Establishing Solar Village Communities in Malaysia towards a Self-Sufficient Electricity Lifestyle: The Feasibility Study

Nur Azfahani Ahmad, Asmalia Che Ahmad, Hugh Byrd, Nur Huzeima Hussain

Abstract: The application of solar PV in rural Malaysia, especially for the village communities are still at its early stages due to the system's high cost and limited access on the technology. Moreover, the widespread access to conventional electricity generated from fossil fuels resulted in greater dependent on electricity and the appliances that it powers. The situation has now changed as the resources to produce electricity cannot be sustained and may create energy insecurity issue in the near future. This paper will try to identify whether solar PVs can practically supplement the grid electricity supply to rural communities towards establishing a more self-sufficient electricity lifestyles. The objective of this study is to allow village communities to gain benefit from this technology. Through a case study and feasibility study, the potential of supplementing households' electricity needs are identified. It is found that through Community-Based Approach mechanism, village communities can have the opportunity to access solar electricity and become resilient if there will be any energy insecurity issues in the future.

Keywords: Community-based approach, photovoltaic, solar electricity, self-sufficient electricity, rural communities.

I. INTRODUCTION

Malaysia dependency on fossil fuels as the electricity generation resources has resulted in a little progress on renewable energy development [1]. In 2012, renewable energy supplies less than 1% to Malaysian energy mix[2].Even though, there is a gradual progress in the renewable energy use in 2016, especially in solar energy development, the RE energy use is still limited in rural areas [3].

With the limited capacity of oil reserves in the near future[4-6], Malaysia has started to expand its renewable energy sectors for energy and electricity generation[4]. This situation has gradually changeafter2000, with the commencing of Malaysia Fifth Fuel Policy [5, 7] that aims to enhance the renewable energy development, particularly solar energy in the country. However, the central argument in this study is there has been little recognition for solar energy technology due to the subsidized electricity costs and expensive costs of PV systems[3, 4]. Rural communities with limited financial resources cannot afford to access this technology [8, 9].

There will be a major issue for the rural communities if there are massive power outage that may caused energy insecurity, like previous cases happened in many Asian countries [10-12]. Therefore, efforts need to be made in order to allow village communities in Malaysia to have the opportunity to access solar electricity and become resilient if there will be any energy insecurity issues in the future.

II. THE BACKGROUND STUDY

In 2012, the targeted RE mix quota (5%) that set by the Government of Malaysia was unable to be achieved since only 0.3% of the quota managed to be fulfilled[2, 13]. Thisimplies that the RE-based electricity in Malaysia still have a long way in progress. There are two main obstacles that hinder the national target.

Firstly, the cost of conventional electricity is 10 times cheaper than the renewable-based electricity [1, 14-16]. The cost of national electricity tariff is MYR 0.218/kWh;which is cheaper than the capital cost for the installation of PV system [17]. This may discourage rural communities from installing the technology.

Secondly, lack of funding access that can help rural people to invest in this technology. At the moment, the cost of PV panels for 1 kW PV system is from MYR 15,000.00 to MYR 20, 000.00 [18-20] which implies that only high-income groups can afford to pay this cost. Therefore, there is a need to identify strategies that can establish special subsidies, loans or scheme for the medium- and low-income groups to invest in this technology. One of the strategies is through the 'community-based approach' mechanism.

Community-based approach

The idea of 'community-based approach' in implementing a solar community project has been supported by several researchers[21-23]. 'Community-based approach' can be defined as an approach that integrates local in the same community, from individuals to the whole community [24] and identified the group that share common background and interests, which forms a shared goals[24]. Through this approach, it can establish a co-operative project for generating electricity by using solar energy. Examples from other

Revised Manuscript Received on March 08, 2019.

Nur Azfahani Ahmad, Faculty of Architecture, Planning and Surveying, UniversitiTeknologi MARA, Perak Branch, 32610, Seri Iskandar, Perak, Malaysia,

Asmalia Che Ahmad, Faculty of Architecture, Planning and Surveying, UniversitiTeknologi MARA, Perak Branch, 32610, Seri Iskandar, Perak, Malaysia, Green Safe Cities Research Group, UniversitiTeknologi MARA, Shah Alam Campus, 40450, Selangor, Malaysia .

Hugh Byrd, Unitec Institute of Technology, Private Bag 92025, Victoria Street West, Auckland, New Zealand.

