Challenges In Using Renewable Energy for Islands in Indonesia: A Case Study of Karimunjawa

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***Abstract*—Karimunjawa subdistrict which is located in Central Java Province received electricity supply in 2006 by using diesel powerplant. The Government of Indonesia also installed solar powerplants in 3 of 5 islands in Karimunjawa subdistrict. The management of the solar powerplants in the islands provides challenges not only in technical, but also in economic and social aspects caused by technology which is still new for community. This paper discussed about the challenges in implementing renewable energy technology in islands. The data was collected by (1) daily energy demand survey in 45 households in Karimunjawa (2) observation and (3) stakeholders' interview. The results showed the importance of (1) developing productive used of energy, (2) the collaboration among many parties (3) technical, social and economic assistance in all project phase and (4) community engagement.**

***Index Terms*— Community engagement, economic and social aspects, Karimunjawa subdistrict, renewable energy, technical challenge**

I. Introduction

People living on small islands are more often experienced with he problems in energy access. It is predicted that 70% of small islands in Pacific Islander do not have access to electricity [1]. Small Island Developing States (SIDS) has a heavy burden related to the need for imported fuel and the commitment to do the energy transition regarding sustainable developments goals [2].

Karimunjawa is one of island in Southeast Asia that has electricity issues. The island is located in Jepara Regency, Central Java Province, which was developed as a tourism area. Karimunjawa Subdistrict consists of four villages: Karimunjawa, Kemojan, Parang, and Nyamuk, which are located in the five biggest islands out of 27 islands in Karimunajawa. Statistics Indonesia data 2019 stated that Karimunjawa Subdistrict was inhabited by 9,649 people, consisted of 4,863 men and 4,789 women. However, the local people's education level was still low, where there were only 132 people who studied in university [3].

Purnomo [4] mentioned that the economy of Karimunjawa sub-district is mainly supported by fisheries, agriculture and tourism activities (including lodging, transportation, culinary and other shipping services) and trade. The development of tourism in Karimunjawa shows a great development since 2004/2005. It can be seen from the visits of foreign tourists who showed nearly 30% of foreign tourists entering Jepara Regency, visiting Karimunjawa. The amount was 8,156 foreign tourists during 2019. This figure was the largest compared to visits to other locations in Jepara Regency [5].

Figure 1. Map of Karimunjawa Subdistrict [6].

TABLE I. DIESEL POWERPLANTS MANAGED BY REGIONAL ELECTRICITY COMPANY IN KARIMUNJAWA SUBDISTRICT

No.	Diesel Powerplant	Location (village)	Capacity (kVA)	Customers
1	Karimunjawa	Karimunjawa	500	888
2	Cek Mas	Karimunjawa	100	229
3	Kemojan Island	Kemojan	200	706
4	Parang Island	Parang	100	273
5	Nyamuk Island	Nyamuk	65	177
6	Genting Island	Karimunjawa	30	70

Source: The Ministry of Energy and Mineral Resources of Jepara Regency, 2016.

To support the tourism development, electricity is among the most important things that must be considered. Karimunjawa Subdistrict is 30 km-away separated from Java Island. Until 2014, State Electricity Company (PT PLN Persero Indonesia) had yet to provide electricity access to Karimunjawa Subdistrict [7]. Therefore, the local people's electricity demand was supplied by diesel powerplant from the Regional Electricity Company managed by the Regional Government. The Regional Electricity Company had six powerplant units with a total capacity of 995 kVA, as shown in Table 1. These powerplants started to operate in 2006-2007, funded by the regional fund from Jepara Regency.

The electricity generators in Karimunjawa were not operate in 24 hours daily. This is because diesel fuel must be purchased from Jepara which can be reached by speed boat for two - three hours. In a high ocean wave condition, the management can face difficulty to buy diesel fuel in Jepara. It then causes possibility of power outages even for several days. Those six diesel powerplants needed 26,750 liters of diesel fuel per month or equal to 321,000 liters per year [7].

