CONNECTING FELDA COMMUNITIES WITH SOLAR ELECTRIFICATION DURING FLOOD DISASTER: THE METHODOLOGY

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ABSTRACT

The Malaysian Electricity Supply Industry Outlook 2016 has highlighted that Malaysia's electricity supply infrastructure is among the best in South East Asia. However, upon flood disaster, the national power supply is easily interrupted and electricity cannot be supplied efficiently to the people, especially for the locals in the rural areas. One of the significant groups affected during flood in the rural areas comes from the FELDA communities. These people are usually left vulnerable in a blackout during flood disaster. Therefore, it is significant to have alternative power supply that can be used as a supporting energy relief during the disaster. One of the potential alternatives energy that can supplement electricity during blackout upon flood disaster comes from solar energy. By using solar energy, electricity can be generated and stored ahead of time at the flood relief center. This flood relief strategies is supported by the National Security Council (KMN) and the Ministry of Rural and Regional

Development of Malaysia part of the national flood disaster blue print agenda. Therefore, this research aimed to explore the potential of using solar-generated electricity in helping the FELDA communities in the rural area in facing power disruption during flood disaster. The focus will be on presenting the overview of FELDA flood areas in Malaysia and provide discussion on the research methodology obtained to overcome the issue.

Keywords: *FELDA, solar electricity, flood disaster, electrification relief*

INTRODUCTION

Malaysia receives abundant solar energy annually with the average irradiance of 1643 kWh/m^2 per year (Solangi, Badarudin, Kazi, & Aman, 2013). According to Shafie, Mahlia, Masjuki, and Andriyana (2011), "The annual average daily solar irradiation for Malaysia is from 4.21 kWh/m2 to 5.56 kWh/m2". It shows that with the tropical climatic condition of Malaysia, it is feasible for this country to have high development in solar energy application. Research done by Solangi et al., (2015) and the 10th Sustainable Energy and Environmental Forum (2015) show that most cities in Malaysia, for instance Kuching, Ipoh, Johor Bahru, Kuantan and Bayan Lepas received high solar irradiance averaging from 1400 kWh/m^2 to 1800 kWh/m^2. However, despite the potential of this energy in Malaysia, the implementation of solar-generated electricity in Malaysia is more focus more in the urban areas and commercial sectors. As a result, it has slowed down the development in rural areas, including the traditional villages, the government-funded settlements (FELDA and FELCRA settlements) and island villages.

THE ISSUE

According to Maps of World (2018), the Malaysia's geographical position is strategically located in latitude, 2°30'N and longitude 112°30'E. The weather and climate of Malaysia is on the equatorial continent with hot, humid climate and annual temperature of 30 to 37 degrees throughout the year (Shareh Musa, Weng, Ku Mahamud, & Abd. Karim, 2013). In Malaysia, the average annual rainfall is 2,400 mm for Peninsular Malaysia, 2,600 mm for Sabah and 3,800 mm for Sarawak (Ismail, 2015) which indicates the possibility for flood is high in Malaysia every year. In addition, Malaysia also receives strong winds from Southwest Monsoon and Northeast Monsoon (Mekhilef et al., 2012; D/iya, Gasim, Toriman, & Abdullahi, 2014). The Southwest Monsoon from May to September brings heavy rain to the East Coast of Peninsular Malaysia, the Coast of Sarawak and Sabah. Whilst, the Northeast Monsoon occurs in November through March and affects the East Coast of Peninsular Malaysia, West Coast of Sarawak and West and East Coast of Sabah resulting heavy rains and flash floods (Ismail, 2015). Due to this situation, states on the East Coast of Peninsular Malaysia, Kelantan, Terengganu and Pahang are experiencing major monsoon floods every year which have damaged many houses and infrastructure. This is why the National Security Council (KMN) and the Ministry of Rural and Regional Development of Malaysia are concern on the flood management strategies of these states, due to its diversity such as (i) allocating the people to the flood aid centre, (ii) providing food and clean water supplies, (iii) arranging medical supplies and (iv) securing electricity supplies to the flood victims (Rabiul, Roslina, Siti Aznor, Jan, & Abdul Rahim, 2016).

When flood disaster strikes, electric power as a crucial service will usually be shut down by the power provider to avoid harmful incident. Without elements such as power, phone line, machine, lighting (Mohamed, Nordin, & Abdullah, 2015) and other critical infrastructure systems for traffic control, water purification and hospital (Lee, Laurent, & Becker-Birck, 2013) daily activities will be interrupted. Bernama (2017a) also highlighted that electricity distribution can be affected by the failure of electrical distribution machines when flood occurs. Without electricity distribution to the building, many important activities or needs cannot be met.