Nur Huzeima Hussain, Faculty of Architecture, Planning and Surveying, UniversitiTeknologi MARA, Perak Branch, 32610, Seri Iskandar, Perak, Malaysia.

*Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication*

successful projects like in the UK [25], Japan [26] and Canada [27] have proven that through community involvement, the residents with limited financial resources can have access to the solar energy facilities by sharing with other community members with higher income [23].

Using this approach, the electricity generated from solar PV panel is fed into the grid system in a community by a specific user as the 'generator' (building with PVs). The people(with no PVs) can purchases the electricity from the PV generator directly so they could receive free electricity so long as the generator pays for the cable hire[28]. However, this method is not resilience in the event of a power outage, since distributed generation cannot be shared if it relies on a grid that is not powered by electricity.

Other method is by establishing micro-grids carrying electricity generated by PV panels. In a community, the PV generators can feed in or take from an independent grid at a tariff agreed within the community. This has been simplified by low-cost pre-pay electricity meters[29]. This can create a self-sufficient community grid in villages and it is also significant to help poor people in the community to access the technology.

This approach can be linked with public building in the community like school, public clinic, mosque and town hall that can be installed with solar PVs[3]. The village leader can act as a focal person to manage the distribution of energy in one shared facilities[9]. This is cost-effective for the community since the installation cost can be shared by many.

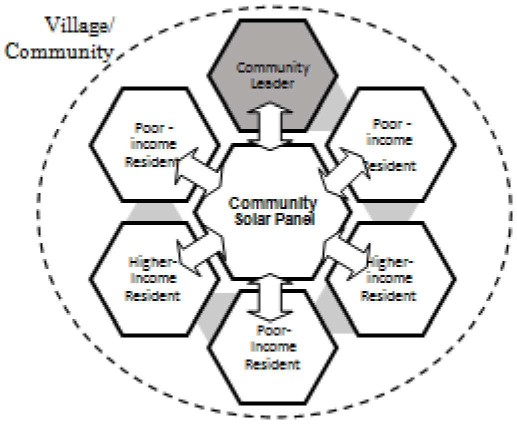

Fig. 1 The concept of 'community-based approach' for a solar-sharing project (author's illustration)

The Case Study

The purpose of the case study is to introduce the idea of a community grid within small rural villages that can exploit excess electricity by sharing it through the community neighborhood. Since not all households can afford a PV system[30], community buildings in the case study may be used for generating, storing and distributing electricity. A case study analysis has been based on data obtained through field research (site visits and observation) in order to collect in-depth information on the potential of introducing solar community projects for rural villages.

Kampung Sawah Dato' Mersing in Johore, Malaysia has been chosen as the case study for this research. This village represents the typical coastal village setting in Malaysia.

Among the setbacks in establishing solar community in rural Malaysia is the lack of financial capability, information and awareness among the people [9, 18, 31]. However, the highest potential that Malaysian rural villages have is the huge roof area with slopes that are typically less than 20°, which is widely known to receive good solar irradiation [32]. If effort can be made to fully utilize the roof areas of buildings from this village for solar PVs, a successful solar village can be established.

The roof potential

In this village, the public facilities include a mosque and a public school. The roof form in this area is a typical gabled roof, with over 100 residents in the village. For all orientations of roofs which generally have a slope of less than 30^o, the efficiency of the solar panels will be at 95%[33] indicating a good potential to receive solar irradiation. The typical roof shapes of houses of this village are shown in Figure 2.

Fig. 2 The typical roof shapes found in the case study (for houses and public buildings in the community)

In general, the roof areas needed for installing a 2 kWp panel system in Malaysia is only 13 m^2[3, 34]. This requires only 10% of the average roof area of public buildings in the case study (overall roof area is 130 m^2). This is a feasible and economic size for both buildings. However, this is depends on the power needed for the community.

Public buildings in the area (e.g. school and mosque)have the potential to supply the solar generated electricity from their panels and acts as electricity storage for the community. Researchers have mentioned that a 20 kWp PV system is feasible for large capacity building like mosque and school buildings [35, 36]. With the aid of batteries, it can be an energy storage device, which can store electricity power and connects into a plug to the power source that known as the charging station. The buildings may act as a charging station which allow nearby villagers to access the electricity from a community shared-PV. The concept is illustrated in Figure 3.

