricity bills cannot be paid on time. Therefore, this research paper will try to determine whether solar panel installation through a community-based approach can help the institutions to gain savings from the monthly electricity bill and provide self-sufficient electricity to charity homes. A case study in the region of Perak Tengah in Malaysia was selected to identify if the community-based approach could help to access this green electricity at the selected charity home. An empirical approach showed that the charity home has the potential to save 70% of monthly electricity bills after installing a 2 kilowatts peak (kWp) solar photovoltaics system under a community service program.

Keywords: Charity homes, community-based approach, solar photovoltaics

1. Introduction

As of 2014, electricity tariffs in Malaysia have increased at a 4% rate annually which has affected the monthly cost of living and electricity bills [1]. The basic tariff rate has increased from Malaysian Ringgit (MYR) 0.22 cents per kilowatt hour (kWh) in 2014 [2] to MYR 0.39 cents per kilowatt hour (kWh) in 2020 [3]. The demand for electricity by Malaysians has also increased by about 4.8% over the past 10 years due to the changing of modern lifestyle and has been influenced by the increasing use of high-tech electrical appliances [4]. Current electricity consumption growth in Malaysia has increased from 135.8 Terawatt-hour (TWh) in 2015 to 149.2 TWh in 2016 [5].

This rapid trend has also influenced uncontrollable electricity consumption in charity institutions that are largely managed by private parties across the country [6]. The use of lights, fans, television, radio and other electrical appliances are important for these charity homes. Although the power load of these electrical appliances is lower in charity homes than other types of buildings, the frequent use within 24 hours of these appliances have resulted in high power consumption annually [6]. Indirectly, this would result in an increase in management costs involving monthly utility bills if electricity tariffs continue to

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increase in the future.

The result of this situation is the insufficient financial resources that have a lasting impact on private charity institutions. There has been a study that suggests the main problem of charity institutions in Malaysia is poor financial management which depended on donations from the public [6]. With inconsistent financial resources, it is feared that if electricity tariff rises in the near future, these institutions will have issues in sustaining the charity homes.

Therefore, one of the recommendations to control this issue is to implement community programs between local communities and the building management in order to provide self-sufficient electricity. To date, there have been limited studies involving community efforts in supplying sustainable electricity to charity institutions through a community-based approach. For this study, sustainable resources of electricity are available through solar energy which is highly available in Malaysia [4]. Clearly, these charity institutions need supports from various government and private agencies in installing solar panel systems on the building before any Government solar scheme can be implemented, whether the Feed-in Tariff (FiT) Scheme or Net-Energy Metering (NEM) scheme [7]. Therefore, this paper limits the study on the economic aspect of introducing these schemes to the charity homes. It will only focus on whether installation of solar panels through a community-based approach could help these institutions to gain the saving benefit of monthly electricity bills from sustainable electricity resources. The findings from this study will have a significant impact on ensuring that charity institutions can continue their operations without facing any financial difficulties especially in maintaining their electricity supply and sustaining a self-sufficient electricity.

2. Literature Review

2.1. The community-based approach

Efforts to help in providing sustainable electricity to local communities through community programs are not uncommon situation for some countries. Among countries that are actively promoting sustainable energy programs under the community service program are Indonesia, Nigeria, Cambodia, Bangladesh and India [8]. Under the United Nations Development Programme (UNDP) effort, these countries are introducing solar energy to rural and low-income people through a network of non-governmental organizations and community-based cooperation [8]. This effort often draws the participation of non-governmental organizations as well as volunteers from technologists, local residents and donors to communities that cannot afford expensive green energy, which generated is from solar, mini hydro, wind and many more.

This community-based approach can be defined as a social mechanism that integrates local characteristics by taking into account the same situation within the community, from individual needs to neighbourhood needs [4], [9], [10]. It also identifies groups that have similar backgrounds and same pattern of living-hoods. These community efforts are actually under the community-based approach introduced by the United Nation in 2008 by targeting sustainable energy-generating opportunities such as solar, hydro and wind energy. Since 2000, this approach has helped to address power supply problems and unstable electricity in third world countries [10]. These sustainable energy generation projects continue to grow rapidly in most countries, enabling the local community to get basic electricity through renewable energy [8]. The positive impact of these projects is on improving the living standard of the local communities and educates them to use green energy as an opportunity for income generation [4], [9], [10]. It also promotes a more sustainable distribution of electricity in small neighbourhoods through the sharing of green energy sub-meters [11]. It has succeeded in shifting the original habits of the people who prefer to use unsustainable fuels, such as coal and firewood in the past to more sustainable resources [8]. However, in the case of Malaysia that has a stable electricity supply from the Government, the problem of electricity consumption is more towards educating local communities on how to save energy consumption while helping them to ease the burden of monthly utility bills [4]. Different approaches are needed to encourage Malaysians to be more open and inclined towards exploiting green energy such as solar energy.

