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Potential of Solar PV System in the Sustainable Empowerment of Rural Communities in Sarawak Malaysia

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ABSTRACT: Malaysia has introduced solar PV electrification to provide electricity to some deprived rural communities that cannot access the national grid. The government plans to explore renewable energy sources to generate electricity, under which Sarawak Energy has undertaken a solar electrification system to satisfy the demand for electricity in the rural communities in the state of Sarawak. These communities were using their generators due to the impracticability of connecting them to the conventional grid. To gather relevant information, a qualitative analysis approach and case study method were adopted to look at the potential social and economic impact of the Solar PV project on the rural people. Apart from the variations in the social and economic impacts of the project, the solar PV system is revealed as an ideal energy alternative for rural communities in Sarawak. The study found that the solar system in the communities brought more quality of life to the people. Moreover, the lights provided enhanced their economic lives as most people are engaged in petty trade, the selling of their produce, and improved the education of children in the remote areas. The level of energy provided makes it possible to extend their buying and selling activities into the night, which boosts their income level. The involvement of the people in solar electrification and the availability of electricity reduced the tendency of the youth to migrate to the urban centres. Potential of Solar PV System in the sustainable empowerment of rural communities in Sarawak, Malaysia. It is novel since the communities that were once using their generators due to the impracticability of connecting them to the conventional grid can now rely on solar PV system.

INTRODUCTION

The use of renewable energy has been recommended by the United Nations as such countries are encouraged to embrace new technologies including solar Photovoltaic PV or solar home systems on a large scale. Graziano and Gillingham, (2015) explained the core concerns about the community utilization of solar PV systems through a panel data analysis that revealed the impacts of the built environment, demographic variables, social, economic, and political related variables on the usage of solar PV systems. Energy plays a crucial role in human development as well as national economic development in fields like health and sanitation, education, and the provision of potable water. In corroboration, Smit, Musango, and Brent (2019) found energy as an integral part of development and the improvement of gender equity, eradication of poverty, improved healthcare delivery, and climate change. Other authors revealed that there are about a billion people without any means to modern sources of energy, with the majority from rural areas (Aklin, Bayer, Harish, & Urpelainen, 2017). To ensure development and empowerment, the UN Sustainable Energy for All SE4ALL expects 70% of rural areas to get new connections through microgrid construction by 2030 (World Bank, 2014; Aklin et al., 2017). Efforts to empower the people at national level include but are not limited to the Fifth Fuel Diversification Strategy, the 2010 energy policy, the Tenth Malaysian Plan from 2011 to 2015, the authority responsible for the development of sustainable

energy (Sustainable Energy Development Authority) and recently Eleventh Malaysia plan (2016-2020) were instances of the government policies and efforts to encourage the development and adoption of renewable energy as an alternative source (Florez, & Ghazali, 2020), thus include solar PV systems.

The most rapidly developing country in the ASEAN next to Singapore is Malaysia with energy consumption rate of 5.6% and was expected to reach approximately 39 million tonnes of oil equivalent Mtoe as of 2005 (Petinrin, & Shaaban, 2015; Borhanazad, Mekhilef, Saidur, & Boroumandjazi, 2013). The demand for electricity in the country increased from 7685-kilo tonnes of oil equivalent (ktoe) (89,377 GWh) in 2007 to 9235 ktoe (107,403 GWh) as of 2011 and 10,011 ktoe (116,428 GWh) as of 2012 (Borhanazad et al., 2013). With an 8.1% growth rate per year, the final energy demand in the country is estimated to hit 116Mtoe by the year 2030 (Hosseini, & Wahid, 2012; Petinrin, & Shaaban, 2015). According to Chong et al. (2015), renewable energy as the source of electricity in residential areas is prominently captured in the Eleventh Malaysia Plan and by the authority (SEDA) responsible for sustainable energy development in the country. The people benefit a lot socially and economically from rural electrification. Based on global standards, Malaysia is believed to have several folds of solar power than the global fossil fuel endowment (Borhanazad et al., 2013; Azhari, Sopian, Zaharim, & Al Ghoul, 2008). The daily amount of solar radiation in the country is said to be 0.6 kWh/m2 in December and about 7k Wh/m2 during the period of August and November. The greater amount of solar radiation in some places in east Malaysia is 3 kWh/m2 throughout the year which is more than the average (Borhanazad et al., 2013). It is revealed that solar panels of about a square meter in the country can lead to the reduction of 40kg of CO2 per year (Sovacool, & Drupady, 2011; Borhanazad et al., 2013). According to Borhanazad et al. (2013), solar energy per day is found to be around 4.3 kWh/ m2 and 5.3 kWh/m2 in Sabah, while that of Sarawak, Kedah, Perlis is estimated at 5kWh/m2, 5.5 kWh/m2, and 5.3 kWh/m2, respectively. In terms of solar radiation, Sabah and Kedah have about 5.4 and 6 kWh/m2/d, with the potential to generate 1,465 and 1,509 kWh/kWp annually, respectively. This implies that the potential for Malaysia to adopt solar energy for electrification is enormous (Mekhilef, Safari, Mustaffa, Saidur, Omar, & Younis, 2012; Borhanazad et al., 2013). Recent studies put Malaysia's monthly average solar radiation as 4000 - 5000 Wh/m2 and solar energy between 4 and 8 h, approximately 2200 h of sunshine per annum (Mohammad, Al-Kayiem, Aurybi, & Khlief, 2020). As such, solar energy is being considered by the government as a significant alternative source of electrification in the country. Borhanazad et al. (2013) peak daily solar radiation in Malaysia is around 5.3 kWh/m2 in Sarawak, making solar energy a potential source for electrification.