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

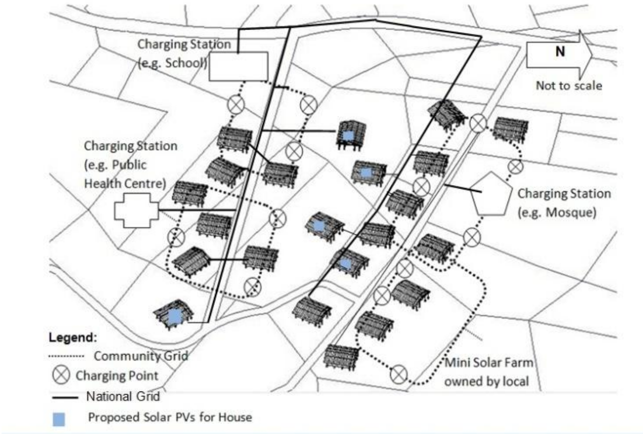

Fig. 3 The illustration concept of the 'Solar Village' (author's PhD research)

Load profile data

In identifying sufficient electricity produced for the villagers, a load profile analysis is presented. Through Figure 3, it is identify that mosque and school can install PV systems and acts as the charging station, whilst the application of batteries into the system allows for storage of solar electricity that can be utilised at night time or during blackouts.

The data were assessed based on 24-hour duration. Differences in the data were affected due to the function of buildings. For school, the electricity is consumed mostly during the day. The mosque only uses electricity during prayers' time. The types of electrical appliances used in the building are also different. For school, the load supply is needed for lighting and fans in class rooms, lighting and fans for the computer lab, lighting, photocopier machine for teacher's room and library with the operation hours are from 7 am to 6 pm (with 2 sessions; 7 am – 12 pm and 1 pm – 6 pm).For mosque, the operation hours are based on 5 times of Muslim prayers, which are (i) early in the morning (dawn) (5 – 6 am), (ii) afternoon (1 - 2 pm), (iii) after afternoon (4 - 5 pm), (iv) early evening (dusk) (7 - 8 pm)and (v) night (8 – 9 pm). The appliances are also limited to lighting, fan and public address (P.A) system only. Table 1 presented the load profile of electricity for both buildings.

Table. 1 Load profile data for school and mosque

Appliances	School			
	Standard Load (Watts) from TNB	Quantity	Daily average usage (h)	kWh/ daily
Photocopier Machine	600	1	2	1.2
Facsimile Machine	100	1	2	0.2
Personal Computer (Teacher)	130	15	10	19.5
Personal Computer (Computer Lab)	130	30	2	7.8
Modem	20	1	10	0.2
Inkjet Printer	50	3	2	0.3
Television	200	1	1	0.2
Ceiling Fan	120	25	7	21
Fluorescent Lights	30	130	1	3.9
Fluorescent Lights (For Night time)	30	10	13	3.9
Electric Kettle (For Teachers' Pantry)	1400	1	1	1.4
Air-Conditioning System	750	3	10	22.5
Appliances	Mosque			
	Standard Load (Watts) from TNB	Quantity	Daily average usage (h)	kWh/ daily
Air-Conditioning System	750	3	10	
Ceiling Fan	120	1	8	0.96
Fluorescent Lights	30	11	8	2.64
Fluorescent Lights (Night-Time)	30	2	10	0.6
P. A. System	150	1	5	0.75
Total load (kWh/day)				87.05

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

With the total load for both buildings are 87.05 kWh per day, it is estimated that the power needed for both building are only 2611 kWh per month; indicating a huge potential if a 20 kWp PV system is installed on the building's roof.

The power generation analysis

This section will analyse the potential of electricity generated from the solar PV system installed on the mosque's and school's roof. The mosque and school are the most significant buildings in supplying electricity because the total demand for electricity for both building is minimum (only 1/3rd) compared to the people's houses of the community and the electricity generation will be consistent throughout a 7 day period since the time of operation are predicted.

Using the information in Table 1, the electricity generated from PV panels of the mosque and school is calculated and presented in Figure 4. It is shown that the load used for both buildings is only 1/3rd (colored line) compared to the overall power generated from a 20 kWp PV system (black line).

