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Techno Economical Study of PV-Diesel Power System for a Remote Island in Indonesia : A Case Study of Miangas Island

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Abstract. The purpose of this study is to conduct the techno economical study of PC-Diesel power system based on renewable energy available locally in a remote island. This research is a case study for Miangas island which is the border island between Indonesia and Philipines. It is located in Talaud Island regency of North Sulawesi province of Indonesia. The monthly average daily radiation in Miangas island is 5.52 kWh/m^2.The research methods used are data collection and data analysis using software HOMER. Based on the simulation result, the techno economic study of PV-Diesel power plant system based on energy demand in Miangas island can be obtained. The Cost of Energy (COE), Net Present Cost (NPC) and operating cost for proposed hybrid PV-Diesel power generation can be assessed for the design power systems uses Canadian solar Max Power C56x-325P of 150 KW PV, 18 string of Surette 6CS25P, Diesel Generator 50 kW and converter Magnum MS4448PAE 25 kW. The annual electricity production from the PV Diesel system for Miangas island is 309.589 kWh in which 80.7% electricity comes from PV, 19.3% electricity comes from diesel with the 109.063 kWh excess electricity. The cost of generating electrical energy in the term of cost of energy (COE), Net Present Cost (NPC) and operating cost are 0.318 US$/kWh, 719.673 US$ and 36.857 US$ respectively.

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.

Miangas 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. Miangas island is situated in regency of Talaud Island. It is located at latitudes 05^0 33’ 20.8’’ North and longitudes 127^0 09’ 6.8’’ East. It takes 3 hours by boat from Malonguane (the nearest city as the capital of Talaud region). The total land area is approximately 3.2 km^2. According to the data from Statistics Centre, the communities of Miangas island consists of 881 people in 324 households. The island of Miangas as the part of Talaud archipelagos is a northest border of Indonesia is shown in Figure 1.

Figure 1. Location of Miangas Island as the northest border of Indonesia
Source: https://www.google.com/maps

Miangas island is facing the high cost of diesel fuel due to remoteness from Sulawesi mainland. This paper presents a techno economical study of PV-Diesel power system for the study of Miangas island in Indonesia.

2. Literature Reviews

This section presents literature reviews 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 [1].

There are many studies has been conducted to study of HOMER utilization for analysing the model of power system generation. Dursun et al [2] studied a micro-grid 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 Palm [3] 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 [4] evaluated the technical and economic potential of hybrid-wind-PV-diesel power systems to meet electrical energy demand of a remote village by using HOMER software. Sen and Bhattacharya [5] state a hybrid system design can overcome the problem of intermittency of renewable energies and increase reliability of supply. In their research for electrification of remote villages they carry out a case study of an Indian village using HOMER software and find that hybrid system ae technically and economically viable in many locations.

Many studies have been reported analysing renewable energy based on power generation using HOMER. Himri et al. [6] study of hybrid power system for a remote village in Algeria, while Nandi and Gosh [7] present a study of a Bangladesh village and Nfah et al [8] report case study of Ethiophia.

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 [9].
The location of the community is important to know as electricity demand patterns differ with geograhical site and cultural habits [10]. HOMER uses the optimizer propietary algoritm to search for the lowest net present cost system for the specific load and condition [11].

3. Methods

The method to conduct the techno-economic study of hybrid power generation for communities in the remote island of Indonesia is using HOMER software. 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.
The monthly load profile of electricity demand for Miangas island community for one year that used in HOMER simulation as shown in Figure. 2

