International Journal of
Innovation in Mechanical Engineering & Advanced Materials (IJIMEAM)
www.umb-intl-journal.com

Vol.1 (No.1). 2015. pp. 27-31
Published online: December 1, 2015
ISSN: 2477-541X

OPTIMIZATION OF SOLAR-WIND-DIESEL HYBRID POWER SYSTEM DESIGN USING HOMER

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Abstract
Indonesia has a lot of potential for renewable energy. Electricity generation from hybrid solar and wind energy will be a prospective solution to fulfill electricity supply for remote and rural communities. Although diesel generator was still part of the hybrid power system, however, with a proper design, the fuel consumption could be reduced significantly. HOMER software was utilized to aid the design process by providing optimum configuration of the hybrid power system components in terms of performance and economy.

Keywords: hybrid power system, wind, solar, HOMER

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1. Introduction

As the largest archipelago country in the world located at the equator Indonesia has a lot of potential for renewable energy such as solar, wind, hydro, and ocean energy. However, those abundant sources of energy have not been explored optimally yet. One of the new renewable energy technologies which should be developed to improve access to the electrical energy for remote and rural communities is electricity generation from wind and solar energy combined (hybrid solar and wind). Solar energy is the energy that can be generated from the conversion of sunlight into electrical energy, while wind energy is the energy that can be generated from the conversion of the mechanical force of the wind movement into electrical energy. Both renewable energy potential can be combined into a single hybrid system to produce electricity in an area that has the potential for continuous sunlight exposure throughout the year and sufficient wind to drive turbines.

The configuration of the hybrid power system is shown in Fig. 1. The entire operation of the hybrid system is controlled by Hybrid Power Conditioner (HPC) which contains bi-directional inverter, solar charge conditioner and power management control system [1].

HOMER software was used for the optimization of the hybrid system. The software simplifies the task of evaluating the various configurations of hybrid systems. The result of the optimization is the optimum configuration of the hybrid system components in terms of performance and economy [2].

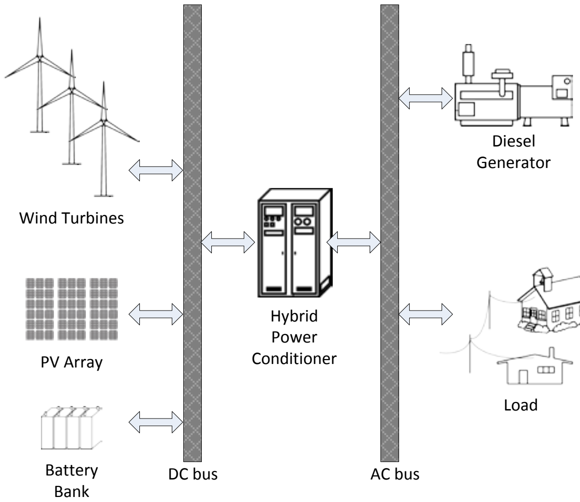

Fig.1. Configuration of Solar-Wind-Diesel Hybrid Power System

2. Wind and Solar Data

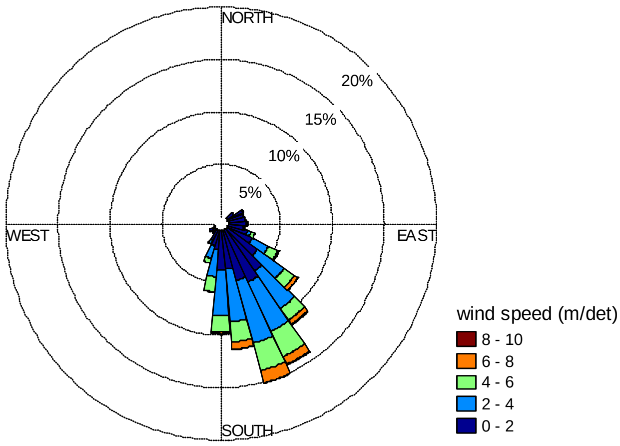

Fig. 2. Windrose of the wind data in the location

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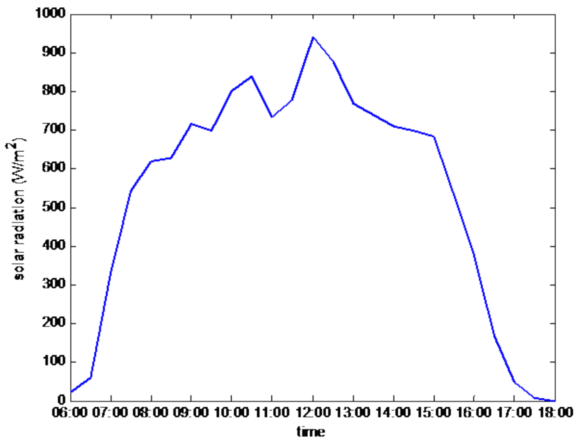

Fig. 3. One day solar radiation in the location

Wind and solar radiation measurements have been performed in the south coast of Java. The wind energy potential in the location is shown by the Windrose in Figure 2. One day solar radiation in the location is shown in Figure 3.

