ISBN 978-602-53531-8-5

Study of Hybrid "Photovoltaic and Wind Turbine" System Using Homer Program for Regional Cidahu Central – District Kuningan

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Abstract
Electricity supply for East Kuningan Regency especially for Cidahu sub-district is experiencing constraints due to frequent power outages caused by natural and other factors. The area is very potential to be a small and medium-sized industrial area that is environmentally friendly due to a lot of unproductive land, sand excavation. The potential of renewable energy in the form of solar energy and wind energy can be built into a hybrid photovoltaic and wind turbine power plant technology so that it does not rely on electricity supply from the Perusahaan Listrik Negara (PLN). Weather conditions in the region produce an average of year is 25.57°C of Temperature Air, 3.44 m/s Wind Speed , 81% Humidity and 5,08 kWh/m²/day of Sun Radiation. The load requirement for the area is 80 kWh/d 8.22 kW peak using renewable energy is Photovoltaics, Wind Turbine, Converter and Battery. This Hybrid Technology study using the Homer program, obtained the highest COE value 1.75 $/kWh, the lowest 1.73 $/kWh and the highest NPC value of 659,703 $ and the lowest 654,139 $.
Keywords : renewable energy, hybrid, photovoltaic, wind turbin, homer,

1. Introduction

The location of astronomical district of Kuningan is at 6 ° 47'-7 ° 12 'South Latitude and 108 ° 23'-108 ° 47' East Longitude. Viewed from the geographical position, Kuningan Regency is located in the eastern part of West Java on a regional road that connects the City of Cirebon with East Priangan region and Central Java Province. Boundaries as follows: North side with Cirebon regency of West Java Province, East side with Brebes Regency Central Java Province, South side with Ciamis Regency West Java Province and Cilacap Regency Central Java Province, West side with Majalengka Regency of West Java Province.

Currently, Kuningan Regency is planning the development of industrial estate in 6 districts of Cidahu district, Kalimanggis district, Ciawigebang district, Luragung district, Japara district and Pancalang district. The development of industrial estate in Kuningan Regency is one of the means for the development of environmentally friendly industry / warehousing. Industrial Estate can act as the driving of regional economy, give the economic effect of multiplier very big for the increase of Original Regional Revenue (PAD), the absorption of labor, the emergence of new entrepreneurs, the purchasing power of the community will rise, the development of markets, financial institutions,

To establish an industrial estate, the accuracy of location, local government policy that is able to attract investors is to provide ease of providing ready-made industrial sites, the availability of facilities and infrastructure needed (electricity network), ease of licensing on the condition of environmentally friendly industrial areas. The type of industry that can be developed consists of various industries that process forest and agricultural resources such as wood, rattan, bamboo and non-metallic minerals, small industries such as food or beverages and tobacco industries, clothing such as leather and textiles, and building materials such as paper, printing, publishing, rubber and plastic goods and metals industries such as machinery, electricity, science tools. To activate the industrial estate, the necessary electricity infrastructure.

In accordance with the government's energy-efficient program, the availability of electrical energy is exploited to utilize as optimally as possible local renewable energy sources such as solar energy and wind energy. So it is necessary to study first for the operation of Wind Energy (PLT Angin) and Solar Energy (PLTS). Overall integration of the two kinds of power plants is called Hydride Power Generation (PLTH). The output of this study is the performance or capability of PLTH, namely the integration between PLTS and PLT Angin based on renewable energy, in the form of total power of PLTH, the excess of electrical energy generated, and the cost of electricity generation. Data processing using HOMER software.

HOMER (Hybrid Optimization Model for Energy Renewable).

HOMER is a software used to help modeling of a power system by using a variety of renewable resources options. With HOMER, the most optimal specification of energy sources can be obtained - a possible source of energy. We must include load data, solar resource data, wind resources from areas where we will build industrial estates (loads), economic data, data constraints, system control inputs, emissions data and solar price data. Energy sources that may be used are diesel generators, solar cells (PV), wind turbines and so on.