The solar system projects in the state include the Sarawak Alternative Rural Electrification Scheme SARES as captured in the National Blue Ocean Strategy NBOS in partnership with the government departments and agencies in the country. It is designed for clusters of rural communities and longhouses in remote areas without access to the national grid currently (Khengwee, et al., 2017; Lau, et al., 2010). The rural communities are put into three categories under the Rural Power Supply Programmes. Category one is unelectrified villages that are grid connectible constitute 340 villages with households of 6498. The second category constitutes villages that are grid possible but need access are 881 villages with households of 17,385. The third category is the remote and not grid connectible is 402 with households of 12,482 (Syed Mohammed 2017). For instance, uninterrupted electricity is made available by the SARES system to enable the people in those residential areas to use electrical gadgets. Besides, Sarawak Energy also initiated Solar Home System SHS as part of the corporate social responsibility of Sarawak Energy. To complement the SHS of the communities, Sarawak Energy added a Solar Freezer System (SFS) which enables the community to freeze fresh foods in a community refrigerator otherwise dubbed communal refrigeration. Apart from the new technology being considered green and sustainable, it is also viewed as the best solution for remote areas inaccessible to the grid. The projects (RPSS, SHS, and SARES) implementation is community-based and makes electricity accessible to rural areas that cannot get connected due to remoteness and the huge infrastructure costs involved (Khengwee, et al., 2017; Wong, & Chai, 2012). The solar-powered home system reduces operational and maintenance costs since people no longer depend on diesel/petrol-powered generators. Hence, the monthly household expenditure is reduced.

The study is generally designed to explore and identify the potential obstacles that may affect the smooth execution of rural electrification programmes in these remote areas in Sarawak. The solar systems under these projects (Solar Home System SHS and Sarawak Alternative Rural Electrification Scheme SARES) are operated and monitored by the people in those communities without much external support and periodic maintenance by the providers. Specifically, the paper looks at the socioeconomic empowerment potential of Solar PV electricity in local communities in Sarawak, Malaysia. The absence of electricity in a community may make the rural communities vulnerable, especially where most of them engage in petty trade of perishable items. They tend to suffer more in situations of energy poverty, considering the hindrances or bottlenecks to their development, like the several household chores and daily domestic workload. Besides, the safety of women at night is often compromised in the absence of electricity; therefore, provision of solar lights might be a major boost to halt the consequences on women, especially in rural communities.

LITERATURE REVIEW

This section provides a relevant review of off-grid electrification in Malaysia and the electrification process in Sarawak, the study site.