To provide electricity for 24 hours and to reduce the use of fossil fuel that emits CO_2, several renewable energy projects were implemented in Karimunjawa Subdistrict. In 2013 and 2014, Parang Island and Nyamuk Island obtained a grant from the Indonesian Ministry of Energy and Mineral Resources. The Ministry installed a 75 kWp-solar powerplant for Parang Island and 25 kWp for Nyamuk Island. In 2018, the Indonesian Government received a solar powerplant grant from Denmark through Environmental Support Program Phase 3 (ESP3). Currently, the total capacity of solar powerplants in Parang Island is 136 kWp, Nyamuk Island is 111 kWp, and Genting Island is 36 kWp. The electricity generated from these solar powerplant is utilized for three lamps and one stop-contact in each house with a daily energy consumption limit of 1500 Wh. In addition, Karimunjawa Subdistrict also received several other solar panel system grants that can be seen in Appendix 1.

Even though the solar powerplant has been installed and used by the community, the diesel powerplant located in each village are still in operation. Each powerplants work in different distribution lines. The reason that both of them have not been combined, is not because of technical issue, but of ownership issue. As the diesel powerplant belongs to the regional government while solar powerplant was built by MEMR, asset ownership is among the main issues in powerplant management in Karimunjawa Subdistrict. This has become one of the big challenges in developing renewable energy in the islands.

Another challenge arises due to local people's mindset. Several grants of solar powerplant came to Karimunjawa Subdistrict from many stakeholders made the community think there will be more grants coming. They don’t have to be worried for the electricity problems. They will be waiting for government or other grants. As a result, the community does not think it is necessary to maintain the assets that they used, because there will be other grants to repair or replace it if damage occurs.

Development of solar powerplant from year to year brought up a desire to add electrical equipment at home. Previously, the community only used diesel generators which operated 3-12 hours a day. Now they think that they can consume electricity 24 hours using solar powerplants. The increase in community electrical equipment had become a problem because people were able to bypass energy limiter in their homes to operate additional equipment. It caused not only technical issue such as overload in solar powerplant, but also social issue. Community need to be informed how solar powerplants worked. The information about how solar panels work is usually presented to men. Although many women have control on managing electricity at home, they did not receive adequate information related to operation and maintenance of solar powerplant.

All problems that have been mentioned provide challenges in the development of renewable energy in the islands. It is obviously not only about technical issues, but also social, cultural and economic perspective. Therefore, as a part of systemic effort to answer, this research has three objectives, including: (1) describing challenges faced by renewable energy development in islands, (2) identifying issues from technical and social aspects, and (3) providing recommendations to address the issues.

II. METHODOLOGY

The methodology applied in this research involved a literature review, observation, and interview. The literature study enriched the knowledge regarding social and economic aspects and renewable energy development in Karimunjawa Subdistrict. The interview was conducted with stakeholders in Karimunjawa Subdistrict, Parang Village, and Nyamuk Village. Aside from the interview, a discussion was also held for women and beneficiaries in school and public health facilities who obtained Solar Water Pumping System (SWPS) and Solar Home System (SHS) from the Center for Energy Studies Universitas Gadjah Mada. The observation was conducted by observing the social condition of the local community based on their daily activities.

