The Sustainability of Photovoltaic System at Rawasari Village, Tanjung Jabung Timur through Student Community Service - Community Empowerment Learning Program

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Abstract. Rawasari is one of location at Tanjung Jabung Timur Regency that installed by photovoltaic system through Millenium Challenge Account Indonesia (MCAI) program by Konsorsium Energi Mandiri Lestari (KEMALA) in early 2018. The total installed photovoltaic system at Rawasari was 41.8 kWp which consisted of solar home system, solar system for public facilities, and solar system for business unit. When Kemala program ended in February 2018, the sustainability of the business unit was threatened because of there was not educated or skilled assistance that ensure photovoltaic system can run well. Therefore, the role of Student Community Service - Community Empowerment Learning Program (SCS-CEL) by Universitas Gadjah Mada (UGM) was deemed necessary to parse that problems. The SCS-CEL program has conducted from June-August 2018 that involved about 27 students from multidiscipline studies. Through two main programs of SCS-CEL namely strengthening the management system for photovoltaic and improving the quality and capacity of production business units. The result showed that an increasing of public awareness of the importance of maintaining a photovoltaic system and developing of drinking water business unit.

1. Introduction
Rawasari village which is located at Tanjung Jabung Timur Regency is one of locations for installing off-grid PV system by the KEMALA consortium through a program Millenium Challenge Account Indonesia (MCAI). The off-grid PV system is intended to provide electricity for 223 residents who are still dependent on diesel engines [1]. An existence of off-grid PV system was designed to increase economic activity for society at Rawasari. An emergence of new business units such as the provision of drinking water, various locally-made foods and the establishment of a Green School building as a place to discuss the progress of their villages is the concrete evidence of the benefits of off-grid PV system for the local community.

Economic and social activities at Rawasari village now relies on local off-grid PV system, therefore it is important to maintain the sustainability of off-grid PV system. Many off-grid PV system in developing countries do not have sustainability due to several things, namely the absence of policy interventions from official institutions, the lack of support and acceptance of the local community and...
the minimum availability of operational and maintenance funds [2]. This condition also occurs at Rawasari after the off-grid PV system have been installed at the beginning of 2018. Therefore the strategy of placing Student Community Service - Community Empowerment Learning (SCS-CEL) with the theme of strengthening sustainability of off-grid PV system through increasing productive business is a way to maintain the sustainability of off-grid PV system. The community empowerment learning program which was conducted periodically is expected to be able to maintain photovoltaic sustainability at Rawasari village through mentoring and training by students to societies there.

2. Material and method

2.1. Off-grid PV system at Rawasari Village
The system of off-grid PV system at Rawasari is consist of centralised off-grid PV system and solar home system. Centralised off-grid PV system was installed in public facilities and business units while solar home system was installed in 223 homes. Total capacity installed of off-grid PV system was 41.8 kWp with detail data shown in Table 1.

Table 1. Off-grid PV system installed at Rawasari village

| System of off-grid PV system          | Unit | Installed capacity (Wp) |
|---------------------------------------|------|-------------------------|
| Mosque (1000 WP)                      | 2    | 2000                    |
| Small mosque (600 WP)                 | 2    | 1200                    |
| Kindergarten (100 WP)                 | 2    | 200                     |
| Health facility (100 WP)              | 2    | 200                     |
| Dock (100 WP)                         | 2    | 200                     |
| Badminton court (100 WP)              | 1    | 100                     |
| Homes (100 WP)                        | 223  | 22300                   |
| Elementary school buildings (1000 WP) | 1    | 1000                    |
| Green school (1000 WP)                | 1    | 1000                    |
| Business unit building (2000 WP)      | 2    | 4000                    |
| Business unit building/drinking water (3600 WP) | 1    | 3600                    |
| Elementary school in Blok O (2000 WP) | 1    | 2000                    |
| Business unit building at Blok P (2000 WP) | 1    | 2000                    |
| Business unit building at Blok P (2000 WP) | 1    | 2000                    |

Total capacity installed **41800**

2.2. Student Community Service-Gadjah Mada University
Student community service- Community Empowering Learning program (SCS-CEL) is student field activities that can be attended by all undergraduate students in the Gadjah Mada University. SCS-CEL held in June 27 - August 11, 2018 with 27 students which coming from faculties of Engineering, Mathematics, Economics and Business, Psychology, Pharmacy, Animal Husbandry, and Veterinary Medicine. The theme of the SCS-CEL program was strengthening the sustainability of off-grid PV system through increasing productive businesses at Rawasari Villages, Berbak District, Tanjung Jabung Timur Regency, Jambi.