Therefore, target groups are needed to introduce this green energy at the rural community scale. In the context of this case study, the aim of the research is to focus on helping charity institutions to operate as usual with the help of sustainable electricity.

2.2. The potential of solar energy in Malaysia

The potential in generating electricity from solar generation is excellent given that Malaysia receives 4 to 5 kWh m^2 of solar radiation per day per annum [11], which is higher than mega solar panel manufacturers such as Germany, Japan and China. Solar energy can be obtained through various means including roof-mounted panel installation, solar farm applications, hybrid and off-grid installation that do not require connection with the national power grid [12]. Malaysia receives high solar irradiance due to the country's location on the Equator line which allows this country to receive more than 4 hours of peak solar hour (PSH) [11]. In addition, the Malaysian roofing system with a gradient of between 10 and 30 degrees allows for the maximum sunlight acceptance [13]. One study has proven that if solar panels (photovoltaic) are successfully installed on 4 million roofs of buildings in Malaysia, it would be able to meet approximately 25% of current electricity demand at 34,194 megawatts (MW) per household [7]. This indirectly contributes to the savings of monthly electricity bill payments in Malaysia. However, at the moment, only 2% of electricity in Malaysia is generated using renewable energy sources, compared to fossil fuels such as petroleum, coal or natural gas [7].

Furthermore, the basic cost of installing solar panels is still considered expensive for the middle and low-income population of Malaysia, which is estimated to be worth MYR 1000 for a 1000- watt panel system [14]. This is equivalent to the average monthly income for low income groups in Malaysia, especially in rural areas. Therefore, various efforts and strategies need to be introduced by many stakeholders in promoting this green energy in order to evade the issue of rising electricity tariff in the near future. To support this effort, an approach can be made through introducing community programs that can provide funding for the installation of this solar panel system to the rural communities. These efforts will lessen the government's burden in allocating funds or subsidies for rural sectors. Many government agencies have been involved in creating these community projects, for instance; research grants that encourage university-based knowledge transfer projects such as the University Community Transformation Center (UCTC) grant, introduced by the Ministry of Higher Education since 2012. Under the Government National Blue Ocean Strategy (NBOS) [15], it helps to mobilize the university's academic resources and physical infrastructure to develop the community environment. In addition, the Electricity Supplies Industry Trust Fund (AAIBE) and e-Funds from the Ministry of Science, Technology and Innovation (MOSTI) [16] have also introduced grants for local communities in obtaining sustainable energy projects [17]. There were also solar state-programs introduced by the state government of Malaysia, like "SuriaKu" program that has been introduced by the Perlis-state government [18] and Kedah Solar Farm that has been introduced by the Kedah-state government [19].

Other than that, there are also community projects that involves private donations with the aid of Malaysian public and private universities, including Universiti Malaysia Perlis [20] and Universiti Teknologi Petronas [21]. Most of the projects have involved indigenous groups who live in remote areas of Malaysia which do not have a stable supply of electricity. This has led them to rely on diesel generators to power electricity at night. However, efforts to help rural communities to use solar energy in a typical and traditional village are still limited. These villages are different from the indigenous villages since they are the majority groups of population in Malaysia and receive a stable supply of electricity from TNB. The residents of these villages comprise major ethnic groups in Malaysia, which are Malay, Chinese and Indian [22].

A study has reported that almost 64% of rural people from traditional villages in Malaysia are still unaware of the importance of solar-generated electricity in addressing the problem of increasing domestic electricity tariffs [13], [1]. These groups also have no other access to electricity than relying on the national utility, TNB alone [4]. Concerns may arise among these groups when electricity tariffs increase or electricity disruption occurs in the communities in which they live in the near future. Therefore, it is

significant to introduce solar-generated electricity through a community-based approach that enables the distribution of solar energy technology through donations from capable stakeholders to the rural communities. This includes all charities homes in rural areas. Through this effort, these groups can enjoy self-sufficient electricity from solar energy without relying solely on government funding.

