Development of Power System Infrastructure Model for the Island Communities: A Case Study in a Remote Island of Indonesia

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Development of Power System Infrastructure Model for the Island Communities:

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Abstract— Electricity infrastructure for a remote island needs to be given attention for the security and wellbeing of island communities. The purpose of this study is to develop a model of renewable energy infrastructure based on renewable energy available locally in an archipelago region. This research is a case study for Kokorotan Island that located in eastern Indonesia region of Talaud Island regency of North Sulawesi province bordering with Philippines. The research method used is primary and secondary data collection, data analysis using software HOMER. Based on the simulation results, a model of renewable energy-based power generation system for the community's electric energy needs in Kakorotan Island is obtained. The cost of generating electrical energy with renewable energy is relatively high then it is necessary to have policies and strategies for the development of power infrastructure for the sake of the energy security of island communities in Indonesia.

Keywords—Renewable Energy; infrastructure model ; island communities; remote island; Indonesia

I. 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 infrastructure needs to be discussed and studied.

Renewable and locally available renewable energy infrastructures for island communities need to be assessed and developed. Talaud Islands 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.

Kokorotan island, which is one of the remote island on the border of Indonesia with the Philippines, situated in regency of Talaud Island It is located at latitudes 04^0 37'North and longitudes 127^0 09'East. It takes 3 hours by boat from Malonguane (the nearest city as the capital of Talaud region). The total land area is approximately 1710 km^2. According to the data, the communities of Kokorotan island consists of 232 households. The island of Kokorotan as the part of Talaud islands is shown in Figure 1.

Figure 1. Map of Talaud Islands and Kokorotan Island [1]

Kokorotan island is facing the poor electricity accsess due to geographical inaccessibility, lack of electrical infrastructure and low population condition. However this island has chosen to be analysis as a model for power system infrastructure based on renewable energy availability for island communities. This paper presents a power system infrastructure model for island communities based on renewable energy that locally available for Kokorotan island as the remote island which is situated in the border of Indonesia and Phillipines.

II. POWER SYSTEM INFRASTRUCTURE MODEL FOR ISLAND COMMUNITIES

This section presents literature review about the analysis works for power system infrastructure model for island communities by utilizing HOMER (Hybrid Optimization of Multiple Energy Resources) software from National Renewable Energy Laboratory (NREL).

HOMER software has been used to perform the techno economic feasibility of possible models in developing the power system infrastructures. HOMER is an optimization software package, which can handle different technologies (including PV, wind, hydro, fuel cells) and evaluate design options for both off-grid and grid-connected power systems for remote, stand alone and Distributed Generations applications [2].

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There are many studies has been conducted to study of HOMER utilization for analysing the model of power system infrastructure. Dursun et al [3] studied a micro-rid wind-PV hybrid system for a remote community with 50 houses in order to find the optimal configuration and present a techno-economic analysis for the considered power generating system by the HOMER software. Bekel and Bjorn [4] presented a feasibility study for a stand-alone solar-wind based hybrid energy system for a model community of 200 families using HOMER software. Shaahid et al [5] evaluated the technical and economic potential of hybrid-wind-PV-diesel power systems to meet electrical energy demand of a remote village by suing HOMER software.

The location of the community is important to know as electricity demand patterns differ with geograhical site and cultural habits [6].

III. METHODS

The research method used is primary and secondary data collection, data analysis using HOMER software.

The primary data collected in this study, in the form of population data, the existing condition of electricity in Kakorotan island are given in Table 1.

Table 1. Communities Data in Kokorotan Island

Number of People	881
Number of Households	232
Power Electricity Demand	260 W/ day/ household
Installed Capacity of Solar Cell	50 kW

Feasibility of solar-wind hybrid renewable energy system mainly depnds on solar radiation and wind energy potential available at the specific location [7]. Data of renewable energy sources in term of solar irradiation and wind speed in Kokorotan island have been taken from NASA (*National Aeronautics and Space Administration*)website through HOMER are summarized in Table 2.

Table 2. Average Monthly Solar Irradiation an Wind Speed in Kakorotan Island [8]

Month	Solar Irradiation(KWh/m^2)	Wind Speed (m/s)
Jan	4.527	2.57
Feb	4.953	2.57
March	5.583	2.57
April	5.714	2.57
May	5.094	2.57
June	4.466	3.08
July	4.601	3.59
August	4.850	4.11
Sept	5.418	3.08
October	5.125	3.08
Nov	4.648	2.05
Dec	4.719	2.57

Hourly power electricity demand in Kokorotan island is decribed in Figure 2.