1. Off-grid electrification in Malaysia

The national grids provide the foundation of electrification initiatives, but it is sometimes not feasible and expensive to expand them to isolated and remote rural villages. Attaining sustainable and equitable access to energy presents both social and technological obstacles. Despite these challenges, Peninsular Malaysia's electrification rate is nearly 100% achievement. For example, micro-hydropower has previously been shown to be a workable and possibly inexpensive solution for producing electricity in remote locations. A reconnaissance study conducted in West Malaysia revealed 109 MHP locations with a combined potential power output of 20,400 kW and filtration algorithms to identify the top 100 optimal Solar Energy Sites (SES) (Jong, & Ahmed, 2024; Raman et al. 2009). The electrification process in Malaysia may be complicated due to its physical features like the deep woods, high mountains, and expansive archipelagos. According to Setyowati (2021), increasing urban-rural disparity and rapid growth intensify these issues. The geographical variation is greatly impacted, especially in rural and island areas, where infrastructure upkeep and expenses are high. A balanced range of technologies is available in Malaysia, as seen by the nearly equal number of projects that use hybrid, solar PV, and mini-hydropower (Wong et al., 2024). Malaysia employs microgrids for off-grid rural electricity in response to these problems. This explains why a thorough understanding of microgrids is important for off-grid rural electrification in the context of Malaysia. As of 2020, the ASEAN Centre for Energy reports that Malaysia's electrification rate was full (Muhammad & Beni 2022). The researcher observed that Malaysia's efforts to electrify the country through micro-hydropower may serve as an excellent example of the vital role that community involvement plays in empowering the populace. Through community involvement, women's changing roles in the socioeconomic aspects of energy projects are brought to light. Through this, the country addresses changes in social structures, cultural norms, and economic systems in line with cultural objectives in sustainable environments in addition to technology advancements in pursuit of energy access. A convincing instance of how energy projects may spur gender equality, community development, and socioeconomic transformation in addition to infrastructure improvements. For example, Malaysia offers a unique combination of opportunities and difficulties that are moulded by certain geographical and socioeconomic circumstances. As such, understanding these subtleties is essential to designing effective solutions that are also egalitarian and culturally sensitive. A recent study by Lias et al. (2024) revealed that solar PV is used in food processing for cleaning, drying, and milling. It is also used for automatically washing vegetables in the field, saving water and requiring no human intervention.

2. Electrification process in Sarawak

The frequency of technologies such as micro-hydropower and solar PV (photovoltaics), show patterns in installed capacity and economic viability in Malaysian rural electrification projects. Several programmes, including the Sarawak Alternative Rural Electrification Scheme (SARES) (Sarawak Energy 2024), has been implemented in rural parts of Sarawak. The country's evolving rural electrification environment, particularly in Sarawak, has exposed community-driven projects that offer chances for greater private sector involvement and bottom-up approaches. To guarantee that organizational and technological innovation provide insights into how to create value for society, stakeholder engagement—as demonstrated by SARES—is crucial (Bealt, & Shaw, 2024). Sabah Energy 2023 and Sarawak Energy 2024, for example, prioritize improving the quality and dependability of current grid connections for rural communities in the State. One essential component of sustainable development is having access to inexpensive, and dependable power. For instance, electricity is a key indicator of energy accessibility and a significant force behind socioeconomic advancement. As such, the state of Sarawak recognises the significance of energy and has made rural electricity a primary priority. SARES concentrates on providing isolated villages with power around the clock and serves as an example of how well government and community cooperation may work. Another initiative for rural electrification in Malaysia is the *Bekalan Elektrik Luar Bandar* (BELB) Program, which uses solar energy and grid extension in remote locations. The Electricity Supplies Industry Trust Account serves as the foundation for this project and focuses on improving supply systems' availability and consistency in addition to developing infrastructure (Ministry of Rural and Regional Development 2010). Through this off-grid project, carried out by Sarawak Energy and supported by the Sarawak Government, isolated homes were equipped with solar or micro-hydro systems. The success of the project was largely due to community training for operation and maintenance, which guaranteed long-term profitability and local ownership.

METHODOLOGY

To ensure a comprehensive analysis of a range of perspectives, the qualitative method was used. Both factual and meaningful levels of analysis are possible with a qualitative research approach. The primary data was collected through qualitative design and structured interview guide protocol to conduct the study over the course of July 2021–October 2021.

The population for this study was taken from the members of longhouses and service providers as key informants from the Lubok Antu District. The members of the longhouses were the target respondents. The researchers used a purposeful sampling technique to draw a sample of 20 respondents from the population and only those from the remote rural communities in Sarawak were captured. The interviews with the respondents were conducted in local languages which were later translated into English by a bilingual expert.

For data analysis, the researcher systematically identified the main elements from the interpretations. The thematic data analysis approach was used as a procedure to manage the information gathered from the interviewees from Lubok Antu. The information

gathered from the field was transcribed verbatim to facilitate data analysis. The cross-case qualitative thematic analysis was employed. Themes were generated from the information taken from the people of the longhouses to be cross-analyzed.