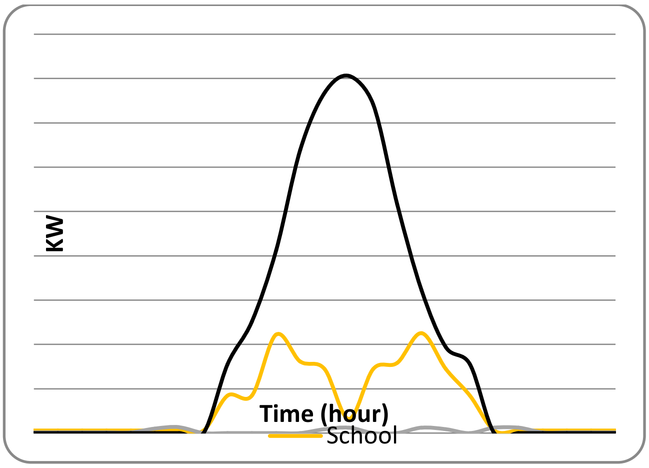

Fig. 4 The electricity generated from a 20kWp PV system VS power demand from school and mosque.

Figure 4 indicates a significant contribution of the electricity generated from PV panels of both buildings in the village between 7 am to 7 pm, which can be identified as a zone of time for the self-sufficient electricity period. However, in order for the community to establish a 'solar village', the amount of electricity generated during this time-zoneneed to be stable and consistent especially during cloudy or monsoon season. Therefore, both buildings need to have sufficient battery banks to restore excess energies from PV panels.

The 'solar village' novelty

Definitely, the significant way for sharing this energy is to set up charging points along the street (just like electric vehicle (EV) charging ports) so that houses can reach these points with extension cables rather than moving batteries.

Existing electric pole can be used to establish charging points and this can be rented from the main utility; Tenaga NasionalBerhad. The charging station would be community owned, may be lead by the village leaders, the head master (for school) or the mosque leader (for mosque). Since these buildings are centrally located, the villagers can access the energy easily by using extension cables. It would be better if the power distributed was in Alternating Current (AC) circuit, in order to allow this charging station to be cost-effective, to reduce distribution losses and to prevent the cost of expensive inverters.

III. CONCLUSION

The analysis from this study has identified that the community can share the electricity that generates from the public buildings in the area, since the roof areas of public buildings are usually wider. It indicates a huge potential in receiving abundant solar irradiation which can be shared locally through a 'community-based approach'. Through this approach, a public building can act as a charging station where all energies generated from PV panel systems will be stored locally in the battery banks of the buildings. The villagers can used the power through the extension of outlet hub for lighting or other electrical appliances of their houses.

IV. ACKNOWLEDGEMENT

Highest gratitude to UniversitiTeknologi MARA (UiTM), Malaysia and Ministry of Higher Education, Malaysia for the PhD scholarship given to further this research.

REFERENCES

1. Shafie, S.M., et al., Current energy usage and sustainable energy in Malaysia: A review. Renewable and Sustainable Energy Reviews, 2011. 15(9): p. 4370-4377.
2. KeTTHA, National Energy Balance 2011 Malaysia, G.T.a.W. Ministry of Energy, Editor 2012, KeTTHA: Kuala Lumpur. p. 65.
3. Ahmad, N.A., et al., Solar Village in Malaysia – A Route Map for Financing Mechanism. MATEC Web Conf., 2016. 66: p. 00057.
4. Alam, S.S., et al., A Survey on Renewable Energy Development in Malaysia: Current Status, Problems and Prospects. 2016. 17(1): p. 5.
5. Kardooni, R., S.B. Yusoff, and F.B. Kari, Barriers to Renewable Energy Development: Five Fuel Policy in Malaysia. Energy & Environment, 2015. 26(8): p. 1353-1361.
6. Selamat, S., and A. Abidin, C. Z, Renewable Energy and Kyoto Protocol: Adoption in Malaysia. 2010.
7. Jalal, T.S. and P. Bodger. National Energy Policies and the electricity sector in Malaysia. in Energy and Environment, 2009. ICEE 2009. 3rd International Conference 2009.
8. Ahmad, N.A. and H. Byrd. Power from the People: The Empowerment of Distributed Generation of Solar Electricity for Rural Communities in Malaysia. in The Asian Conference on Sustainability, Energy and the Environment 2013. 2013. Osaka, Japan: ACSEE.
   Ahmad, N.A. and H. Byrd, Empowering Distributed Solar PV Energy For Malaysian Rural Housing: Towards Energy Security And Equitability Of Rural Communities. International Journal of Renewable Energy Development (IJRED), 2013. 2(1): p. 59-68.
9. Matthewman, S. and H. Byrd, Blackouts: a sociology of electrical power failure Social Space (Przestrzeń Społeczna), 2014.
10. Epstein, J., Thailand Suffers Power Outage, Leading Many to Question What Happened to Its Power Protection Plan, in Power Protection2013, Technology Marketing Corp: US. p. 3.
11. Romero, J.J., Blackouts illuminate India's power problems. IEEE Spectrum, 2012. 49(10): p. 11-12.
12. Oh, T.H., S.Y. Pang, and S.C. Chua, Energy policy and alternative energy in Malaysia: Issues and challenges for sustainable growth. Renewable and Sustainable Energy Reviews, 2010. 14(4): p. 1241-1252.