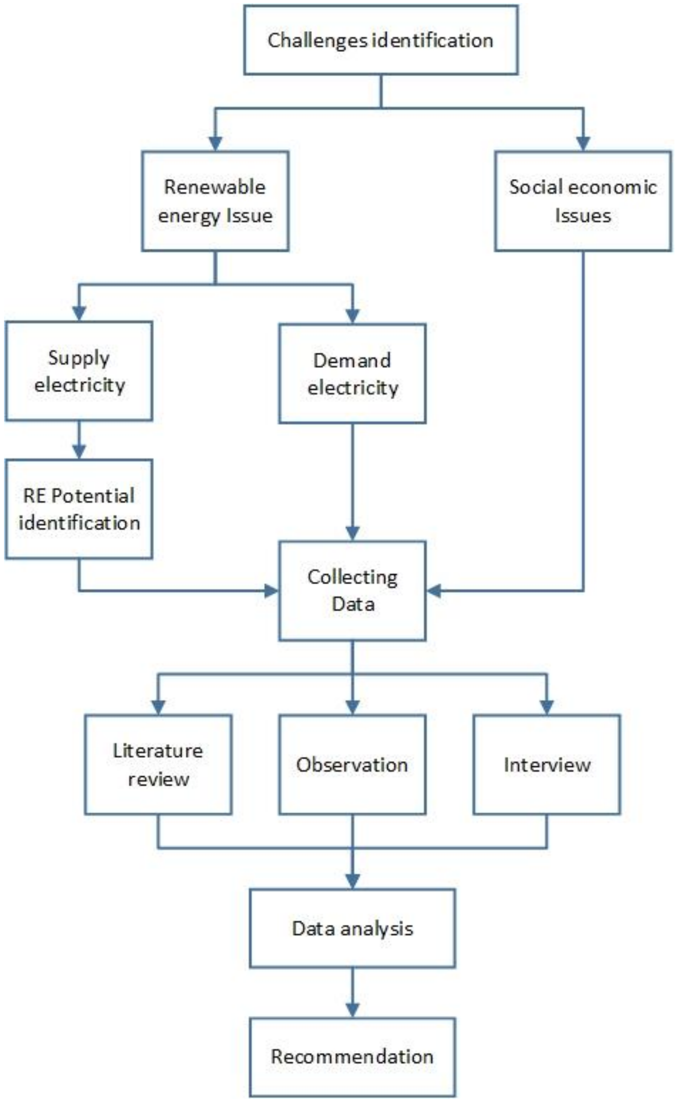

Figure 2. Flowchart of analytical framework

Figure 2 shows the framework analysis of this paper. Challenges identification was divided into renewable energy and economic-social issues. Renewable energy issue was presented by analyzing supply and demand electricity data by observation and interview with community. Renewable energy potential data was taken from literature review and online tools, such as global solar atlas and global wind atlas. Social economic data was taken from literature review, observation and interview community. After the data was collected, analysis was conducted to provide the recommendation.

The analysis was carried out based on electricity demand and renewable energy potential data in Karimunjawa Island. There are 45 households in energy demand survey. This survey records the electrical equipment in the respondent's house as well as the time of the electrical equipment was used. After data collection of electricity needs is carried out, data on renewable energy potential is obtained through secondary data.

Social and economic issues were obtained through interviews with housewives, village officials and fishermen in Karimunjawa. Differences in the work backgrounds of respondents were carried out to see different points of view to face the problem.

III. RESULTS

Renewable energy development programs in Karimunjawa Subdistrict provides benefits or advantages for many parties. One of them is that the local community have access to electricity for 24 hours. An adequate electricity facility is proven to increase the tourism sector in the past few years significantly, providing new job fields for the local community [8]. It also encourages the economic aspect and increases the local community and regional incomes [7][8]. Karimunjawa Subdistrict also has potential to promote green tourism partly powered by the development of renewable energy.

A. *Renewable energy resources*

By looking at the geographical condition of Karimunjawa Subdistrict, analysis of electricity based on renewable energy resources becomes an interesting topic for research. Use of solar, wind and wave have a large opportunity to be developed for isolated islands.

Permana [9], in 2013 wrote an analysis using the Hybrid Optimization of Multiple Energy Resources (HOMER) to simulate the existing diesel powerplant (500 kVA in Karimunjawa village) with the wind energy on the island. The results showed that 72 wind turbines each 800 W capacity are needed to reduce 67.69% of diesel fuel from existing diesel powerplant.

Novitasari [10] in 2016, also conducted simulation using HOMER with a study case on energy demand in Nyamuk Island. Diesel powerplants used in this simulation was modified with budget estimation on 10% of new diesel machine price. Nyamplung (Callophyllum inophyllum) oil would be used as a fuel for the diesel powerplant. Nyamplung is an endemic plant in Nyamuk Island; thus, the local community could process and develop it. The results showed that to meet the energy demand in Nyamuk Island, which was 233.55 kWh/day, it required several energy sources. Those are solar panels with a capacity of 27 kWp, lister machine (Nyamplung fuel-based diesel machine) with a capacity of 7 kW, 26 kVA of existing diesel machine, 40 kW of inverter, and 128 batteries.