The description of the protocol was first discussed by the researchers for the research assistants to understand the content and expectations of the study. This process facilitated the information gathering by the researchers from the respondents.

The next was to review the interview protocol to extract phrases and sentences that have bearings on the research topic.

Thirdly, themes were generated from the discovered hidden meanings about the issues under investigation as contained in the protocols. Based on commonality, the themes were put into clusters to be compared and further categorized them. The recordings from the interview were reviewed again by researchers to ensure the appropriateness of the theme. The findings were put together in a descriptive way to discover the needed data.

RESULTS

The informants were asked how they think about solar PV electricity if it impacts their lives economically as well as the benefits that they gain from the supply of power from the solar PV system. Bacon and Kojima (2016) already found a strong relationship between the level of energy supply, rate of economic growth, and eradication of poverty. The current study focuses on solar energy because it is believed to be readily available, stable, and has the potential to provide for the increasing need for electricity in rural communities across the country. The findings are put into two categories such as the social and economic impact of solar PV projects on the lives of the people. The themes generated to assess the social impact of solar include satisfaction with solar electricity, meeting energy needs, acquisition of socioeconomic skills, and effects on children's education.

Improves education of children

Children in communities without electricity will prefer to do their homework early in the day to avoid the use of candles or paraffin lighting at night to study even for short periods. The respondents indicated that solar energy provides an alternative source of electricity to meet the needs of school children thus affecting their education positively. The majority, especially, those whose children are still schooling found solar PV beneficial considering the length of time spent studying during night time. None of the respondents indicated negative effects of solar PV on children's education.

The interest in renewable energy technology is evident in these parts of Sarawak the organization of which is still in the early developmental stages. The households in the rural communities have limited capacity to bear the full cost of the technology suggesting that the sustainability of this alternative rural renewable energy must overcome certain economic obstacles. One respondent indicated that the development of the rural solar electricity project has led to greater economic impact as it creates many opportunities such as the ability of the people to save some money for other important things. Hence, the residents can be opened to other benefits to have extra savings and increase the quality of their livelihoods.

> "...can help reduce the financial burden such as adding more savings towards children school funds… apart from various benefits such as being more economical and environmentally friendly and also a good thing good facility to have." Respondent 4

Most of the informants indicated that solar PV is useful for their children's education as such it is financially beneficial to them.

Extended socio-economic activities

The study uses two different perspectives (social and economic) in explaining the potential benefits of solar lights for rural people. The people in the study area have a strong passion for innovative technology especially renewable energy technology as indicated in the enthusiasm shown towards the solar PV system. They seem to consider renewable energy in the area as part of the stages of their socioeconomic development. As indicated, the solar PV system served the long-households from fueling generators in paying the current prices for fuel. This will have been costly compared with solar energy technology considering the constant availability of solar radiation in the country. So, the sustainability and empowerment potential will mean rural renewable energy has to meet the series of socioeconomic needs of the people. The successful implementation could propel a robust initiative to use innovative renewable energy technology in the communities of rural Sarawak, Malaysia.

To get information on the economic impact, the income level of the household, distribution of family income, cost advantage over other forms of electricity, and improved economic activities considering solar PV electrification project policy implementation in the rural area. The study found evidence for social and economic benefits as respondents talked about savings, being able to meet household expenditures, business creation, saving and spending productive time, use of light for study by children as well as women empowerment. The expression of socioeconomic benefits of the solar PV system is an indication that the rural electrification intervention was a success.

> ...can provide benefits in terms of the use of electronics. with the availability of energy, we can engage in income generating activities which provide … with regular or irregular income through the sales of goods and sometimes … irrespective of the kind of business, its size or location. Respondent 2

Concerning the socioeconomic impact, how solar PV electricity benefits rural society in general has also been asked of the longhouse residents and each of them responded differently about its benefits. This is an indication of its immense contribution to the socioeconomic lives of the people. The connection of electricity has enhanced socialization, especially through other agents of socialisation like school, religion, and social media. Thus, it has strengthened the already existing strong knitted relation among the people in the longhouses and the community as a whole as they socialise in the homes of the head of the community or houses of prominent people. As part of maintaining the knitted relation and social bonds, families can support members either financially or in kind from the servings for paying less cost for electricity as well as from economic activities which are considered the foundation of social relations. The social relation relations and interaction with family members and friends at their social gatherings and during economic activities or engagements bring about a feeling of belongingness. One respondent shared that;