There are various problems and potential harms when flood occurs. For the electrical aspect, Suruhanjaya Tenaga (2015) has listed the risks of flood disaster to the electricity supply system such as the power supply disruption, loss of life, property damage, electric shock, high or excessive voltage, fire and damage to the consumer electrical appliances.

Flood disaster can also impacted the community movement and activities (Qazi & Qazi, 2014). Since power interruptions that lead to blackout may also interrupt telecommunication networking of the people, the victims' safety condition may also be affected. In addition, the authorities may fail to assist the flood victims since the physical communication has been paralysed due to floods (Ismail, 2015). This will also impact the national affairs. For instance loss of lives, property damages, economic losses and environmental degradation.

Each district or mukim in villages is linked with the electricity generated from a national grid powered by Tenaga Nasional Berhad power station and sub-station (Suruhanjaya Tenaga, 2015). The issues may arise since most sub-stations are located in rural areas and are vulnerable to the flood risk due to the topography of the place which leads to flooding areas (Idris, 2016). This causes the rural areas to be exposed to the risk of power failure.

Therefore, it is significant to have alternative plan to secure the power supplies of these people during flood disaster. This is parallel with the aim of Majlis Keselamatan Negara (2012), which acquire the government to have sustainable resources to assist the floods victims (Majlis Keselamatan Negara, 2012). Thus, the alternative energy supplies are significantly needed so it can be used during flood events.

THE POTENTIAL OF SOLAR ELECTRIFICATION DURING FLOOD DISASTER

Solar photovoltaic (PV) electricity generation is a form of renewable energy (RE) which is clean, non-depleting and does not emit any greenhouse gases since it generates energy directly from the sun by means of PV system (Chua & Oh, 2012). It is a significant energy that generates clean energy to overcome the issue of depletion of fossil fuels (Solangi et al., 2013). It has an important role in providing modern energy access to the billions of population in developing countries where traditional energy sources are still mainly depended (Hassain et al., 1998). According to Bujang, Bern, and Brumm (2016), solar power in Malaysia generated by PV system is four times higher than the capacity of world fossil fuel resources. However, only 9% of the national solar power capacity has been used to generate electricity for this country (Ibrahim, 2017).

In addition, the solar photovoltaic (PV) system has the ability to meet critical power needs during emergency situations such as natural disaster, and in this case; the flood disaster. Usually, during flood disaster, most of the settlements in rural Malaysia are affected and the affected people are vulnerable and left without electricity. Therefore, the solar PV systems can help to supplement electricity during blackouts, whether at their homes or at the flood evacuation centre. Nevertheless, to make it economic for the rural people, solar PV system should be installed at the evacuation center.

During rainy days, the solar energy ability is decreased to 30% of its efficiency (Suruhanjaya Tenaga, 2016). However, with the support of solar battery banks, energy from PV panels can be used even during flood season (Treado, 2015). Minister of Energy, Green Technology and Water of Malaysia (2015) highlighted that solar energy has the potential to be used as an alternative energy during flood disaster (Hassan, 2015). Hassan (2015) mentioned that the ministry is anticipated to install solar energy systems at flood relief centres as one of the alternatives to supply electricity during the disaster. Datuk Seri Mahdzir Khalid (2015) has highlighted that it would be helpful to the people if they experienced electricity interruption during a disaster like flood, there should be a system that can help provide electricityto the affected people.

Besides, the solar PV system can resolve electrification problems especially during critical situation (Hossain, Hasanuzzaman, Rahim, & Ping, 2015), since the system can offer as a small and portable system for miscellaneous applications, backup power for emergency shelters, communications, emergency lighting, and transportation (Lee et al., 2013). In addition, even during flood, rainy season or when the sky is overcast (which limits 50% of its irradiance), the solar PV system is still able to function with the backup of battery banks as storage for the generated energy (Hassan, 2015).

Cases from Japan and the United States of America have proven the importance of solar PV system in helping the natural disaster victim during power interruptions (Initiative for Global Environmental Leadership, 2013). In Japan, a portable solar PV system is used to power houses during earthquake and tsunami (Initiative for Global Environmental Leadership, 2013; Wharton School, 2013). In America, solar PV system is used to help powering the electricity during flood, hurricane and tornadoes disaster (Qazi & Qazi, 2014; Young, 2006; U. S. Department of Energy, 1999) . Both countries have less solar energy irradiance than Malaysia, where Japan has only 4.3 to 4.8 kWh/(m^2/day) of solar irradiance (Wildman, 2015) and America has 3 to 9 kWh/m^2/day of solar irradiance (Badescu, 2014). With these examples, it is proven that Malaysia is also able to explore the utilisation of electricity generated from solar PV system and as an electricity relief mechanism in facing flood disaster for Malaysia.