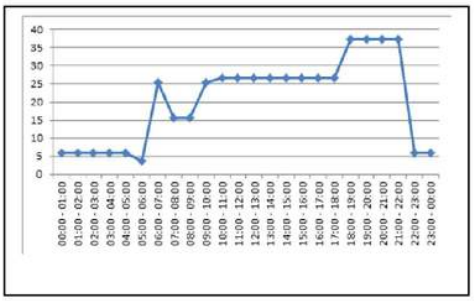

Figure 2. Load curve of Power Demand for Kokorotan Island

This data collection required for input to software HOMER is primary data, secondary data and literature study. This software developed by the National Renewable Energy Laboratory (http://www.homerenergy.com) a division of the US Department of Energy used to design a hybrid power plant system using renewable energy. Modeling using Homer is valid and can be used for modeling in research as has been done in various locations [9], [10], [11] and [12]. Homer's software capability for modeling has been demonstrated, through two experiments on small-scale systems by comparing Homer modeling results with direct measurement results [13].

IV. RESULTS

For the determination of the type of wind turbine to be proposed, the average wind speed in the Kakorotan islands is crucial in the selection of wind turbines. This is done to optimize the existing wind potential in Kakorotan Island. It is proposed that turbine type HY-1000-L (1 kW) with consideration of wind speed that exist in Kakorotan island.

The design for solar power systems uses 305 Watt solar panels with a polycrystalline silicon type. The batteries used in this system simulation are battery type Surrette 4KS25P deep cycle batteries that have a normal voltage of 4 volts, capacity 1.350 Ah.

Input parameters required on HOMER software are load data, wind speed, solar light intensity, and component data used such as price (capital), replacement, O & M and others. The proposed of power system infrastructure model based on renewable energy for Kakorotan island as shown in Figure 3.

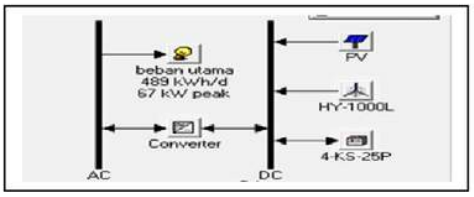

Figure 3. The Proposed of Power System Infrastructure Model based on Renewable Energy for Kakorotan Island

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The simulation results of system model are shown Figure 4. HOMER determines the value of the appropriate component capacity so as to produce a good and reliable power system in serving the load in terms of capacity of power plant component, yearly electric energy production, initial capital cost, total Net Present Cost (NPC), energy cost per kWh (COE), O & M cost and excess electricity.

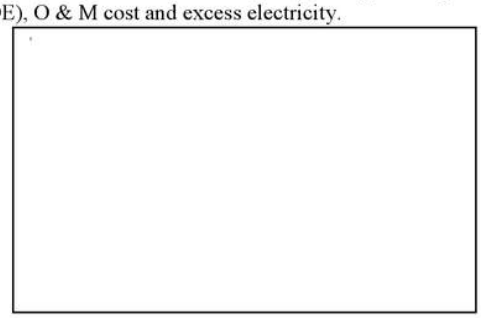

Figure 4. The result of Simulation for the Model of Power System Infrastructure Based on Renewable Energy for Kokorotan Island

Figure 4 shows the blue block that indicates the results with best result of hybrid power plant configuration on Kakorotan island is with a PV component of 100 kW or 328 units of 305 Watt PV, 18 units of 3 kW wind turbine of, 360 units of 4 V 1350 Ah battery, 18 units of 3.8 kW Converter. The HOMER calculations also show the value of initial capital, operating cost and total Net Present Cost (NPC). Total value of NPC (Net Present Cost) is the cost value of the overall cost of the plant operates for 25 years minus the selling price or revenue from the system obtained so that the NPC value is $ 974.767.

Production of electricity generated by hybrid power plants is 271,518 kWh/year, which is the total power of PV production 68% and HY-3000L wind turbine of 32%. With electricity consumption (load) of 178,367 kWh / year (100%). The excess energy of this system is 57.396 kWh /year (21.1%), in other words unused electrical energy generated by PV and wind turbines is 21.1% (57.396 kWh/year). From the simulation results, the excess electrical energy generated by PV and wind turbine generators can be use for backup electrical energy of energy consumption on Kakorotan Island.

V. CONCLUSIONS

Based on the simulation result using HOMER software, the model of power plant system for island community's electric energy needs in Kakorotan Island can be obtained.

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.

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