HOMER simulates the operating system of a system based on the calculation of each energy for 8,760 hours in 1 year. The HOMER compares the electrical and thermal loads within an hour for the energy that the system can supply at that time. If the system meets the load throughout the year,

HOMER estimates the lifecycle cost of the system, calculates capital costs, replacement, operation and maintenance, fuel and interest. The hourly energy flow can be seen in each component, as well as annual costs and performance summaries.

After simulating all possible system configurations, HOMER displays a list of system feasibility, which is sorted by lifecycle cost. The lowest cost system is at the top of the list so it can easily be found as well as a list of other eligible systems eligibility.

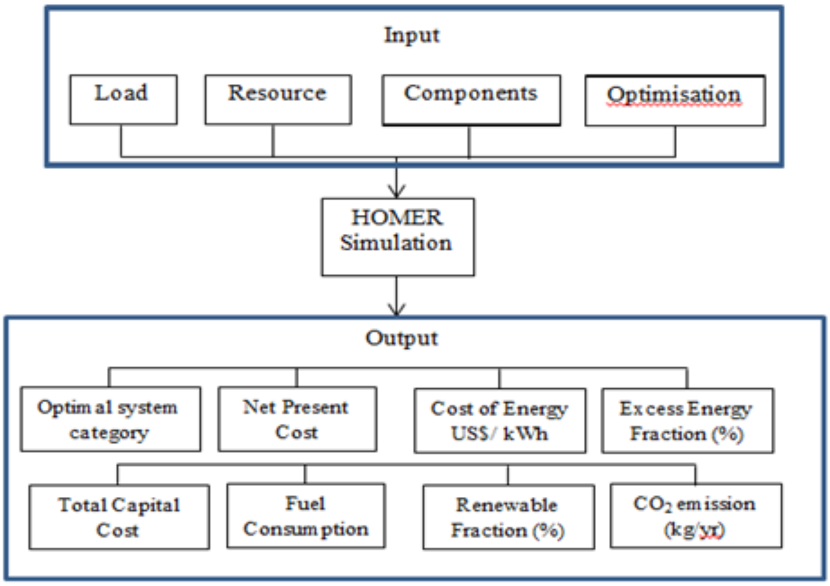

Fig. 1: HOMER Simulation and Optimization System

To know the optimum design of renewable energy, especially wind energy and solar energy. The output of this study is a configuration between PLT Angin and PLTS based on renewable energy in the form of total power of PLT Angin, PLTS, excess electricity generated, electricity generation cost and emission output.

The problems that will be discussed in this paper are as follows:

1. How is the potential of renewable energy in Cidahu District, Kuningan Regency, West Java in this case wind energy, solar energy
2. Why in need optimumisasi using software HOMER.
3. Optimization study of PLT Angin and PLTS development in Cidahu District, Kuningan Regency West Java using Homer software.
4. Evaluation of capacity optimization of PLT Angin and PLTS development using Homer software.
5. Environmental impacts that occur from the development of PLT Angin and PLTS to the community local, in terms of the amount of emissions generated.

Hybrid Power Generation System

Renewable energy sources have great potential when used to generate electrical energy, which can be used in isolated areas using hybrid generating systems. Hybrid generating systems are designed to produce electrical energy. The system consists of several generating units such as PV, wind turbines, micro hydro, and generators. The size of a hybrid generating system varies, from systems that have the capacity to supply one or more homes, to systems with very large capacity to supply power grids in remote areas. The hybrid generation system is one way to provide electrical energy to remote areas in different parts of the world where the cost of developing large-scale power lines is too high and diesel fuel transportation costs are also very high. The use of hybrid generation systems reduces the use of expensive fuels, enabling clean and environmentally friendly electricity production and improving living standards of people living in remote areas.