TABLE II. THE DISTANCE BETWEEN THE VILLAGE AND THE SUB-DISTRICT CAPITAL [3] AND THE NUMBER OF DIESEL POWERPLANT CUSTOMERS

No.	Village	The distance between village-sub district capital (km)	Customers*
1	Karimunjawa	0	1,187
2	Kemojan	20	706
3	Parang	32	273
4	Nyamuk	38	177

*Source: The Ministry of Energy and Mineral Resources of Jepara Regency, 2016.

Another research on technology, economy, and the environment in Parang Island conducted by Naimah [11] showed that centralized solar powerplant in Parang Island had an excellent performance in technical and environmental aspects with a capacity factor of 25.76%, 12 hours of daily operation, and CO_2 reduction of 4.81 per year. From the economic aspect, its Levelized Cost of Energy (LCOE) was USD 0.11 per kWh, which was higher than the retail electricity price (USD 0.09 per kWh). With 20 years of life span, the system showed an unattractive investment with minus Internal Rate of Return (IRR) and failure to achieve the return. A sensitivity analysis was conducted to check the effect of assumptions on the results. In this study, sensitivity analysis showed that energy production significantly affected LCOE rather than its capital cost, operational and maintenance cost, panels, and battery capacity. This evaluation only considered six indicators due to the lack of field data.

Technically, electricity development in Karimunjawa Subdistrict was independently manage in each island. This is due to the considerable distance between the islands and the number of customers spread across each island with a number that is not too large in other than Karimunjawa Village as shown in Table 2. For this reason, the electrical solution that can be provided to these islands is a pattern centered on each island.

For further analysis, a case study was carried out on Parang Island. Based on observations, some electrical equipment owned by the community can be seen in Table III. The equation used in energy calculations is the relationship between power in appliances and the duration of using the appliances.

$$E = P \times t \qquad (1)$$

with:

E: Energy (Watthour)

P: Power (Watt)

t: time (hour)

TABLE III. ELECTRICAL APPLIANCES OWNED BY COMMUNITY IN PARANG VILLAGE

Appliances	Total	Power (W)	Average time	Duration (hour)
Lamp	3	10	18.00 – 06.00	12
Fan	1	50	12.00 – 14.00	2
Rice cooker	1	300	05.00 – 06.00 16.00 – 17.00	1 1
TV	1	80	16.00 – 22.00	6

In Parang Village, most of community use electrical appliances such as lights, fans, rice cookers and television as shown in Table III. Some houses have refrigerators which generally also have stalls. The refrigerators are used to cool the drinks they sell or to make ice to supply the food stalls in the village. For those who have refrigerators, electricity supply only relies on diesel powerplant for 6 hours at night. Washing machines were not found in Parang Village.

Figure 3 shows the daily load profile in Parang Village for a household. Different color of area shows the appliances and the blue line show total energy consumption per day which is limited for 1,500 Wh per house.

The highest peak load occurs in the morning and evening when they use a rice cooker. Interview shows that rice cookers are only used to cook rice, not to warm because the electricity is not enough to warm rice all day. During the day, almost no electrical equipment is used because in general the community saves the electricity for watching TV and lights at night. The highest total energy consumption in the morning is 330 Wh and at night with a total of 380 Wh.

Based on the appliances and operating time, we can calculate the total energy for 273 houses.

