Empowering remote island communities with renewable energy: a preliminary study of Talaud Island

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Abstract. This paper describes a preliminary study of the empowering remote island communities with renewable energy. This research is a case study for Talaud island which is located in the border island between Indonesia and Philippines. It is located in Kiama village Talaud Island regency of North Sulawesi province of Indonesia. Method of implementation of this program consists of several stages, namely: (1) Implementation of small-scale solar home system and a wind turbine; (2) Through technology transfer in the capacity building activities to the selected community, in order to provide the skill and knowledge to island community in Kiama Village, Talaud Islands of Indonesia. It is expected that technology implementation will be maintained in the future and sustainable. The life cycle cost analysis is done by comparing two system of pilot projects, namely solar home system and solar home system with a wind turbine. The cost of generating electrical energy with renewable energy is relatively high then it is necessary to provide strategies for the development of power infrastructure for the sake of the energy security of island communities in Indonesia. Further both monitoring and evaluation of the renewable energy system implementation should be conducted for the detail report and analysis.

1. Introduction

The eastern region of Indonesia, especially the island which is the outermost island that becomes the front border requires special attention in the case of energy problems. Dependence on the supply of fossil fuels from the island to the island that have high transportation costs and produce greenhouse gases need to be minimized. For this reason the utilization of renewable energy as an alternative energy source for energy generation needs to be studied.

Talaud island was chosen as the location to be studied because of its specificity located on the border between Indonesia and the Philippines is the outermost island which became the front porch of Indonesian territory. Geographically, Talaud island is located between 125° 9'28'' – 125° 24'25'' E and 02° 4'13'' – 02° 52'47'' N. Talaud island is situated in regency of Talaud Island. It takes 10 hours by boat or 1 hour by flight from Manado, the capital city of North Sulawesi province. The island of of Talaud islands is shown in Figure 1.
Talaud islands are facing the high cost of diesel fuel due to remoteness from Sulawesi mainland. This paper presents a preliminary study of renewable energy utilization based on local availability of renewable energy resources in the remote island of Indonesia for an independent system electrical power on a rural house scale.

2. Literature Reviews

Analysis of solar energy potential has been done through a research [1]. The implementation of solar home system in rural Bangladesh [2] has also been reviewed as a reference for the implementation of solar power plant systems in rural Indonesia.

Many small islands in every region in the world use or propose to use renewable energy: the Azores and Canary islands in the North Atlantic, Gotland and Samsoe in the Baltic, Sardinia and Sicily in the Mediterranean, Mauritius and Reunion in the Indian Ocean, Fiji and the Hawaiian islands in the Pacific, as well as Dominica and the Guadeloupe islands in the Caribbean. Many small islands have achieved their goal of transitioning to renewable energy [3].

References [3] stated that around the world a few islands already have taken the decision to become a Renewable Energy Island (REI) in the short or medium term. Samsoe (Denmark), Pellworm (Germany), Aeroe (Denmark), Gotland (Sweden), El Hierro (Spain), Dominica and St. Lucia have an explicit target of becoming 100% self-sufficient from renewable energy sources. Nearly 70% of the islands in the overview that are utilising renewables for electricity generation are producing between 0.7-25% of their electricity from renewable energy sources.

References [4] states “Life cycle cost (LCC) analysis is a tool used to compare the ultimate delivered costs of technologies with different cost structures”. The function of LCC analysis is to calculate the cost of delivering over the life of the projects, is not only calculate the initial costs or operating cost.

The life cycle cost (LCC) analysis which is consist of capital cost, recurring maintenance cost, fuel cost and replacement cost has been used for economic evaluation of a stand alone residential of photovoltaic for remote area in Bangladesh [5]. The LCC was analyzed by considering 20 years of life cycle, discount rate as 7%, general inflation as 3% and the estimated of the load power supply as 640 Wh per day. In this analysis, the result indicated the LCC to be economically feasible compare to conventional electricity using diesel generator.

The cost of generating electrical energy with renewable energy is relatively high then there is a need for policies and strategies for the implementation of renewable energy in the archipelago, among others: cooperation with parties that have been successful with the implementation of renewable energy technologies, increased priority implementation of renewable energy-based energy infrastructure for potential locations. The adoption of a pro-island energy policy in the foremost island
as a terrace that needs to be enriched for the sake of security, welfare and beauty as an added value in Indonesia's border region [6].

3. Methods
The data collected for the input, in the form of population data, the existing condition of electricity in Miangas island are given in Table 1.

| Number of People | 775 |
|------------------|-----|
| Number of Households | 324 |
| Daily Load Average | 500 kWh |
| Installed Capacity of Diesel Powerplant | 250 kW |

Table 1. Communities Data in Talaud Island

Feasibility of solar energy system mainly depends on solar radiation available at the specific location [7]. Data of solar energy sources in term of solar irradiation in Talaud island have been taken from NASA (National Aeronautics and Space Administration) website by input the latitude and longitude of the location. The average annual solar radiation equals to 5.53 kWh/m²/day. NASA also gives the wind speed data for Talaud island. The data of solar radiation and wind speed in Talaud island are presented in Table 2.

| Month       | Average Solar Irradiation (KWh/m²/day) | Average Wind Speed (m/s) |
|-------------|----------------------------------------|--------------------------|
| January     | 5.01                                   | 2.57                     |
| February    | 5.43                                   | 2.57                     |
| March       | 6.05                                   | 2.57                     |
| April       | 6.40                                   | 2.57                     |
| May         | 5.73                                   | 2.57                     |
| June        | 5.00                                   | 3.08                     |
| July        | 5.32                                   | 3.59                     |
| August      | 5.50                                   | 4.11                     |
| September   | 5.84                                   | 3.08                     |
| October     | 5.71                                   | 3.08                     |
| November    | 5.38                                   | 2.05                     |
| December    | 5.01                                   | 2.57                     |