2. Research Methodology

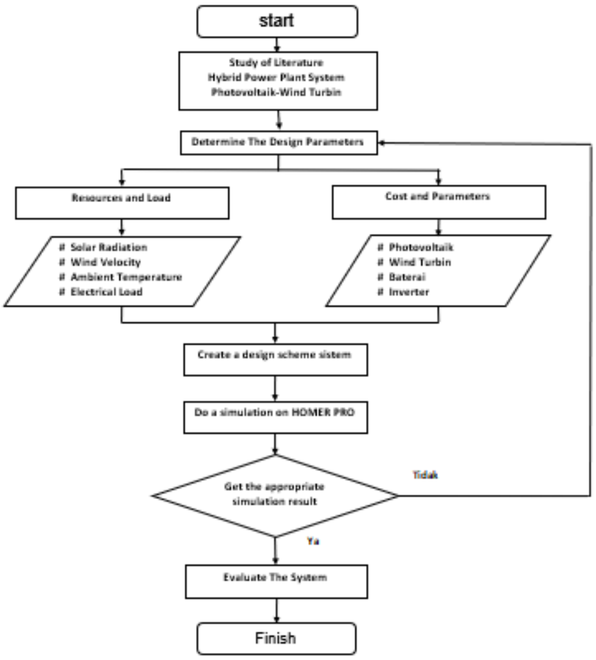

Fig 2: Flow Diagram of Research

Study of literature

Learn the working principles, characteristics and configurations of photovoltaic hybrid power generation systems, wind turbines and generators.

Define Design Parameters

The choice of location for this study is Cidahu District, Kuningan Regency, West Java, by obtaining design parameters such as solar radiation, wind speed and temperature of BMKG, and other conditions that can affect hybrid system performance, as well as component cost and technical specifications of the manufacturer.

Create a System Schema

Schematic design of hybrid power plant system with 20 kW design capacity and component specifications made using HOMER software.

Conducting Simulation

The simulation is done by using HOMER software to get some optimization results from the design of hybrid photovoltaic power system-wind turbine generator, so that can be selected combination of expected system based on capacity and cost.

Evaluating the System

To evaluate macro (economic and technical) to the simulation result by conducting sensitivity analysis to see the effect of a variable on the simulation result, in this case to the selection of system combination viewed from the cost factor of photovoltaic capital, wind turbine and generator, and the performance of any component if the design of this system is operating later.

3. Research Result and Discussion

3.1. Research Sites

Research location for industrial area / factory is in Cieurih Village Cidahu District Kuningan Regency West Java. (6 ° 57.8 'South Latitude, 108 ° 39.5' East Longitude).

Fig.3: Research Site

3.2. Environmental Data Conditions

Data of environmental weather conditions that occurred in the research location of Cidahu sub-district from HOMER average in 1 year are as follows:

- Temperature = 27.28 ° C
- Wind Speed = 6.81 m/s
- Moisture = 81%
- Solar Radiation = 5.04 kWh/m^2/day

Fig 4: Temperature Data and Graph at the research location

Potential Wind

Based on data obtained average wind speed in District Cidahu Kuningan measured with a height of 10 meters from the surface of the soil and altitude of 1450 m above sea level is 6.810 m / s. Wind speed data of Cidahu sub-district of Kuningan District for one year can be seen in Fig 6.

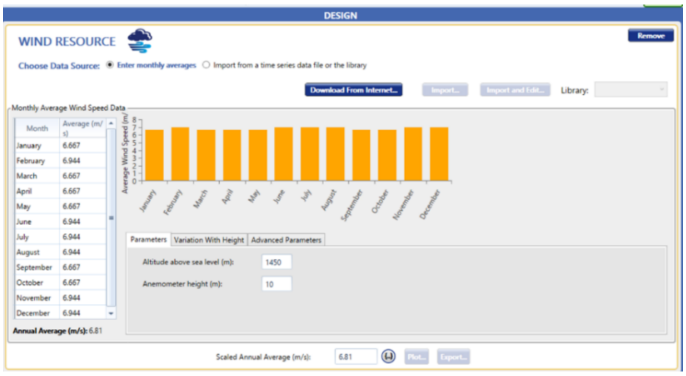

Fig. 5: Wind Speed Data and Graph at the study site

The Potential of Solar Radiation

HOMER required data to perform optimization of power plant system is clearness index and daily radiation (kWh/m^2/day) for one year in District of Cidahu Regency of Kuningan. Clearness Index and Solar Radiation data are the global average of solar radiation on a horizontal surface, expressed in kWh/m^2, for every day of the year. Clearness Index averaged 0,509 and average daily radiation for Cidahu District of Kuningan Regency is 5.040

kWh/m^2 /day. Data sources are obtained through HOMER assistance that will connect to NASA satellite via internet connection by providing latitude and longitude of research location.