3. Hybrid System Design

The design process of the hybrid system is shown in the diagram in Fig. 4. Basically, the design determined the type and capacity of the wind turbines, PV and batteries and then the optimization process using HOMER software calculated the capacities of the diesel generator and HPC.

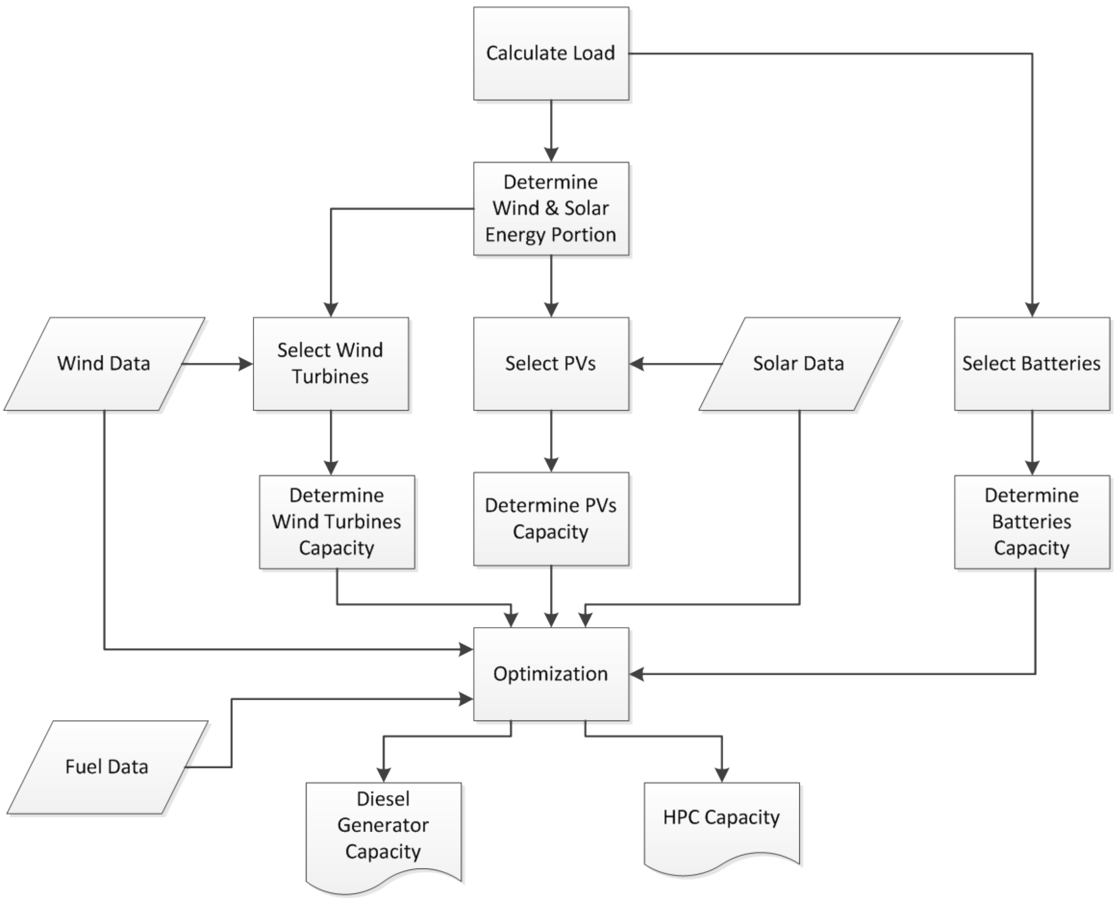

Fig. 4. Design process of the hybrid system

4. Results and Discussion

4.1 Load

The system was designed to supply 326kWh per day with 63 kW peak to the load. The energy demanded by the load was estimated by considering the losses in the system [3]. By considering the amount of the wind and solar energy potential in the location, it was decided that 20% of the total load energy would be supplied by wind turbine system and the remaining 80% by the PV system. This portion was the initial estimation because the diesel generator was not considered yet. The actual values of the portion for each component would be specified in the result of the optimization.