Table 2. Average Monthly Solar Irradiation and Wind Speed Data in Talaud island

The implementation of solar home system technology in coastal communities of Talaud island provides measurable outcomes that affects the application of appropriate technology to the community and improves the welfare and convenience of the community in Kiama village as described in Figure 2.
Implementation of solar home system technology in Kiama village has been done in several stages as described below:

3.1. Introduces small-scale solar wind power plant technology.
Implementation of solar home system as a small pilot in a home which is located in Kiama village in Talaud island has been done by using a solar panel 50 Wp, battery, inverter and system controller. The total capital cost of equipments and installation are counted about Rp. 5,000,000,-. The cost of wind turbine with capacity 50 Watt and the simple tower are counted about Rp. 5,000,000,-.

3.2. Technical assistance and guidance on small-scale solar power plant operation.
Assistance on how to operate an installed solar power plant at sample houses has been done by the team who has knowledge of this technology. A standard operating guide has been written and taught to small home-scale solar power plant users. Assistance was carried out after the installation of the solar power plant at the sample house was done.

First, the approach methods are survey, interview and field visit. Based on preliminary survey, site observation, and data collection in Kiama village, identify the problem by Implementation Team.

Second, at this stage the approach method is to conduct a focus group discussion between implementation teams and partners in Kiama village for finding solutions to the problems of coastal communities in the demand of energy.

Third, the approach method is the application of appropriate technology through the design of the installation of solar home system as a solution in solving communities’s problems, mentoring and technical guidance, as well as counseling for increasing the knowledge and skills of the community on technology and given solutions.

From the results of observation and interviews, it is known that this village has a problem of limited access of houses to the electricity grid. In the initial discussion, implemented team offered a solution that introduces the community to small-scale solar power plant technology. Through the introduction of small scale home system technology, the problem of limitation of electricity access in the village could be solved.

Since Hybrid Home System technology is still relatively expensive, the team decided to install the system at the sample house located in Kiama village, which is located in Talaud island, one of the remote island in North Sulawesi province of Indonesia.

Installation of a small-scale SHS system in a Kiama village in Talaud island is followed by mentoring and technical guidance on the operation of the system and training on how to treat the SHS and wind turbine for rural and remote communities.

4. Results
The proposed of hybrid power generation model based on PV and wind energy for a rural house in Talaud island as shown in Figure 3.

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Figure 2. Implementation Method of the Hybrid Home System Program Activities

Preparation To the Implementation Program:
1. Site observation
2. Survey for Problem Identification
3. Interview and Focus Group Discussion

Program Implementation in Kiama Village:
1. Introduce solar home system and a wind turbine for a sample house
2. Technical assistance and guidance
3. Training for solar home system and a wind turbine maintenance

Report of the Implementation Program:
1. Monitoring
2. Evaluation
Monitoring and evaluation of program implementation of solar wind power model for a rural house in Kiama village are done by observation and economic evaluation through life cycle cost analysis. The sustainability of this program can be sustained through the transfer of knowledge and skills regarding the operation and maintenance of technologies that already introduced to the coastal communities in Kiama village, Talaud island.

The results of economic evaluation of a stand-alone solar home system in Talaud island are presented in Table 3.
Table 3. Economic Evaluation of a SHS in Talaud Island

| Daily Energy Generated (Wh) | Total Energy in 20 years (kWh) | LCC of SHS only (Rp/ kWh) | LCC of SHS with wind turbine (Rp/ kWh) |
|-----------------------------|-------------------------------|--------------------------|-------------------------------------|
| 1                           | 200                           | 1460                     | 3424                                | 6848                                |
| 2                           | 300                           | 2190                     | 2283                                | 4566                                |
| 3                           | 400                           | 2920                     | 1712                                | 3424                                |
| 4                           | 500                           | 3650                     | 1369                                | 2738                                |
| 5                           | 600                           | 4380                     | 1141                                | 2282                                |

The economic evaluation analysis of a Solar Home System in Kiama Village which is located in Talaud island has been presented in Table 3. It is found that the Life Cycle Cost of a SHS will be varied depend on the daily energy generated to supply energy for a home. The more energy generated for this system installed, the more total energy could be generated for 20 years of the system life. The life cost for this SHS will be achieved good price in the below of 2000 Rp/ kWh as compare to the electricity price from the grid of PLN. The LCC analysis shows double cost of Solar Home System with a wind turbine installation to power a rural house in Kiama village. Through direct observation of wind turbine indicates frequently work due to the wind has no occur in the area of installation.

5. Conclusion
The problem of limited access of electricity for the coastal community in Kiama village, which is located in Talaud island has been searched to find the solution. Implementation of small scale solar home system technology has been introduced in a house as a small pilot project. In the future, detail data will be collected from the implementation in order to monitor and evaluation of the practices.

The implementation of SHS in Kiama village which is located in Talaud island have been done through the introduction and capacity building of SHS technology and a wind turbine in a sample house as a small pilot.

The outcomes the implementations of SHS system in coastal communities are as follows: design and installation of SHS technology for a small pilot home as well as improvement of the community’s knowledge and skills about SHS technology by a training.

6. References
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