> "...enhanced closer social relations between the community and makes knowledge of solar energy technology available to many of us… it creates a social bond between residents who know the use of solar electricity." Respondent 3

The spare time made available due to the usage of electrical gadgets and services rather than manual, particularly for women, can make use of the spare time for home-based economic activities. The availability of electricity tends the people to establish new economic activities like investing in the use of electrical gadgets in new social and economic activities like shops to produce and sell fresh drinks, ice-cream, operating cold stores, and rural entertainment such as movies tents, and community TVs. Several factors such as type of job, income, size of household, and social standing seem to influence the energy needs of the people in most rural communities. Most of the respondents revealed that their varying energy needs are met by the electricity from solar PV. Most people use electricity for heating and cooking (rice cookers) even though the majority are reported using Liquified Petroleum Gas LPG in this regard to prepare family meals. The respondents suggested that where there is an extension in time of productive activities will bring about an increase in household earnings in addition to a low cost of electricity. As shared;

> none payment or knowing we don't have to pay any electricity bill that usually puts pressure on the family budget takes off the burden alone is … relief as it strongly contributes to the wellbeing of members … the family our wellbeing

Reduced tendency of youth migration

A comprehensive explanation has been provided on solar energy PV systems in the state of Sarawak focusing on what residents of longhouses may identify as social and economic benefits from the implementation of solar projects. It was clear from the respondents that the availability of electricity in the rural area brings a glimpse of hope of greater opportunities lack of which compels the youth to immigrate to seek greener pastures in towns and cities. The issues that appeared and might guarantee hope for the youth to stay in the hinterlands are numerous. The availability of jobs and employment security, good salaries, access to services from the public sectors in government departments, improved living conditions and exonerated mental threats from the uncertainty surrounding their economic well-being cannot be over-emphasized. A respondent shared that:

> the youth … university graduates will stay they may no longer move outside the community in search of work jobs and offer their skills as they are sure of better living and rewarding working conditions at home now that electricity is available.

It is worth noting that retention of the youth in rural areas can result in increased economic growth and development of the country. Besides, the dynamics and the prospects of solar energy as expressed by the respondents can be seen in the increasing satisfaction about the potential benefits of the energy supply, the state considering renewable energy as an alternative to serve their needs as well as improving the socioeconomic lives of the people. It can be said that electrification leads to the provision of employment opportunities for the teaming youth, social amenities like good healthcare facilities, and modern infrastructure like an effective and efficient internet connection for which most of the youth relocate to the cities and towns. Thus, maintain the best brain in the rural communities for sustainable development.

Complementary knowledge and skills

When asked about the economic benefits of solar PV systems to the residents in the longhouses at the household level, most of the respondents replied that they learned a lot of things about other sources of energy. Which according to them, helps to ease their financial burden in terms of paying for utility bills, service, and maintenance charges. The respondents compared the solar project to other sources of energy which adds to their knowledge of their environment. After comparison, they indicated that they can save some money by paying less for electricity bills with the presence of solar PV electricity and not paying any service charges since they do it by themselves. In explaining the benefits:

> ...longhouse residents do not have to pay for electric utilities…so the money served can be used school funds school expenditure house upkeep Respondent 3

Again, they considered the cost of fuel in running a personal generator. Most of the respondents preferred renewable energy (solar light) to different kinds of electrification systems or other alternatives. Solar energy is adopted due to the high cost of fuel as that could be the reason for the extensive maintenance cost associated with fuel-reliant generators. These are opinions expressed by the

respondents or the energy users as they believed that fuel-reliant generators are less reliable. Their responses also suggested their understanding that it is not possible to have electricity when one runs out of fuel and therefore considered renewable energy systems the most convenient for them. When the researchers asked the informants to express their opinions about shortages of energy, it was associated with renewable resources to ascertain or demonstrate electricity reliability. They indicated that there are not many energy shortages in the longhouse after the introduction of renewable energy in the area since energy output is determined by solar radiation. With this knowledge, respondents perceived renewable energy as reliable. More specifically, the majority of respondents believe PV systems to be reliable considering the possibility of it being able to be replenished. Such responses from respondents demonstrate technical knowledge acquired about how renewable energy systems can be considered in other rural and remote areas of the country as reliable sources of electricity that can meet their energy needs