4.2 Wind Turbines

By taking into account the wind potential at the location, the most appropriate wind turbine to be applied was small-scale wind turbines with the capacity around 0.1 kW to 20 kW [4]. Five wind turbines with different capacities and constructions have been evaluated by applying wind data at the location in a simulation. The result showed that the most efficient wind turbine was the wind turbine with a capacity of 10 kW. Therefore, the hybrid system was planned to use two horizontal axis 10 kW wind turbines to meet the energy required which is 60 kWh per day.

4.3 Solar Panels

Solar panels with a capacity of 100Wp power were selected. From the test, the solar panels had an efficiency of 7.09%. Simulation of solar radiation at the location which was applied to the selected solar panels has been performed. It resulted the required number of solar panels was 484.

4.4 Batteries

In the night, the there was only few electric supply from the wind turbines and solar panels, while during the day the supply was excessive, therefore needed to be stored in a battery bank for reserve. The capacity of the battery bank was calculated by following the steps in [5]. The result was that the system required 8600 Ah battery capacity and would be realized with 96 2 V 2000 Ah batteries.

4.5 Hybrid System Model in HOMER

The model of the hybrid system was created in HOMER software by assembling elements of load, PVs, wind turbines, batteries, converter and generators as shown in Figure 5. In this model, HPC was represented by the converter. Data of the energy resources such as solar, wind and diesel fuel as well as other matters such as economic parameters etc. needed to be put in HOMER.

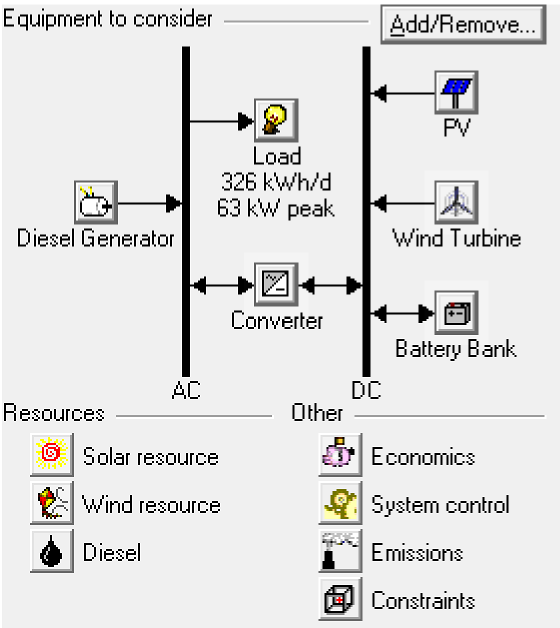

Fig. 1. Wind-Solar-Diesel hybrid power system model in HOMER

5. Optimization Results

The hybrid power system architecture as the The hybrid power system architecture as the result of the optimization is shown in the upper part of Fig. 6 which consists of 48.4kW PV arrays, 4 wind turbines 35 kW diesel generator, 96 2V 2000Ah battery, 45 kW inverter and 45 kW rectifier.

The cost summary is shown in Fig. 6. It can be seen that for PVs, wind turbines, and battery although required high initial capital but there was no or at least little amount in operating and maintenance costs. However diesel generators required a lot of extra costs on fuel to operate.

The annual electricity production of each hybrid system component is given in Fig. 7. It appears that the contribution of electricity from renewable energy is 76% while from conventional energy is 24% of the total production.