Fig. 7 is data clearness index and daily radiation.

Fig. 6: Sunlight radiation data and graphs at the study sites

3.3. Schematic Configuration Systems

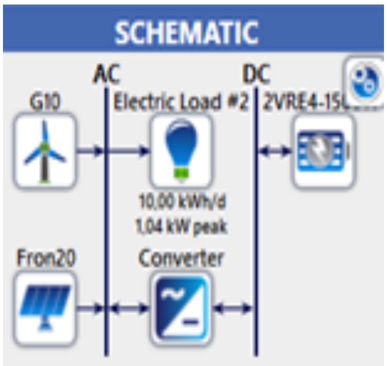

Fig 7: PLTH design using HOMER program

3.4. Electrical Expenses

Electrical system in Cidahu District Kuningan Regency to condition or supply a small and medium industry is isolated system. Electrical needs are supplied by PLT Angin and PLTS with a capacity of 10 kWh/day 18.36 kW peak. The main load here is the burden for small and medium business activities with a daily average load of 7.38 kW and 177 kWh/d and for peak loads of 10 kW occurs at 5:30 to 21:30 pm, with a load factor of 0.4.

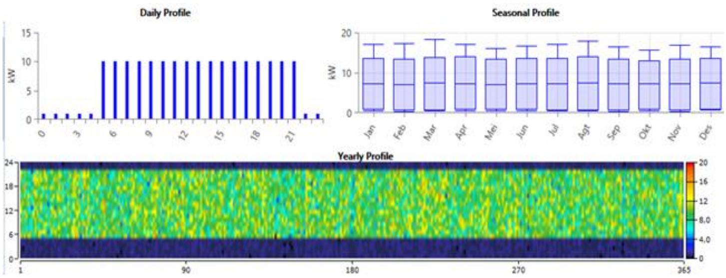

Fig 8: Graphs and daily load curves at the research site

3.5. Photovoltaik

The Photovoltaics module used in this study is

Table 1: Technical details and Photovoltaics costs

PV SYSTEM	
Model name	Fronius Symo 20.0-3-M with generic PV
Rate capacity	1 kW

Derating factor	96 %
Panel type	Flate plate
Ground reflection	20 %
Operating temperature	45°C
Efficiency	17,30 %
Capital cost	$ 3.000
Replacement cost	$ 2.250
O & M cost	$ 10 / year
Life time	25 years

3.6. Wind Turbine

The wind turbine used is

Table 2: Technical details and cost of Wind Turbine

WIND TURBINE	
Model name	G10 Generic 10 kW
Rate power	10 kW
Hub height	24 m
Capital cost	$ 4.500
Replacement cost	$ 3.000
O & M cost	$ 50 / year
Life time	20 years

3.7. Battery

Battery used is

Table 3: Technical details and Battery cost

BATTERY	
Model name	Discover 2VRE24-1500TF
Nominal capacity	1,48 kWh
Nominal voltage	2 Volt
Roundtrip efficiency	85 %
Min. State of charge	40 %
Float life	18 years
Max. Charge life	1 A/Ah
Max. Charge current	158,7 A
Capital cost	$ 300
Replacement cost	$ 275
O & M cost	$ 10 / year
Life time	1.750 kWh , 15 years

3.8. Converter

The costs and the technical details of the power converters

Table 4: Technical details and Converter costs

CONVERTER	
Rated power	1 kW
Capital cost	$ 800
Replacement cost	$ 600
O & M cost	$ 5 / year
Efficiency	95 %
Life time	15 years

3.9. Cost On PLTH System (PLT Angin - PLTS)

The overall costs of the Hybrid Power Plant generated by the combined system of the Wind Power Generator (PLT Angin) and the Solar Power Plant (PLTS) are the initial Investment Capital ($ 3,000), the Operating Cost of $ 497,81 per year, Net Present Cost (NPC) of $ 659,703, Electricity Cost (COE) of $ 1.75/kWh.

3.10. Results Of Design

RESULTS

Tabular Graphical

Sensitivity Cases
Left Click on a sensitivity case to see its Optimization Results.