In answering the question about how solar influenced their skill development ability aimed at its contribution to human capital capacity building, most of the respondents shared that it has a positive impact on their social and economic skills development. The Interviewees did not have any misgiven or expressed any negative influence instead were much about the skills acquired or developed after the implementation of the project. For its sustainability, respondents indicated that appropriate technological skill training on how to maintain those facilities was offered alongside the installation. Respondent Ten shared that:

> ...more savings in terms of electricity payments…we learn how to maintain, how to service and how to replace some of the component or parts that are worn-out or not functioning properly we are trained so the skill to do that is there we don't wait or we don't call the energy people to do it for us we do it ourselves

Create business opportunities

The respondents who are the key decision-makers in these communities regarded the solar PV systems in the residential areas as a blessing and did not have any problem in terms of any potential social or economic issues that might hinder the implementation of similar projects in other areas. They did not find any economic issues that can serve as barriers to the implementation of solar PV systems in the area. They believed the use of electrical gadgets and appliances could create opportunities. Respondent A shared that:

> for we can start to venture into… start the production and sell of fresh cold drinks start a business-like cold drink, ice-cream, you need lights … you need a continuous supply of… reliable electricity

There are different solar power technologies utilized to achieve rural sustainable electric power generation. As such, the appropriate kind of electricity and its availability can lead to the creation of trade in cold drinks like yogurt as well as provide photocopy and printing services to the local students, government departments, and offices. Many factors come into play in rural electrification interventions. The current rural electrification in most of the world including the study area focuses on solar photovoltaic (PV) and other renewable energy technologies as authorities consider the types, mechanisms, efficiency, and cost as indicated by some key informants. Information from the field suggests that solar PV electricity is commercially appropriate for both small- and large-scale applications in different economic activity models in the areas. For instance, it is found to be suitable for large-scale applications which people believe produce higher economic benefits. It is further revealed that the usage of solar power technology depends on specific conditions which implies merits and demerits as the rationale for its acceptance and adoption.

> "...contribute to a cleaner environment and help reduce the cost of living…" Respondent 10

Another respondent indicated that:

> "...reduce financial burden…this relief can be served can be used for … to start a trade or do business" Respondent 6

The responses from the field demonstrate the acceptance of solar power projects to economic liberation and empowerment in the rural communities in the country. This suggests that solar PV technology is considered an alternative source of energy that is beneficial, especially for social and economic activities. The Solar power technology based on solar power plants may be considered the most appropriate considering its user-friendliness and the largest source of energy for remote rural communities in the country. For instance, solar energy is used on a small scale like electrification of a few remote communities, powering of refrigerators and air-conditioners as well as street lights, solar heating, and others. These responses demonstrated the level at which technology has been accepted in the rural or local communities as a significant number of the people expressed the usefulness in terms of expansion in economic activities and production. The informants expressed how suitable it is for them at both (large scale) community-wide- and house-level (small scale) application.

DISCUSSION

The potential of solar PV projects in responding to the energy needs of remote communities in beneficial ways is undeniably clear from these findings. It can be said that the availability of energy is an integral part of development that can empower and improve rural lives and livelihoods. Issues in this case are related to poverty eradication, improved healthcare delivery, gender equality as well as climate change. Unfortunately, most rural communities do not have electricity because the cost involved in connecting the remote communities to the national electricity grid is high (Mahapatra, & Dasappa, 2012). These caused concerns about the rising costs of energy, concerns about quality environments, and sustainable rural electrification as factors that contributed to increased interest in renewable energy in countries across the globe. That explains why the Sustainable Development Goals SDGs emphasised

on sustainable and equitable developmental progress. It is emphasised in SDG7 the need to provide energy that is accessible across the globe considering its affordability, reliability, and sustainability in supply without leaving anyone out. Hence, the solar system project receiving greater acceptance across the globe. Studies have shown that solar photovoltaic PV has achieved international benchmarks by becoming a recommendable source of electricity to small businesses and households in rural communities (Zhang, 2014; Islam et al., 2017). The people in places where solar PV system is implemented demonstrate a high degree of satisfaction with solar PV electrification even though positive satisfaction varies among the communities as it depends on specific circumstances. For instance, apart from the absence of noticeable differences in attitudes among the respondents from the study area, there is also no sign of dissatisfaction among them which is an indication that solar PV systems could be replicated in other communities with similar circumstances of remoteness. The demonstration of acceptance suggests that solar energy has the potential to address the challenges of the provision of electricity to rural communities across the country. This was manifested in the way thoughts were expressed on how beneficial solar PV has been and therefore gave commendation that promotes the rural solar electrification projects as a viable venture. Several studies corroborate the importance of acceptance by emphasizing the way by which primary stakeholders who are considered as the end-users have accepted the solar PV technology (Heras-Saizarbitoria et al., 2011). For this level of successful adoption of solar power innovation and technology, it is accepted by members of the community as an alternative means of source of power.