3. The Methodology

The purpose of this research is to introduce the concept of a community-based approach (CBA) program [23] for charity homes located in rural areas by supplying solar panels in generating self-sufficient electricity. The methodology used is based on a case study selected through 2 processes, namely (i) field research (site visits and observations) and (ii) action-research methodology (live-research) conducted directly on the research site. Action-research methodology can be defined as a research effort that directly involves practitioners to see the results of the study and the actual strategies used at the site [23]. This methodology involves practitioners among technologists and volunteers during the installation of the solar panel systems on a fully-operational site. Researchers conduct live observation and record all data on-site in order to evaluate significant strategies, installation procedures and system capabilities. Meanwhile, donors and the communities involved (building owners and residents) act as observers and provide physical assistance when needed. These research phases were conducted in the selected case study, a private charity home located in the Parit district of Perak Central in the Perak state of Malaysia. The charity home has 80 occupants and 6 staffs who use 2 blocks of buildings with an area of 30 m x 40 m. There are (i) a concrete-block hall and (ii) an open-space activity area.

3.1. Empirical data on site

From the field survey, it was found that the electrical appliances used in the case study consisted of 10 lamps, 7 fans, 4 radios, 4 televisions, 1 rice cooker, 1 computer and 1 printer. Table 1 shows the details of electrical appliances, including power load (watt), number of electrical appliances used and duration of use (hours).

Table 1. Electricity consumption/hour in the case study

Appliances	Power Load (Watt)	Nos	Consumption (Hour)	Power Consumption (Watt/hr per day)	Power Consumption (Kilo-watt/hr per day)
Fluorescent Lamp	15	10	10	1500	1.500
Ceiling Fan	100	7	10	700	7.000
Radio	35	4	2	280	0.280
Rice Cooker	350	1	1	350	0.350
Television	60	4	5	1200	1.200
Desktop PC	250	1	8	2000	2.000
Printer	50	1	1	50	0.05
	Overall Total			12,380	12.38

From Table 1, it is found that the daily electricity consumption of the case study is 12.38 kW. The installation of a solar panel system for the case study involves the installation of photovoltaics (PV) panel system which is mounted on the roof, together with; solar batteries, inverter system and solar charge controllers. From the load consumed at 12.38 kW per day, it is then multiplied by 30 days (12.38 kW x 30 days) which is equivalent to 371.4 kW per month. In accordance with the electricity tariff regulations provided by Tenaga Nasional Berhad [2], every electricity tariff rate for a private building that exceeds 300 kWh per month should be rated under TNB Commercial Rate (Type B - Low Voltage Commercial Rate). In accordance with this rate, this case study will be charged MYR 43.50 cents per kWh for the first 200 kWh/month and MYR 50.90 cents per kWh for the next 201 kWh/monthly (Refer to Table 2).

Table 2. Monthly electricity bill

Electricity Rate (Based on TNB Electricity Tariff – Type B - Commercial)	Total to Be Paid (MYR)
Electricity Consumption/kWh (12.38 x 30 days)	371.4 kWh
○ The first 200 kWh	MYR 0.44 x 200 kWh = MYR 88.00
○ 201 kWh – onwards	MYR 0.51 x 171.4 kWh = MYR 87.42
Total:	MYR 175.42

Based on Table 2, the management of this institution has to pay MYR 175.42 for the monthly electricity bill. Even though the amount is considered small for a charity home, it is still able to affect the financial condition of this charity home. They still have to depend on donations from the public. Therefore, the installation of solar panel systems is significant to ensure that energy savings can be achieved for this building through green resources

3.2. The analysis

At the beginning of this research, a PV system sizing were calculated and the specification is obtained (See Table 3). A 2-kWp PV system often used as a basic indicator for medium and small-scale buildings (Ahmad, Salleh, et al., 2019). In this research, the selected case study has a medium size building. A 2-kWp stand-alone solar PV system has been suggested for a 10 m^2 building roof with an efficiency of 20% to achieve a good peak of energy load. It was successfully installed on the roof of this charity home and connected to the storage battery, inverter and solar charge controller.