Architecture							Cost				System	ABB315	
ABB315 (kW)	ABB315-Inv. (kW)	EO25IIA	2VRE4-1500TF	Converter (kW)	Efficiency1	Dispatch	COE ($)	NPC ($)	Operating cost ($)	Initial capital ($)	Ren Frac (%)	Capital Cost ($)	Production (kWh)
315	315		600	100	0	CC	$1,73	$654.139	$397,52	$649.000	100	3.000	646.842

Optimization Results
Left Double Click on a particular system to see its detailed Simulation Results.

Architecture							Cost				System	ABB315	
ABB315 (kW)	ABB315-Inv. (kW)	EO25IIA	2VRE4-1500TF	Converter (kW)	Efficiency1	Dispatch	COE ($)	NPC ($)	Operating cost ($)	Initial capital ($)	Ren Frac (%)	Capital Cost ($)	Production (kWh)
315	315		600	100	0	CC	$1,73	$654.139	$397,52	$649.000	100	3.000	646.842
315	315	2	600	100	0	CC	$1,75	$659.703	$479,81	$653.500	100	3.000	646.842

EO25IIA			2VRE4-1500TF		Converter	
Capital Cost ($)	Production (kWh)	O&M Cost ($)	Autonomy (hr)	Annual Throughput (kWh)	Rectifier Mean Output (kW)	Inverter Mean Output (kW)
			160	10.802	1,33	1,08
4.500	66.312	50,0	160	6.537	0,807	0,654

Fig 9: Results of HOMER program optimization of PV system, Wind Turbine, Battery and Converter

The cost of the initial capital of a component (capital cost) is the total component installation cost at the beginning of the project. At the time of zero of the project periods for all components; diesel generators, wind turbines, power converters, batteries and PV arrangements. The replacement cost is the cost of replacing the components and includes the cost of disposal of waste at the end of its useful life. In the 25th year of project age for PV systems, 20th year for wind turbines, in the 15th year for batteries and in 15 years for converters. The component O & M cost is the cost associated with operating and maintaining that component.

4. Analysis and Conclusion

4.1. Analysis

According to the optimization results shown in Figure 9, obtained from HOMER software, it can be noted that the optimal configuration is a hybrid system (PV / wind turbine / converter / battery), consisting of 315 kW PV, 0 kW wind turbine, 100 kW converter power and 600 batteries. The leveled COE (Cost Of Energy) of this hybrid system is $ 1.73 / kWh; it is the cheapest COE compared to other configuration systems (wind / PV $ 1.75 / kWh).

The total NPC (Net Present Cost) of a system is the present value of all costs incurred during the process, minus the value of all revenue it earns during the process. Costs include; cost of capital, replacement cost at the cost of waste disposal, operation with maintenance cost and fuel cost. This NPC system is $ 654,139, which is the cheapest NPC in comparison with other system configurations. Renewable fraction of the energy of the optimum system is 100%, ie the energy fraction is sent to the load coming from renewable resources.

4.2. Conclusion

Based on the analysis presented in this paper, it can be concluded that the PV / wind turbine / converter / battery hybrid system is a practical and cost-effective solution to meet the electrical energy needs for environmentally friendly small and medium enterprises in Cidahu district, Kuningan Regency. According to the simulation results, using Home software, a hybrid system consisting of PV, wind turbines, power converters, and batteries, each found an optimal hybrid system configuration in accordance with NPC (Net Present Cost) and COE (Cost Of Energy).

In the results of the HOMER program analysis the cheapest NPC is the NPC of the optimum configuration system ($ 654,139) (PV / converter / battery) compared to other NPC system configurations ($ 659,703) (PV / Wind Turbine / converter / battery); The resulting COE is also small $ 1.73 / kWh.

In the techno-economic studies of the designed PLTH system. These techno-economic parameters can be summarized as follows;

1. The most selected PLTH system is Base System without Wind Turbine added with PV, Converter and Battery.
2. The combination of selected PLTH systems requires Initial Capital ($ 649,000).
3. The combination of selected PLTH systems requires COE ($ 1.73 / kWh), NPC ($ 654,139) and Operating Cost ($ 397,52) the lowest compared with other combinations.
5. Renewable Fraction of selected PLTH system of 100%.

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