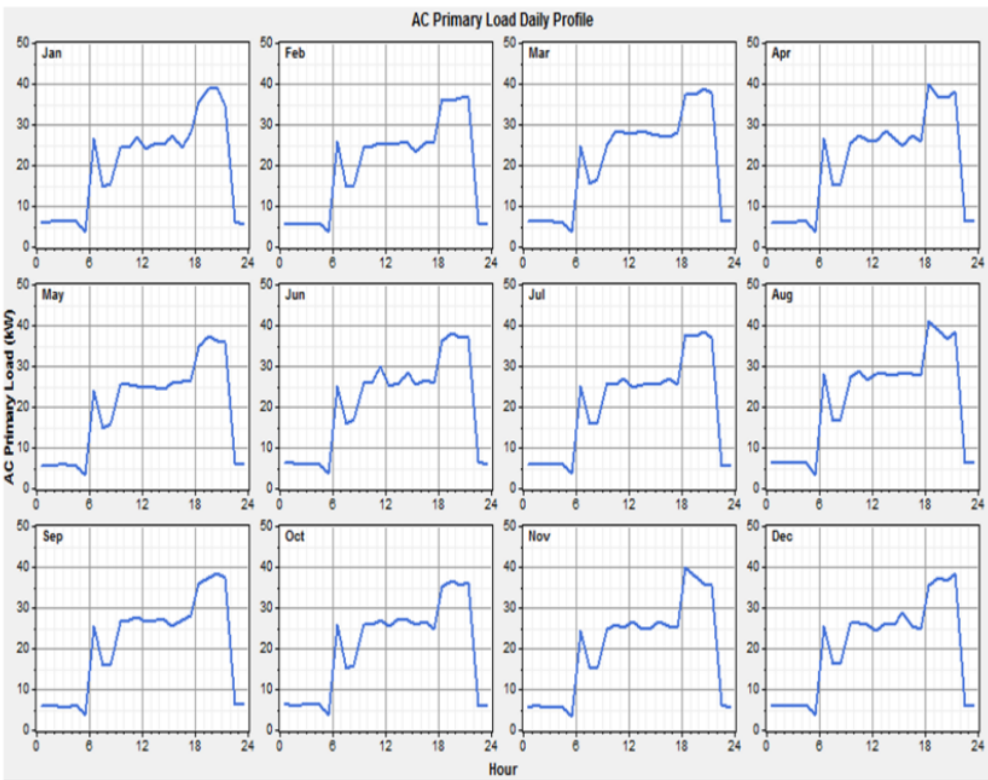

Figure 2. The Monthly Load Profile for Miangas Island

Feasibility of solar energy system mainly depends on solar radiation available at the specific location [12]. Data of solar energy sources in term of solar irradiation in Miangas 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/m^2/day. HOMER also gives the clearness index data for Miangas island. Clearness index is the amount of global solar radiation on the surface of the earth divided by the extra-terrestrial radiation at the top of the atmosphere [1]. The data of solar radiation and cleaness index in Miangas island are presented in Table 1.

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Table 1. Average Monthly Solar Irradiation in Miangas island

Month	Solar Irradiation (KWh/m^2/day)	Clearness Index
January	5.01	0.53
February	5.43	0.54
March	6.05	0.58
April	6.40	0.62
May	5.73	0.56
June	5.00	0.50
July	5.32	0.51
August	5.50	0.54
September	5.84	0.57
October	5.71	0.57
November	5.38	0.56
December	5.01	0.54

4. Results

The schematic of hibryd power generation model based on PV and diesel for Miangas island as shown in Figure 3.

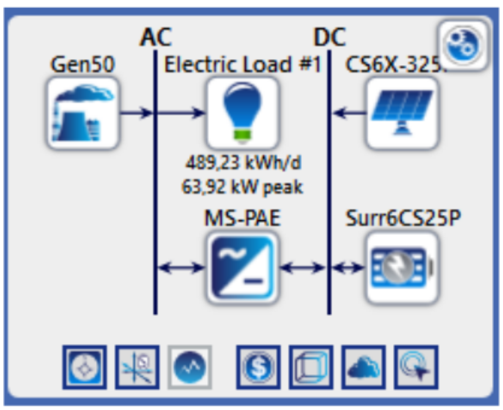

Figure 3. The Schematic of PV-Diesel Power System for Miangas Island

The design for PV-Diesel power systems uses Canadian solar Max Power C56x-325P of PV, battery Surette 6CS25P, Diesel Generator 50 kW and converter Magnum MS4448PAE. 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, years electric energy production, cost of energy (COE), total Net Present Cost (NPC), and operation cost. Techno Economic Analysis of PV Diesel Power System for Miangas Island are shown in Table 2.

Table 2. Techno Economic Analysis of PV-Diesel Power System for Miangas Island

Capacity of PV	150 kW
Capacity of Diesel	50 kW
Capacity of Battery	80 string
Capacity of Converter	25 kW
Yearly energy production from PV	249.688 kWh
Yearly energy production from Diesel	59.901 kWh
Energy cost per kWh (COE)	0.3118 US$
Net Present Cost (NPC)	719.673 US$
Operating Cost	36.857 US$

The simulation results of the electricity production of PV-Diesel power system and monthly average electricity generation are shown in Figure 4.

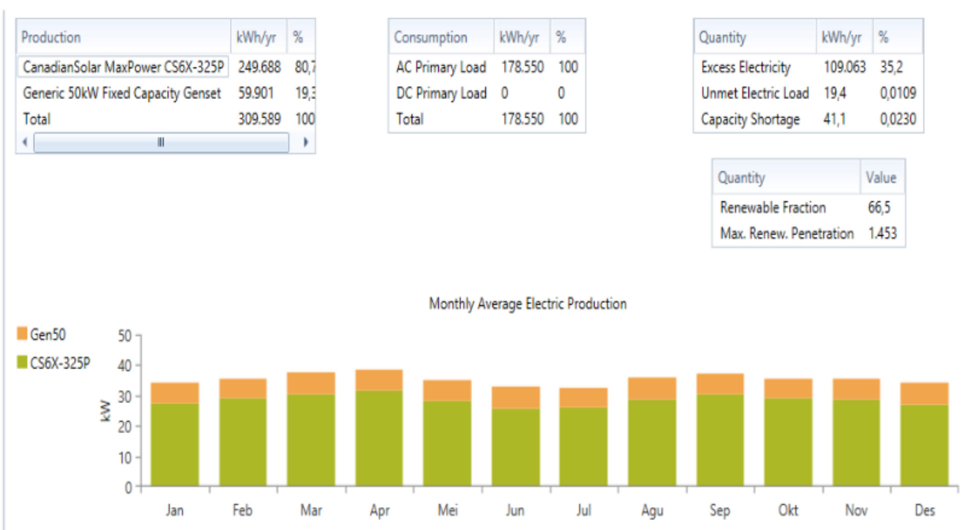

Figure 4. The Simulation Results for the PV Diesel Power System in Miangas Island

The annual electricity production from the PV Diesel system for Miangas island is 309.589 kWh in which 80.7% electricity comes from PV, 19.3% electricity comes from diesel with the 109.063 kWh excess electricity.

5. Conclusion

Based on the simulation result using HOMER software, the techno economic study of PV-Diesel power plant system based on energy demand in Miangas island can be obtained. The Cost of Energy (COE), Net Present Cost (NPC) and operating cost for proposed hybrid PV-Diesel power generation can be assessed for the design power systems uses Canadian solar Max Power C56x-325P of 150 KW PV, 18 string of Surette 6CS25P, Diesel Generator 50 kW and converter Magnum MS4448PAE 25 kW.

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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