Energy requirement for 273 houses = 1,500 Wh/day x 273

= 409.5 kWh/day

= 149.467 MWh/year

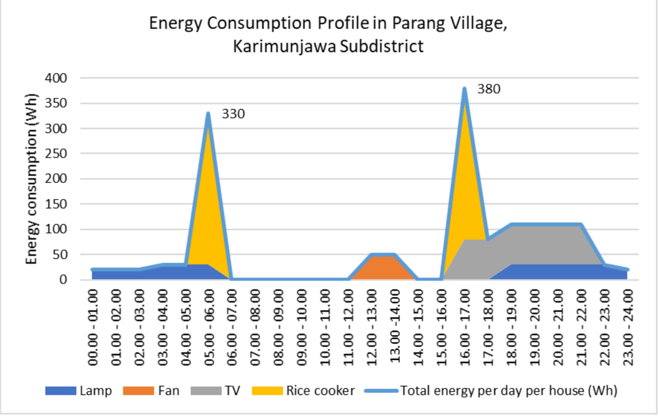

Figure 3. Energy consumption profile in a house in Parang Village

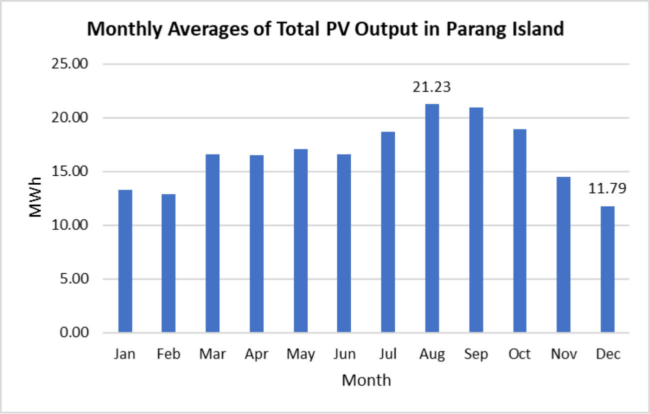

Figure 4. Monthly average PV output in Parang Village (https://globalsolaratlas.info/)

In terms of supply, the calculation is limited to the energy output of the 135 kWp solar powerplant. Due to system using different distribution line for the diesel powerplant, the calculation of supply is applied separately. The community present different load profile for diesel powerplant. Calculation of solar powerplant for energy supply uses the following data.

- Solar powerplant capacity: 135 kWp
- Efficiency of system (assumption): 80%
- Optimal operational time: 5 hours (9:00 a.m. – 2.00 p.m)

Energy generated = installed capacity x optimal time x system efficiency

Energy generated = 135 kWp x 5 hours x 80%

= 540 kWh / day

= 197.1 MWh / year

Figure 4 shows the estimated PV output based on https://globalsolaratlas.info/ in Parang Island. It showed the highest output which occurred in August with an estimated value of 21.23 MWh, while the lowest was in December reaching 11.79 MWh.

Solar powerplant output based on the software using installed capacity data is 198.93 MWh/year. This value is 1.83 MWh higher than the calculation with 80% system efficiency. Supposing that electricity production ranges between 197.1 MWh/year - 198.93 MWh/year, then the maximum electricity consumption that can be delivered to the community would be 1,800 Wh. This value is 300 Wh higher compared to the existing energy limit of 1,500 Wh.

The data shows that community does not have many electrical appliances. In general, they also have limited access to electricity and need additional powerplants in Parang Village and Karimunjawa District. Among some renewable energy options that can be implemented are the addition of solar powerplants, wind powerplants or might be wave powerplant.

Average hourly profiles

Total photovoltaic power output [Wh]

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0 - 1												
1 - 2												
2 - 3												
3 - 4												
4 - 5												
5 - 6	2			1	1			0	5	10	10	6
6 - 7	53	44	56	72	81	64	59	76	115	125	106	69
7 - 8	151	152	192	212	232	212	217	258	302	282	228	153
8 - 9	256	268	324	352	373	356	374	429	469	433	336	244
9 - 10	344	353	433	460	476	475	497	570	605	547	420	314
10 - 11	404	430	510	537	544	545	587	660	692	618	476	364
11 - 12	433	461	533	567	568	573	632	704	717	633	493	388
12 - 13	431	465	528	559	554	556	624	699	696	614	471	383
13 - 14	392	447	499	502	485	507	564	635	616	503	414	341
14 - 15	329	357	417	402	389	411	456	517	490	394	326	271
15 - 16	227	256	296	270	259	273	310	352	324	257	206	182
16 - 17	117	136	149	122	111	119	140	162	136	100	88	91
17 - 18	27	32	24	9	6	8	11	13	9	5	6	10
18 - 19												
19 - 20												
20 - 21												
21 - 22												
22 - 23												
23 - 24												
Sum	3166	3400	3961	4067	4079	4097	4469	5073	5176	4524	3580	2817