The investigation is on renewable energy, particularly, solar PV systems which made electricity available to the rural communities in Sarawak for domestic use. As shown, remote rural life in Sarawak like other countries could be very challenging. In this sense, solar PV systems are relevant in terms of their prospect for rural electrification solutions for remote communities, particularly those in inaccessible areas of the hinterlands. Findings suggest that the electricity or energy generated has a direct connection with the global main instrument in rural poverty reduction, changes in the environment across the globe, as well as ensuring the issue of security in food supply the world faces today (Purohit et al., 2013; Khan & Arsalan, 2016). The people in these areas are often deprived of necessities of life like delivery of basic healthcare, supply of potable drinking water, and good roads apart from their high-risk involvement in crude farming and other socioeconomic activities. The significant role played by the rural duelers is echoed in the way foods and local commodities are produced for local and national consumption. They however constitute those who benefit less from the infrastructure and other socioeconomic enhancement amenities (Khengwee, et al., 2017). Ironically, the little developmental projects most of the time face sustainability challenges thus in the likelihood of any. To meet the developmental needs of all, the Malaysian government rolled out plans to provide sustainable energy for the residential buildings in rural communities including the longhouses of Sarawak. As indicated, residential consumers constitute about 7.5 million (Abdullah et al., 2019). The long hours of sunshine grant Malaysia a sustainable source of renewable energy supply through solar PV systems by using panels to convert sun energy into electricity to ensure the empowerment of the rural communities (Safari et al., 2020; Mekhilef, Barimani, Safari, & Salam, 2014; Amin, Lung, & Sopian, 2009). Riva et al. (2018) found that the time saved can be a source of empowerment as it allows for the setting up of income-generating activities over an extended period at the disposal of rural folks. Others also emphasis that access to electricity should be sustainable to guarantee activities and services, enhance educational activities, create business opportunities, and raise income levels in rural (Riva et al., 2018; Colombo et al. 2013).

The electricity demand is suggested to have increased proportionately to both the population and the rate of economic growth in most countries across the globe. It is argued that sustainable social and economic activities for empowerment are determined by the way energy is produced currently with emphasis on renewable sources (Khan, & Arsalan, 2016; Wilberforce et al., 2019). In this regard, solar PV system serves as a great source of electricity system that enhances the income and living standard of the people in rural areas. It also serves as a recreational and revenue mobilization source, and security system as well as supports children's education. Studies confirmed that rural electrification has the potential to improve educational attainment, and livelihood and boost the standards of living of the people (World Energy Outlook 2015; Aklin et al., 2017). In further corroboration, studies recognized that access to electricity can improve household income, educational attainment, access to both print and social media, and boost standards of living (Khan, & Arsalan, 2016; Ghaffour et al., 2015). Several agencies, organisations, and the government of Malaysia have taken renewable energy technology as a matter of commitment to the generation of sustainable energy in the country. Current studies suggest that the sustainability potential solar PV system of any country needs to consider significantly its technological viability, social acceptability, and economic competitiveness (Safari, Masseran, Jedi, Mat, Sopian, Bin Abdul Rahim, & Zaharim, 2020; Moula, Maula, Hamdy, Fang, Jung, & Lahdelma, 2013). For instance, several policies including the National Renewable Energy Policy 2010 were among the numerous initiatives the Malaysian government pursued to maintain sustainable resources for future generations. This is aimed at encouraging the citizens to consider renewable energy an alternative way to generate electricity that can offer a range of social and economic benefits through the expansion of domestic industry and work opportunities. Other renewable energy projects initiated include the Small Renewable Energy Power program and the Energy Efficiency Centre to support the renewable energy policy just to ensure the rural people are empowered.