SCS-CEL students prioritize their work programs in assisting of existing productive businesses and offering new businesses that are suitable to the community needs. The work program is arranged based on the results of field surveys and interviews with the key person of the off-grid PV system project which is conducted before they are deployed.
2.3. Off-grid PV system Sustainability

Post-installation of off-grid PV system problems are more complex than pre-installation problems, it occurs because off-grid PV system has become an asset that has economic value so that many external factors that influence it. The sustainability of off-grid PV system is influenced by several factors, namely economic, social, environmental and institutional factors [2-6]. The economic aspect is seen from how off-grid PV system driving economic activity for the local community like providing additional incomes and the ability of local community to fund the operational dan maintenance of off-grid PV system [2]. Institutional aspect sees the role of the local formal institutions that influence off-grid PV system management policies. The social aspect sees the community acceptance and the availability of local skilled workers who can overcome off-grid PV system technical problems.

3. Result and Discussion

SCS-CEL students with the theme of sustainability of off-grid PV system through strengthening productive businesses have implemented work programs for 50 days. The main work program was managing the drinking water business and optimizing the Green School building as center for community activities in advancing their village and maintaining off-grid PV system. The two main programs were taken based on a previous survey which showed that the drinking water business was a business unit that had good prospects but had not been well managed by the local community. The results of the SCS-CEL student work program would be analysed based on three aspects of sustainability of the off-grid PV system namely economic, social and institutional aspects [2].

3.1. The social aspect of the sustainability of off-grid PV system at Rawasari village

After the Kemala program ended in 2018, the community was not only occupied by off-grid PV system but also small group that manage off-grid PV system which is called Kader Hijau (green cadre) [1]. However, in practice the community have been confused when there were technical problems that befalls the electricity network in their house. The Center for Energy Studies of Gadjah Mada University noted that there were more than 45 complaints from residents related to the off-grid PV system technical problems. Another problem was the use of electrical energy at homes exceed of existing capacity, it occurred because of the local community have been accustomed to turning on TV, charging phone, radio and installing more than 4 units of light when they still using diesel engines.

A placement of SCS-CEL students at Rawasari village is one way to improve the technical capabilities and institutions of green cadres in managing off-grid PV system. This strategy is more efficient than presenting an expert to retraining on off-grid PV system management, moreover SCS-CEL students who come from engineering faculties are provided with technical skills in off-grid PV system management from the Center for Energy Studies. SCS-CEL students provide socialization to residents not to use electricity exceeds of their existing capacity, namely 4-unit lights. Energy use beyond the installed of off-grid PV system capacity will accelerate battery damage.

The other problem experienced by the community at Rawasari village is the lack of citizens awareness in paying contributions of IDR25,000/month for off-grid PV system maintenance costs. That fee amount is classified as cheaper than the cost that must be spent when they use diesel engines, which is IDR 90,000/day. Some residents who are reluctant to pay has view that off-grid PV system is a gift from the government so that when there is damage there must be certain parties who will repair it. Even though when the Kemala program ended in 2018 the person in charge of the off-grid PV system was handed over to each citizen under the supervision of the local village head. The monthly contribution is the capital that will be used for operational and maintenance costs for off-grid PV system such as replacing damaged batteries and inverters.

The existence of the SCS-CEL is proven to increase citizens awareness of the importance of mandatory monthly contributions. Residents in P and N blocks who previously did not pay monthly contributions have now paid, the level of citizen participation in paying contributions reaches ± 85%. The approach taken by the SCS-CEL team is activate key people in the community to sounding the importance of monthly contributions and create a special team for recording and reporting the
collected funds. The number of green cadres who are active in withdrawing contributions and making reports until the SCS-CEL program ends has increased from 6 to 14 people.