Figure 5. Monthly average PV output in Parang Village (https://globalsolaratlas.info/)

1) *Potential of Solar Powerplant*

The information on potential of solar energy in Karimunjawa Subdistrict is available at https://globalsolaratlas.info/. The data shows that 1 kWp solar panel can produce 1,474 MWh/year with maximum energy obtained in August and the lowest obtained in December. Calculation based on area shows that using 1 m^2 has the potential to harvest energy of 1,846 kWh. The detail distribution of each hour in each month can be seen in Figure 5.

2) *Potential of Wind Powerplant*

Wind potential data is taken from https://globalwindatlas.info/. Based on the data, the maximum wind speed on Parang Island is about 5 m/s, which only occurs less than 10% in a year. Wind speed data in Figure 6 shows hourly and monthly wind speed index. The figure presents potential of wind energy in Parang Village, which is relatively small.

The calculation of wind energy utilization is based on kinetic energy principle that using the following basic equation.

$$E_k = 0.5 \text{ x } m \text{ x } v^2 \quad (2)$$

with:

E_k: Kinetic energy (J)
m: air mass (kg)
v: wind speed (m/s)

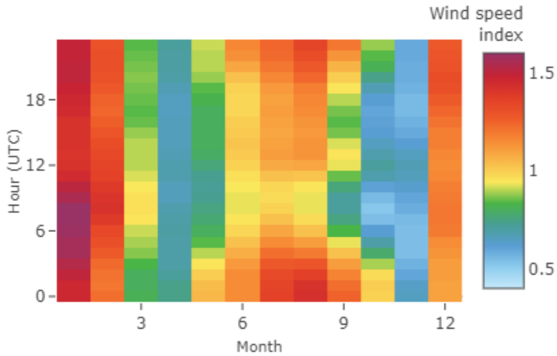

Figure 6. Wind speed in Parang Village (https://globalwindatlas.info/)

Meanwhile, the calculation of effective power generated by wind turbines as follows.

$$E_a = 0.5 \text{ x } (A \text{ x } v \text{ x } \rho) \text{ x } v^2 \quad (3)$$

$$E_a = 0.5 \text{ x } A \text{ x } v^3 \text{ x } \rho \quad (4)$$

with:

E_a: Effective power generated by wind turbines (watts)

A: cross-sectional area (m^2)

v: wind speed (m/s)

ρ: air density (kg/m^3)

Wind energy potential depends on the cross-sectional area of the turbine. Although the cross-sectional area is proportional to the effective power, the larger the wind turbine the more it is possible for the turbine to rotate. Note that the local wind speed is too small. The size of the wind turbine should be chosen based on the wind speed that is the most or most likely to occur.

B. Social and economic Issues

The installation of solar powerplants forces people in the village to understand the technical performance of technology. Increasing community capacity in terms of social and economic aspects is also needed to manage solar powerplants in each village. Amadei [12] mentions that in community development process, there are five steps that must be carried out sequentially and continuously: (1) engage stakeholders on capacity development, (2) assess capacity assets and needs, (3) formulate capacity development program, (4) implement capacity development response and (5) evaluate capacity development. As these five processes are repetitive cycles, when it reaches the fifth step it can be continued by returning to the first step. In addition, there are at least eight capacities that must be owned by the community in managing sustainable energy, namely:

1. Service capacity
2. Institutional capacity
3. Human Resources capacity
4. Technical capacity
5. Economic/financial capacity
6. Energy capacity
7. Environmental capacity
8. Social and cultural capacity

Meanwhile, tourism in Karimunjawa Subdistrict opens new job fields and increasing the local community's income [8]. This research suggests an integrated planning involving various sectors, which are spatial planning, calculation of carrying capacity (ecological, physical, social), utilization of natural resources that are environmentally friendly as well as the roles and responsibilities of each stakeholders.