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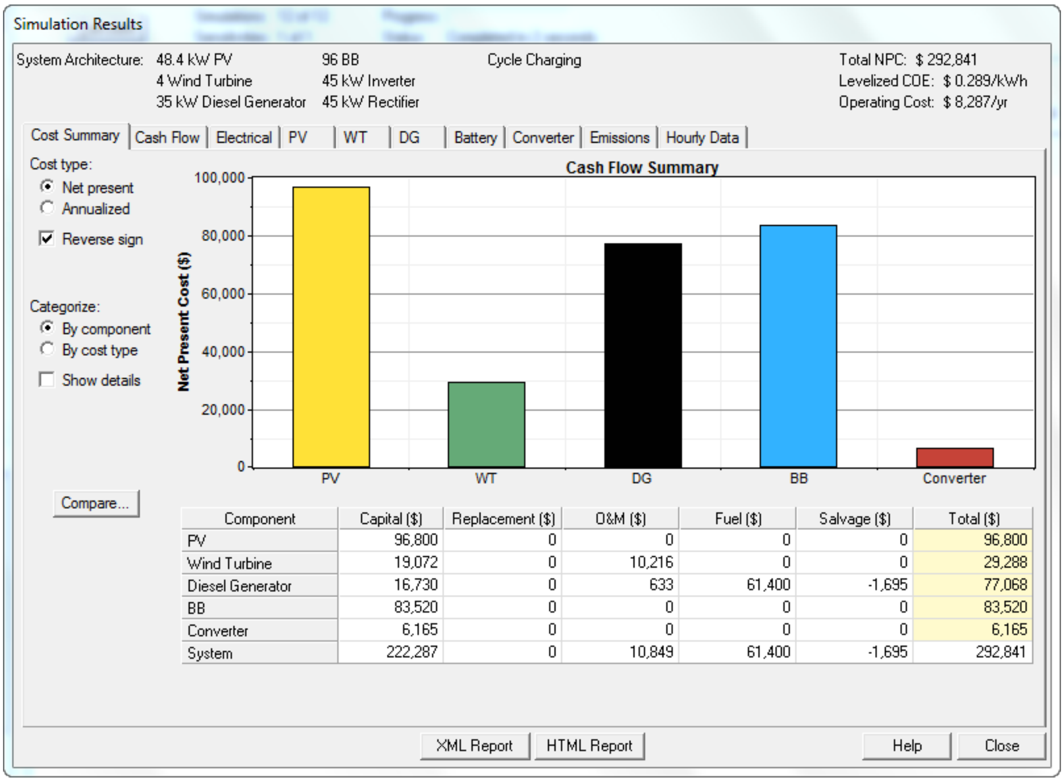

Fig. 6. System architecture and cost summary

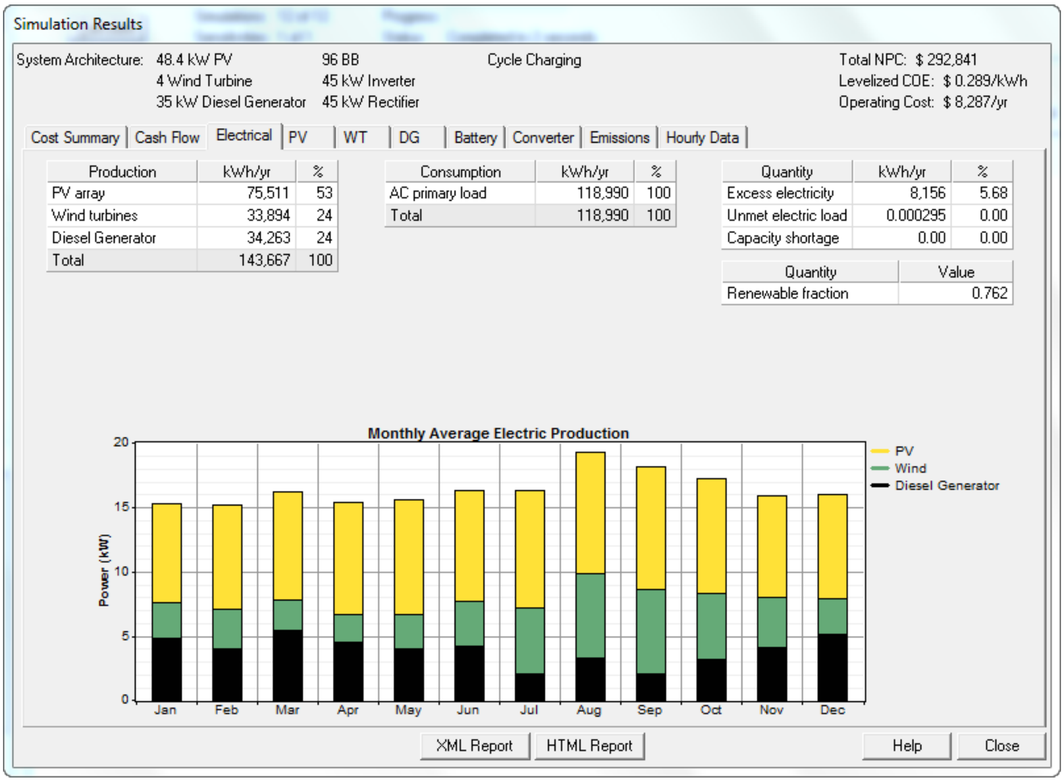

Fig. 7. Electricity production

6. Conclusions

The design of a solar-wind-diesel hybrid power system in the south coast of Java has been performed. HOMER software has successfully optimized the system. The design can be summarized as follows:

- Load: 326 kWh per day with 63 kW peak
- Wind turbines: 4 x 10 kW horizontal axis
- Solar panels: 484 x 100 Wp

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- Battery: 96 x 2 V 2000 Ah
- Diesel Generator: 30 kW
- Hybrid Power Conditioner: 30 kW
- Capital: $217,842

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