3.2. Economic aspect of the sustainability of off-grid PV system at Rawasari village

The society at Rawasari village use diesel engines as the main source of electricity to support their daily activities before the existence of off-grid PV system. Every household pays IDR 90,000/month to buy fuel. The diesel engine only lights up at night to reduce operating costs. The Kemala Program has installed off-grid PV system for every household, public facilities, educational facilities, places of worship and green school buildings. Residents are only charged a monthly contribution of IDR25,000/month for operational and maintenance funds. Based on the comparison of the cost of expenses that is held by the residents show that the living cost for residents after the off-grid PV system installation is lower than before. This condition is a strong capital to maintain the sustainability of off-grid PV system because the burden of people's lives is reduced due to the existence of off-grid PV system [2].

The off-grid PV system installation in green school building has driven a new business unit in the form of drinking water. The drinking water business is designed to open new jobs where the profits will be used for off-grid PV system operational and maintenance and funding installed of off-grid PV system in public facilities such as schools, mosques and sports area. Drinking water business conditions at Rawasari village is still running but cannot yet get a maximum profit due to pricing issues. The price of drinking water is set at IDR3000/gallon for consumers at Rawasari village but for consumers outside the village of Rawasari the price is IDR4000/gallon. The price of bottled water only generates a profit of IDR1000/gallon so it cannot contribute to the welfare of workers. The management of the drinking water business cannot increase the price of the product because they could not analyse the real price of it.

The presence of SCS-CEL students at Rawasari village tries to unravel the problem by conducting a price assessment. They gather village officials, residents and workers to discuss the right pricing. The results of the discussion were decided that the price of bottled water was IDR5,000/gallon for consumers at Rawasari village and IDR6000/gallon for consumers outside of Rawasari village. With this price scheme, managers of drinking water business can get a profit of IDR2500/ gallon, which means that it’s higher than the previous which is only IDR1,000/gallon. After the business unit gets enough profit, finally they bought 100 unit of gallons as an asset because the demand for bottled water increase over time. Many studies shown that many project funded by donor failure because it only providing in initial cost of off-grid PV system and avoiding the long term of maintenance and operation cost [7,8], when drinking business unit and monthly fee running well it can fund the operational and maintenance of PV system at Rawasari village.

Based on the description above, it clears that an existence of off-grid PV system has been able to reduce the living cost of the community and able to maintain the sustainability of off-grid PV system with the drinking water business unit. The benefits obtained from the drinking water business will be used to fund the operation and maintenance of off-grid PV system in public facilities. The sustainability of off-grid PV system can be guaranteed if the existence of off-grid PV system able to drive the economic activities for local resident, reducing living cost for residents and providing funds for maintenance costs [2].

3.3. Institutional aspect of the sustainability of off-grid PV system at Rawasari village

Previous efforts have revealed that sustainable off-grid PV systems need strengthened formal institutions [9-11]. Strengthened formal institutional are characterized by their stability (durability) and their enforcement [12]. To maintain the sustainability of off-grid PV system at Rawasari Village, the KEMALA program provided a off-grid PV system grant to the Rawasari village. Then, as a result of community discussions with the Rawasari village government, it was agreed that a statement was signed by the residents as recipients of the solar home system with the village government which agreed to maintain the off-grid PV system properly. In addition, in that statement there was also a
clause if the residents did not maintain the off-grid PV system properly then cause a damage to off-grid PV system, all the spare parts of the off-grid PV system must be returned to the village government. Furthermore, the village government could use the off-grid PV system for public facilities. The agreement stated in the statement letter could avoid the practice of selling off-grid PV system spare parts by residents. Village apparatus could also reprimand people who do not want to pay monthly fees, this condition will strengthen the sustainability of off-grid PV system after installation.

4. Conclusion
Problems that arise after the installation of off-grid PV system are far more complex, this occurs because of the delegation of responsibility from official institutions to people who have limited knowledge and skills. It is necessary for third parties to facilitate community needs with official institutions (campuses) that have the capacity to manage off-grid PV system. The presence of SCS-CEL students in the community has proven to be able to increase public awareness in maintaining off-grid PV system and is able to improve the management of drinking water business which is a source of funding for off-grid PV system maintenance.

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