The feasibility of renewable energy particularly solar PV is based on the comparison and analysis of the current solar electrification projects as an alternative source of electricity for the rural areas. Riva et al. (2018) revealed how access to electricity enhances energy-reliant income-generating activities in the rural communities. To guarantee sustainability and empowerment, the

applicability of these renewable energy technologies considers the practicability and replicability as well as the environmental and socioeconomic benefits to the people in the country. There are indications that similar projects can be implemented as alternative energy sources suitable for domestic use and economic activities in those communities. The effects and sustainability of electricity provided to rural communities through solar PV systems are demonstrations of efforts to decentralize rural electricity supply. Rural electrification may have positive implications like the growth of income-generating activities, saving time, facilitating educational activities, and enhanced healthcare delivery in those areas. Bacon and Kojima (2016) found a strong relationship between energy supply, poverty reduction, and socioeconomic growth especially in rural communities. In corroboration, studies indicated that other energy-driven services like computer centers, laundry services, hairdressers, photo studios, sawmills, welding shops, and rural entertainment like community TVs and cold stores for coastal areas are some potential sources of empowerment for rural people (Riva et al., 2018; Matinga & Annegarn 2013). The benefits of rural electrification through reliable and efficient energy supply for cooking, mechanical power, and telecommunication services are very significant. Access to energy seems to improve socioeconomic welfare considering the increase in productivity, booming businesses, and the automated processes that substitute manual work (Feron, 2016; Kaygusuz. 2012). Sustainable energy guarantees sustainable development as demonstrated by the United Nations UN in devoting goal number seven to sustainable energy emphasising affordability, reliability, and universal access to modern energy supply, especially solar PV systems (Feron, 2016).

The usage of any form of solar power technology depends on specific conditions which implies that all the forms of solar power technology have merits and demerits. Solar PV is observed to have been developed commercially and is suitable for large to small-scale applications. This is explained by several authors as the reason why it is rapidly taking over fossil fuel production at peak times daily and emphasising the high price of wholesale electricity (Channell et al., 2013; Foster, Contestabile, Blazquez, Manzano, Workman, & Shah, 2017; Yaqoot, Diwan, & Kandpal, 2016). For instance, the usage of PV systems varies from very small applications like one to ten watts from Solar Pico System SPS for lightning to replace kerosene lamps. It could also be a mid-scale solution usually with a capacity of 10 to 130- or 250-watt peak through the Solar Home System SHS installed in households in rural areas (Rolland, 2011; Feron, 2016). The SHS can supply energy to several lamps, radios, and TVs among others. The PV system technology which is suitable for large-scale applications is believed to produce higher economic returns. The study focuses on solar energy due to its availability, stability, and potential to provide for the increasing need for electricity across the globe (Khan, & Arsalan, 2016; Sharon, & Reddy, 2015). Riva et al. (2018) found positive effects of electrification on rural communities through the enhancement of income-generating activities and improvement in education and healthcare delivery. However, studies in the northern part of the country found cost or financial challenges as the major and sensitive obstacle that prevents the usage of solar energy among some rural populations (Hossain et al. 2014; Tasbirul Islam et al. 2019; Florez, & Ghazali, 2020).

CONCLUSION

Countries in the tropics receive a reasonable degree of solar radiation most of the year and therefore have the potential to produce solar energy to generate power in a significant manner. Sarawak Energy and other relevant bodies played important roles in installing solar PV systems for the residents of the longhouses in East Malaysia. As such, the acceptability of solar power technology in most communities may be due to its endless availability, environmental friendliness, and effectiveness. It is an open secret that most rural communities in developing countries remain without basic electricity due to the high cost of extending the electricity grid which makes solar power the best alternative. It is common knowledge that access to electricity might be capable of improving household income, educational attainment, access to both print and social media, and as well boost standards of living. The rural folks seem to have adopted the solar PV system by demonstrating support for innovation probably due to the lower cost and awareness of the environmental effects of the conventional electricity systems. This knowledge might contribute to energy sector policy-making, especially the usage of electricity produced through solar PV systems in the remotest parts of countries that do not wish to leave anyone behind. This information may add to data on the long-term benefits of solar power technology in terms of affordability, durability with minimal environmental hazards, and cost effectiveness that meet the needs of rural and urban areas. Therefore, solar PV systems utilization could be considered an effective way of empowering rural people by making use of the available natural resources to counter the effects of social and economic challenges due to electricity generation systems. Apart from the solar power being endless, the technology also enhances power security locally and globally.

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