RESEARCH METHODOLOGY

THE RESEARCH PHILOSOPHY

The research was based on the Sociotechnical System Theory research (Sawyer, 2013; Klein, 2014). The issue of the research comes from the context of pragmatism paradigm (Hall, 2013; Dimitrokali, Mackrill, Jones, Ramachers, & Cain, 2015). The theory applied was : i) the mutual connection between people and technologies, ii) the contextual embedded of this mutuality; and, iii) the importance of action (Sawyer, 2013; Klein, 2014). In addition, the involvement of rural settlers as (i) the user of the technology which involved the theory of engagement; and (ii) the technology; solar PVs as a medium that can establish a high quality of working efficiency which produce a comfortable life accomplishment. Table 1 and Figure 1 show the description of theory approaches related to the research.

Figure 1 explains the interconnection of solar PV technology and the rural communities that was based on the sociotechnical theory, which involves human development in linking social aspect and technical aspect, in order to make a better and comfortable social life. For this research, the comfortable social life applies towards the life during the flood disaster event.

Table 1: Sociotechnical Theory related to the Research

No	Description of theory	Solar Engagement
1	The mutual connection between people and technologies	People – Rural Community Technology – Solar photovoltaic (PV) system
2	The contextual embedded of this mutuality	Public engagement approaches: Information gathering Advice Information dissemination
3	The importance of action	The effectiveness of Public engagement technique The feasibility of Solar technology application

Sources: Constructed by the Author

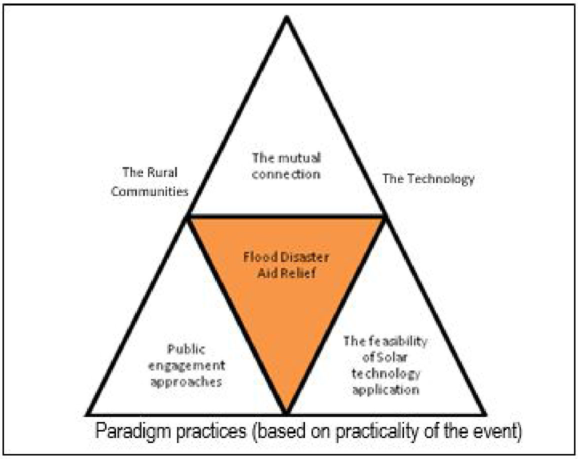

Figure 1: The Sociotechnical Theory Pyramid
Sources: Constructed by the Author

Sunders, Lewis and Thornhill (2009) mentioned that research methodology process need to be explored while identifying the research philosophy, research approach, research strategies, research choices, time horizons and research procedures. This research employed exploratory mixed method research combining the qualitative and quantitative data. The idea of introducing solar PV technology to flood disaster area need to be explored and investigate in detail since it is a novel approach in Malaysia. In realizing this research, the knowledge of solar photovoltaic is needed to enable this study to be planned and solved effectively. According to Kilpinen (2008) and Westskog (2014), the primary focus of pragmatism research is to focus at the end result of the research within the context of practicality, which emphasizes integration and interaction of the samples (Rylander, 2012).

THE CASE STUDY: FELDA RURAL SETTLEMENTS

The case study for this research was the rural settlements of Federal Land Development Authority (FELDA). Federal Land Development Authority is a statutory body that was established on July 1, 1956 by the Malaysian Government (FELDA, 2014) in order to establish the resettlement of rural poor into newly developed areas and to provide smallholder farms for growing crops, which basically are rubber trees and palm oil trees (FELDA, 2014). Every FELDA communities are supplied with a house, electricity, water and community buildings (a mosque, a school, a public clinic and a public hall).

FELDA has 317 settlements with almost 10,000 houses throughout Malaysia (FELDA, 2014), which indicates the social-engagement approach is considered significant to disseminate the solar technology in these communities and can be chosen as the alternative energy relief mechanism during flood disaster in FELDA settlements. In addition, FELDA has its own financial capability that can generate their own income to support various developments through a variety of businesses. FELDA has a number of private corporate entities primarily such as FELDA Global Ventures (FGV), FELDA Investment Corporation (FIC) and FELDA Capital Cooperative (Cooperative FELDA) in an effort to generate income (FELDA, 2014).