Another research conducted by Thelisa [13] explained that the rapid growth of the tourism sector increases the local community's income. Socially, the local community's condition started to change. There are seven points of socio-cultural changes that occur, namely livelihood, division of labor, hospitality, education, language, lifestyle and social solidarity. There is a demand to manage the change to improve the sustainability of the community and society in the future. It should be conducted properly by all parties involved.

Observation shows a relationship between increasing community income with the availability of electricity in the village. Socially, the community has ability to buy various equipment and household needs. This increase the competing situation in which people purchases electronic equipment no longer based on needs but desires. For instance, many people have rice cooker and refrigerator at home, although the equipment do not work properly due to inadequate quality of electricity.

It is showed that the addition of powerplant capacity in Karimunjawa using renewable energy would provide advantages, both directly and indirectly. The direct impact would be 24-hour access to electricity, while the indirect one is the change in consumption trends and social alteration in the local community.

Following are several points required to be highlighted in the development of renewable energy in the island areas:

1) The development of new and renewable energy should be supported by the development of sustainable productive enterprises

Analysis on Parang Island clearly shows that in general 1,500 Wh electricity in household was not consumed for productive purposes. For general in Karimunjawa Subdistrict, tourism becomes one of the prospective sectors to increase the economic level. Therefore, sufficient electricity supply is required to support development of the tourism sector in this area. Environmentally-friendly renewable energy can be a tagline or an exciting spot to attract tourists or visitors. Karimunjawa Subdistrict can also introduce eco-green tourism as one of its tourism attractions.

2) The collaboration of all related parties is needed

Providing solution to the problem of renewable energy development in Karimunjawa District is not only the task of the local government, but also the regional and central government. An example of the problem is related to unclear legal status of assets of centralized solar powerplant on Parang and Nyamuk Island. Therefore, as an impact, local stakeholders need to be very careful to manage the operation and maintenance of the powerplant. Furthermore, if there are disruption or failure, the local stakeholders have no idea who will be responsible to solve the problems. It is very important that each stakeholder must understand their role in supporting renewable energy development in rural area.

Moreover, academics need to collaborate with other stakeholders to increase capacity of the community in many aspects mentioned before: service capacity, institutional capacity, human resources capacity, technical capacity, economical capacity, energy capacity, environmental capacity as well as social-cultural capacity.

3) Community assistance, both during and after projects

The trend showing the local community's lifestyle that becomes more consumptive needs to be addressed. As a solution option is assistance and capacity building to the local community regarding the proper utilization of renewable energy installation and productive use of energy to increase their economic level.

Proper assistance can be provided when the local community demands more electricity, which is higher than the solar power system capacity. Energy limiter in each house is applied to limit their electricity consumption. However, some of them cheat by looking for other way to obtain more electricity. One of them is through a bypass. It can cause a failure for the system and management. These issues can be prevented if the local community comprehends the wise and proper use of energy technology.

4) Community engagement in operating technology for a long period

In some cases, local community could conduct an energy limiter bypass to obtain more electricity. Another issue related to the community is the price of electricity. Centralized solar powerplants installed by the government and ESP3 grants is the system with many batteries. The battery replacement and other related management matters become the local community's responsibilities. Therefore, the electricity price determination should be calculated correctly. Should the system undergo damage, the local community already has savings to replace or repair those broken components. For this capacity to be implemented, it is needed to build sense of belonging to the system including the community's awareness and willingness to pay the monthly fee.

IV. Conclusion and Recommendation

This case study shows following challenges faced for electricity management in the islands: (1) the development of renewable energy needs to be accompanied by capacity of productive used of energy, (2) the collaboration of all related parties is needed, such as community, government, academics, etc., (3) Technical, social and economic assistance are carried out in the pre-project phase, during development and after the project, and (4) community engagement in the management of renewable energy in the islands is indispensable.

Further discussion on other renewable energy sources, including wind and wave for next research is recommended. In addition, the social and environmental problem caused by the tourism sector has to be addressed in order to develop sustainable tourism in Karimunjawa.