Table 3. PV system sizing and specification

A	Power Consumption	Detail	Remarks
i	Watt/day	12380	
ii	Total Watt-hours per day needed from the PV modules (x 1.3 energy lost in the system)	16094	
B	Sizing the PV Module		
i	Total Watt Peak Rating (*needed for PV panels to operate appliances)	4598.285714	Power Generation Factor Malaysia = 3.5
ii	Watt Module (Wp)	2000	
iii	The number of PV panels for the system	2.299142857	
iv	Actual Requirement (Equivalent module needed)	3	

Parameter	Specification
Size of the system	2 kWp
Energy Demand (During Peak Hours)	2.29 kWh
Peak Solar Hour (PSH)	11 am - 2 pm (4 hour)
System Efficiency (%)	85%
Depth of Discharge (%)	60% (for 3 days)
Battery (Volt)	12 Volt
Battery Nos	5
Total of Ampere/Hour	150 Ah

It supplements the power supply to both buildings, with no connection to the existing TNB national grid. This is to avoid any disruption to the existing power supply. It also takes into account that the energy supplied by this system will be maximized with the help of a storage battery.

4. The Findings

Through previous researchers, it was found that the 2-kWp solar panel system could generate 10 kWh of electricity per day [4]. This equates to 300 kWh of electricity per month. This is obtained by calculating = 10 kWh x 30 days which is equivalent to 300 kWh per month. Table 4 compares the cost of the monthly electricity bill before the solar PV installation and the saving gained for the monthly

electricity bill after the installation of the solar PV system.

Table 4. PV system sizing and specification

Electricity Tariff (From Malaysian Tenaga Nasional Berhad TNB)	Total (MYR) (Before Solar PV Installation)	Saving (MYR) (After Solar PV Installation)
First 200 kWh	MYR 0.44 x 200 kWh = MYR 88.00	371.4 kWh – 300 kWh = 71.4 kWh
201 kWh and above The Remaining Power kWh	MYR 0.51 x 171.4 kWh = MYR 87.42	0.44 x 71.4 kWh
Amount to be paid (MYR)/monthly:	175.42	31.42

Table 4 shows that after the installation of solar panels, the management of the institution only has to pay MYR 31.42 for the electricity bill with a saving of 70% from the previous bill. This reflects a positive impact in using solar-generated electricity and will encourage the use of sustainable energy. A survey has been done in identifying the actual installation cost collected from the community-based approach (CBA) program through donations (mentioned in Section 3) and two (2) local solar contractors in Perak for a 2-kWp PV system (See Table 5). With the overall cost of MYR 5000, the PV system installation at the case study has been conducted with the aid of researchers, technologists and volunteers and the return on investment (ROI) for this project has been achieved in only 2.9 years with the overall cost of MYR 5000 (See Table 6). This cost is lower than the cost provided by contractors.

Table 5. Comparison of cost

	CBA Program (self-buy)	Local Contractor 1* (MYR)	Local Contractor 2* (MYR)
2 kWp PV System	MYR 2000	Lump Sun	Lump Sum
Inverter	MYR 350	-	-
Battery	MYR 2600	-	-
Solar Charger Controller	MYR 50	-	-
TOTAL:	MYR 5000	MYR 8000	MYR 10000

Table 6. Return of Investment (ROI)

Item	Overall Cost (MYR) (Before the Installation)	Saving (MYR) (After the Installation)
Amount to be paid/monthly	MYR 175.42	MYR 31.42 *(Revenue: MYR 175.42 – MYR 31.42 = MYR 144)
ROI: The Cost of the System/Monthly Cost		RM 5000 / RM 144 = 35 months = 2.9 years

5. Conclusion

Based on the research that has been conducted, it is found that an action-based methodology approach enables the realization of community-based projects to provide sustainable electricity to those in need,

even though the system is considered expensive. The analysis of this study has identified that private charity homes can save the monthly electricity bill by up to 70%, if the electricity is generated from 2-kWp solar panels, in consideration with the types of appliances in that building. This energy can be shared locally through a Community-Based Approach (CBA) program with a return of investment (ROI) of 2.9 years. It is recommended for the Government of Malaysia to provide holistic financial assistance to local communities in order to ensure that all communities are able to experience self-sufficient and sustainable electricity from solar energy. Future studies involving the development of green technology at the micro (rural) level will be needed, which will involve the dissemination of knowledge within local communities involving the use of Malaysian FIT or NEM energy schemes.

Conflict of Interest

The authors declare no conflict of interest.

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