The function of settlement in FELDA is for agricultural purposes, for instance as a producer of palm oil and rubber trees. There are various types of earth surface in FELDA settlements, for example low lands, hilly lands, corrugated areas and valley in highlands. This type of earth surface also contributes to the occurrence of floods in FELDA settlements. There are two types of floods that always occur in FELDA settlements, which is flash flood and monsoon flood (Sulaiman, Mastor, Husain, & MananSamad, 2013). Usually, during flood, most of the houses in FELDA settlements have to face blackouts. Therefore, FELDA communities are the significant option to disseminate solar PV technology during flood disaster.

THE QUANTITATIVE AND QUALITATIVE APPROACHES

The quantitative and qualitative approaches for this research are divided into several phases (Table 4), namely:-

Load profile and Field Surveys

Load Profile form was used for the survey. The objective was to collect the data on electrical appliances consumption in order to investigate the current electricity profiles and pattern. This included measuring the roof sample of FELDA hall which act as an evacuation hall in FELDA settlements. The aim of load profiles was to understand the electricity pattern and electricity consumption of FELDA halls. The data collected from load profile survey were processed using analysis numerical software known as HOMER. According Cook et al. (2005) in Shyu (2013) study, the load profile data was an empirical data for the future energy study for this research.

Interview and Questionnaires

Semi-structured interviews technique was guided with a list of closed-ended questionnaires. The session was conducted with the FELDA Management Department at FELDA Berhad. The purpose of the interview was to gather FELDA readiness and acceptance information on solar PV as an alternative energy aid during the flood disaster. To analyse the data, the NVIVO software was used as analysis tool. On the other hand, the data from the interview and questionnaire were used to support the case study and conceptual framework (Sovacool & Lakshmi Ratan, 2012).

The samplings were based on the criteria below;

i. House must be owned by the residents.
ii. Duration of occupancy (24 hours-basic)
iii. Life style Occupancy
iv. Types of settlements (based on topography)
v. Distance from the city (more than 100km)

Literature reviews and pilot survey enabled the development of the research problem. In the pilot survey, data were collected in order to determine potential site for sampling and the outcome guided the selection of the sample for main data collection. The data of qualitative and quantitative were integrated and analysed before producing the interpretation of entire analysis (Creswell, 2009). This is supported with Ahmad (2014) who mentioned that the appropriate methodologies used able to achieve the research objectives and questions for exploring the research area. For this research, there are 4 approaches involved (Table 4);

Focus Group

The aim of the focus group was to collect the experience and idea of FELDA settlers based on the energy practice, the prospect of solar photovoltaic development, and the settler's readiness of solar application in FELDA settlements. All settlers were gathered into small groups with the help of facilitator. The in-depth information was needed to gather more spontaneous discussion between the members of the group. The Snow Ball sampling approach was suitable for the study (Alam, Nor, Ahmad, & Hashim, 2016) since the nature of the respondents that can only be approached by people that they are familiar with.

The Ketua Kampong (village leader) was appointed and the briefing of research information was informed through him. Then, the Ketua Kampong appointed the participants to be involved in the discussion through snow ball approach. The small groups were formed where one group was represented by 5 or 6 members. All the data from the focus group discussion were analyzed using NVIVO. The results of the questionnaires and interviews from focus group were used to support and cross-validate the questionnaire findings.

Case studies

Table 2 and Figure 2 show the provinces and settlements of FELDA. In Peninsular Malaysia, 10 provinces of FELDA are situated at Negeri Sembilan, Johor, Kelantan, Pahang, Perak, Terengganu and Kedah.

Table 2: Provinces and Settlements of FELDA (FELDA, 2017)

No	State	Province	No of Settlements
1	Johor	Johor Bahru	42
		Segamat	36
2	Kedah	Alor Setar	13
3	Pahang	Jengka	37
		Kuantan	42
		Mempaga	36
4	Perak	Trolak	21
5	Negeri Sembilan	Raja Alias	49
6	Terenggahu	Terengganu	21
7	Kelantan	GuaMusang	11
Total			317