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APPENDICES

Appendix 1. Energy Data in Karimunjawa Subdistrict

No.	Location	Power plant	Capacity	Number of Powerplant (Unit)	Number of Consumers	Information
1.	Karimunjawa Village	Diesel	500 kVA	1	888	Jepara Regional Budget, 2013
2.	Cikmas/Nyamplungan Hamlet	Diesel	100 kVA	1	229	Jepara Regional Budget, 2006
3.	Genting Island	Diesel	30 kVA	1	70	Jepara Regional Budget, 2006
4.	Genting Island	Hybrid Solar and Wind	10 kWp	1	70	Grants from Ministry of Energy and Mineral Resources, 2009
5.	Kemojan Village	Diesel	100 kVA	1	706	Jepara Regional Budget, 2007
6.	Kemojan Village	Diesel	100 kVA	1	706	Jepara Regional Budget, 2007
7.	Kemojan Village	Diesel	250 kVA	1	706	Grants from Ministry of Energy and Mineral Resources, 2009 (Broken)
8.	Parang Village	Diesel	100 kVA	1	273	Jepara Regional Budget, 2016
9.	Parang Village	Diesel	100 kVA	1	273	Jepara Regional Budget, 2016 (Broken)
10.	Parang Village	Centralized Solar	75 kW	1	338	Grants from Ministry of Energy and Mineral Resources, 2014
11.	Nyamuk Village	Diesel	65 kVA	1	177	Jepara Regional Budget, 2006
12.	Nyamuk Village	Diesel	30 kVA	1	177	Jepara Regional Budget, 2008
13.	Nyamuk Village	Centralized Solar	25 kW	1	199	Grants from Ministry of Energy and Mineral Resources, 2013
14 *	Karimunjawa Village (Genting Island)	Centralized Solar Powerplant	36 kWp	1	96	ESP3 Denmark, 2018
15 *	Parang Village	Centralized Solar Powerplant	60 kWp	1	273	ESP3 Denmark, 2018
16 *	Nyamuk Village	Centralized Solar Powerplant	86 kWp	1	177	ESP3 Denmark, 2018

Source: Ministry of Energy and Mineral Resources, Jepara Regency, 2016.

*data taken from observation

Appendix 2. Energy consumption ini Parang Island

Time	Lamp	Fan	TV	Rice cooker	Total energy /house (Wh)	Total 273 houses (kWh)
00.00 - 01.00	20	0	0	0	20	5.46
01.00 - 02.00	20	0	0	0	20	5.46
02.00 - 03.00	20	0	0	0	20	5.46
03.00 - 04.00	30	0	0	0	30	8.19
04.00 - 05.00	30	0	0	0	30	8.19
05.00 - 06.00	30	0	0	300	330	90.09

Time	Lamp	Fan	TV	Rice cooker	Total energy /house (Wh)	Total 273 houses (kWh)
06.00 - 07.00	0	0	0	0	0	0
07.00 - 08.00	0	0	0	0	0	0
08.00 - 09.00	0	0	0	0	0	0
09.00 - 10.00	0	0	0	0	0	0
10.00 - 11.00	0	0	0	0	0	0
11.00 - 12.00	0	0	0	0	0	0
12.00 - 13.00	0	50	0	0	50	13.65
13.00 - 14.00	0	50	0	0	50	13.65
14.00 - 15.00	0	0	0	0	0	0
15.00 - 16.00	0	0	0	0	0	0
16.00 - 17.00	0	0	80	300	380	103.74
17.00 - 18.00	0	0	80	0	80	21.84
18.00 - 19.00	30	0	80	0	110	30.03
19.00 - 20.00	30	0	80	0	110	30.03
20.00 - 21.00	30	0	80	0	110	30.03
21.00 - 22.00	30	0	80	0	110	30.03
22.00 - 23.00	30	0	0	0	30	8.19
23.00 - 24.00	20	0	0	0	20	5.46
Total	**320**	**100**	**480**	**600**	**1500**	**409.5**