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

13. Byrd, H., The Potential of PVs In Developing Countries: Maintaining An Equitable Society In The Face Of Fossil Fuel Depletion, in International Conference on Environment 2010, USM, Editor 2010, USM: Penang.
14. Rahman Mohamed, A. and K.T. Lee, Energy for sustainable development in Malaysia: Energy policy and alternative energy. Energy Policy, 2006. 34(15): p. 2388-2397.
15. Fayaz, H., et al. Solar energy policy: Malaysia vs developed countries. in Clean Energy and Technology (CET), 2011 IEEE First Conference 2011.
16. TNB. Pricing and Tariff. 2016 [cited 2016 2 Sept]; Available from: http://www.tnb.com.my/residential/pricing-tariffs.
17. Muhammad-Sukki, F., et al., An evaluation of the installation of solar photovoltaic in residential houses in Malaysia: Past, present, and future. Energy Policy, 2011. 39(12): p. 7975-7987.
18. Bosch Energy, Bosch Solar Energy AG Solar Panel Price, 2010.
19. MBIPV. PV System Cost. 2011; Available from: http://www.mbipv.net.my/content.asp?zoneid=4&categoryid=12.
20. Brumback, E., Utility co-op offers community-based approach to access solar energy, in MiBiz2013: Michigan.
21. Musall, F.D. and O. Kuik, Local acceptance of renewable energy—A case study from southeast Germany. Energy Policy, 2011. 39(6): p. 3252-3260.
22. Iler, S., Assessing The Potential For Community Solar in Durham, North Carolina in the Nicholas School of the Environment2012, Duke University: North Carolina.
23. Frame, D., et al. A community based approach for sustainable off-grid PV systems in developing countries. in Power and Energy Society General Meeting, 2011 IEEE. 2011.
24. Westmill. Westmill Solar Coop. 2013 [cited 2014 19 Feb 2014]; Available from: http://www.westmillsolar.coop/.
25. JFS. Japanese NPO Starts Residential Solar Co-Ownership Project. Energy 2012; Available from: http://www.japanfs.org/en/pages/031892.html.
26. SolarShare. Invest in a Brighter Future. 2013 [cited 2014 19 Feb 2014]; Available from: http://www.solarbonds.ca/.
27. Martinot, E., No Rooftop Left Behind, in Solar Journal2014: UK.
28. PowerGen. Micro Grids. 2014 17/7/2014]; Available from: http://powergen-renewable-energy.com/micro-grids/.
29. UBBL, Uniform Building By-laws, 1984 [G.N. 5178/85] (as at 10th November 1994). 1994, Kuala Lumpur: International Law Book Services,
30. Legal Research Board of Malaysia,.
31. Haw, L.C., K. Sopian, and Y. Sulaiman. Public Response to Residential Building Integrated
32. Photovoltaic System (BIPV) in Kuala Lumpur Urban Area. in the 4th IASME / WSEAS International Conference on ENERGY & ENVIRONMENT (EE'09). 2009. Cambridge, UK.
33. Ahmad, N.A. and H. Byrd. Photovoltaics in Malaysia: Challenges and Strategies Towards Resilient Rural Areas in Malaysia. in International Malaysia-Auckland Research Conference (iMARCA 2012). 2012. Auckland: The University of Auckland.
34. Fadzil, S.F.S. and H. Byrd, Energy and Building Control Systems in The Tropics. 2012, Penang, Malaysia: USM.
35. HSM. How to Make Money From Home Solar Energy 2013 [cited 9 Dec 2013; Available from: http://www.homesolarmalaysia.com/.
36. EcoDirect. 4000 Watt Micro Inverter Solar Panel Kit. 2014 14/07/2014]; Available from: http://www.ecodirect.com/4kW-Micro-Inverter-Solar-Panel-Kit-p/eco-4000w-micro.htm.
37. Mahmud, A.M. Evaluation of the solar hybrid system for rural schools in Sabah, Malaysia. in Power and Energy (PECon), 2010 IEEE International Conference on. 2010.