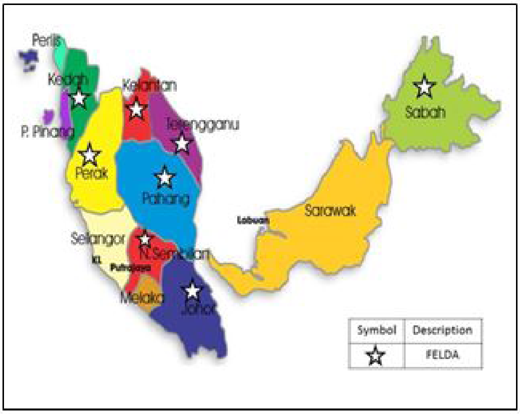

Figure 2: FELDA Malaysia
Sources: Constructed by the Author

Figure 3 shows the maps of flood disaster in Peninsular Malaysia. The map shows that Kelantan receive the highest number of flood incidents which is 124,966 occurrences followed by Terengganu with 36, 410 occurrences. For evacuation centre, Kelantan and Pahang have the same number of evacuation centre which are 127. The flood disaster also occurs in most of the FELDA areas; for example; FELDA settlement at Gua Musang, Kelantan and at Kemaman, Terengganu. Table 3 shows the list of FELDA flood areas in Malaysia.

Table 3: FELDA flood areas in Malaysia

No	State	FELDA Settlement
1	Pahang	FELDA Tersang 1, 2 & 3
		FELDA Bukit Kuantan
		FELDA Jengka 8, 11, 15 & 16
		FELDA Kota Gelanggi
		FELDA LurahBilut
2	Kelantan	FELDA Aring
3	Terengganu	FELDA SeberangTayor
		FELDA Tenang
		FELDA Neram 1 & 2
4	Negeri Sembilan	FELDA Gugusan Raja Alias 2
		FELDA Jelai 4
5	Perlis	FELDA Chuping
6	Johor	FELDA Pemanis

Figure 3: Map of flood disaster for FELDA Areas
Source: Bernama (2014)

Usually, during flood disaster in FELDA areas, affected FELDA settlers will be transferred to a safe evacuation centre, for instance, schools, mosques or public halls (Mohamad, 2015). The flood relief centres are managed under the Regional Office of FELDA (Ismi, 2015;Berita Harian, 2015;Bernama, 2017). Figure 4 shows the example of FELDA hall as an evacuation centre during flood disaster.

Figure 4: The Flood Evacuation Centre in FELDA

Typically, roof pitches in FELDA' community buildings are angled at 45° or less, with wide area of roofs are more than 100m^2 (Yuan, 2010). This will allow PV panels to be arrayed effectively at each flood evacuation centres. By using the large roof area, solar irradiance can generate more solar electricity and help the flood victims to use electrical appliances (Ahmad, 2014). This is a good potential for FELDA since the community buildings in FELDA has wide areas for Photovoltaics (PV) panels.

Two settlements of FELDA were selected from the 12 FELDA settlements affected by the floods across the country in 2015; namely (i) Rancangan FELDA Seberang Tayor in Kemaman, Terengganu and (ii) Rancangan FELDA Chiku in Gua Musang, Kelantan. Both case studies were selected because in 2015 this location was highlighted as the worst affected areas by the flood disaster (Berita Harian, 2015b). On the other hand, both locations also face flood disaster continuously during monsoon season in November and December with high intensity of rain (Ismi, 2015; Utusan Malaysia, 2014).

Table 4.0: Data Collection and Data Analysis Approaches

Data Collection and Data Analysis			
Research Strategy	Case Study		
Approaches	Field Survey	Interview	Focus Group
Sampling Design	-	Non-Probability Sampling	Snow Ball Sampling
Technique	Load Profile Analysis	Semi-Structured Interview	Discussion & Questionnaires
Respondents	FELDA Community	FELDA Management	FELDA Community
Sample Location	FELDA Settlements	FELDA Berhad	FELDA Settlements
Analysis Tools	Numerical Analysis (HOMER)	Nvivo	Nvivo & SPSS (SM)

CONCLUSION

This paper has set out the issues that have been faced by FELDA communities in Malaysia upon flood disaster. Usually, during flood disaster, the power is interrupted and the settlers have to face power blackouts. To make the situation worse, the breakdown telecommunication has slow-down the evacuation relief operation by the Government. The solar energy can be generated and distributed as an alternative energy during flood disaster at the evacuation centres. The flood victims can use the electricity generated from solar PV upon arriving at the evacuation centre and before receiving aid relief from the national evacuation team. The Socio-technical System Theory has been used for this research which involves the interaction of people (FELDA settlers) where the technology (solar electrification) can help in facing flood disaster. The research approaches involved in collecting data were interviews, focus group and load profile surveys in the FELDA Settlements to get the better result in order to help the FELDA settlers to be resilient during flood disaster.

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