International Journal of Energy and Environmental Research
Vol.7, No.1, pp.18-25, September 2018
Published by European Centre for Research Training and Development UK (www.eajournals.org)

POWER GENERATION TECHNOLOGY WITH SOLAR PV-BIOGAS IN RURAL AREAS OF EASTERN JAVA

[1]Aris Ansori [*], [2] Bellina Yunitasari, [3] Soeryanto, [4] Muhaji
[1,2,3,4] Mechanical Engineering Department, Universitas Negeri Suarabaya, Indonesia.

ABSTRACT: *Increasing human activity has an impact on energy needs. Electrical energy is the most dominant type of energy used daily. the increase in electricity demand in East Java was due to an increase in industrial activity in several cities in East Java, such as Surabaya, Mojokerto, Sidoarjo. Meanwhile, the electrical energy needs of several rural areas in East Java, such as in Bodowoso, Bangkalan, Sumenep have not been fulfilled due to geographical factors. The solution to fulfillment of electricity in rural areas can utilize the potential of alternative energy, such as solar energy and biogas. The high potential of solar energy and biogas can be used as an energy source for solar PV-biogas hybrid power plants. The aim of the study was to study the application of a solar PV-biogas power plant model in rural areas. The research method of the solar PV-biogas hybrid power plant is carried out in several stages to assess the potential for the application of hybrid power plants in rural areas in eastern Java. The research method uses a 100 Wp solar PV hybrid system model and 1 KW biogas generator set by analyzing the potential of electricity produced on average per day. The results of the study of the analysis of the potential application of solar PV-biogas power plants show the configuration of the power plant model of generating diesel PV-biogas generators produced by solar PV electric power 1.26 KW per day and 1,244 KW biogas generator with a total electrical energy of 2.50 KW / day. Electric energy consumption per family head is an average of 1 KWh / day with the application of a solar PV-biogas hybrid power plant still with a surplus of 1.50 KW of energy, so the model of solar PV-biogas hybrid generator has a good effective and efficient level to be applied in rural Java east*

KEYWORDS: Environmentally, electricity generation, solar PV, biogas, rural

INTRODUCTION

Electrical energy is one type of energy that is widely consumed in everyday human activities, while others are used for lighting, cooking, production activities. The level of welfare of the population in an area is determined by the availability of electrical energy. Electricity consumption needs can be used as an indicator to measure the level of community welfare. The electricity consumption of the people of East Java experienced an increase of around 15.2 percent from January to September 2017. The largest electricity consumption was in West Surabaya, Pasuruan, Mojokerto, Bojonegoro, Sidoarjo, the amount of electricity consumption due to the industrial area in East Java. (wisnu yulianto Manager of Legal Communication and Administration of PT PLN Distribution of East Java). Meanwhile, there are still some villages that have not been electrified, including in Bangkalan there is one village that has not been electrified, in Bondowoso 3 villages and in Sumenep 29 villages. In percentage, currently only 99.61 percent of villages have electricity. Constraints faced in the provision of energy; energy in rural areas of East Java, one of them is the geographical location factors, such as the difficulty

ISSN 2055-0197(Print), ISSN 2055-0200(Online)

of access roads, the absence of an electrical installation network. The problem of electrical energy needs in rural areas in East Java can be overcome by utilizing renewable energy power plants. Utilization of renewable energy PV-biogas solar hybrid power plants is very potential seen from the intensity of sunlight in East Java in the range of 800-900 W / m^2, while biogas energy can be produced from cow manure with a population of 60% [1].

Table 1. Livestock Population in East Java Province

No	Livestock Type	2013	2014	2015	2016	2017
1	Beef Cattle	3.949.097	4.125.333	4.267.325	4.407.807	4.511.613
2	Dairy Cows	237.673	245.246	255.947	265.002	273.881
3	Buffalo	28.118	28.507	27.792	27.304	26.622
4	goat	2.937.980	3.090.159	3.178.197	3.279.732	3.376.323
5	Sheep	1.185.472	1.221.755	1.282.910	1.370.878	1.362.062
6	Pigs	46.090	41.875	44.602	50.243	57.906
7	Horses	10.581	10.536	10.368	10.416	10.758
8	Chickens Buras	33.806.963	34.539.123	35.728.314	36.490.697	36.439.200
9	Chickens lying	43.066.361	41.156.842	43.221.466	45.880.658	46.900.549
10	Chickens	52.288.601	179.830.682	194.064.874	200.895.528	224.815.584
11	Ducks	4.213.379	4.912.393	4.983.776	5.543.814	5.600.921
12	Entre	946.323	1.261.425	1.354.956	1.444.691	1.494.137
13	Rabbits	326.776	331.476	265.865	344.597	365.990
14	Birds Dara	734.378	978.134	986.371	1.176.582	1.008.033
15	Quail	2.377.749	2.770.908	2.931.450	3.281.998	3.682.453

Source: East Java Provincial Livestock Service, 2017

The potential of large energy sources of solar PV-biogas cannot be utilized by the community as a source of electrical energy in rural areas. Biogas energy produced from livestock manure can produce ± 2 $m^{3\ of}$ biogas per day for one cow / buffalo. Energi biogas for energy sources is highly dependent on the amount of methane gas. Methane gas from fermentation is the main content of biogas which has a calorific value between 590 - 700 K.cal / m3. Another source of heat from biogas is from H_2 and CO in small amounts, while carbon dioxide and nitrogen gas do not contribute to the heat value. The heating value of biogas is greater than other energy sources, such as coal gas (586 K.cal / m3) or water gas (302 K.cal/m3). The biogas heating value is smaller than natural gas (967 K.cal / m3). Each cubic of biogas is equivalent to 0.5 kg of liquefied natural gas (liquid petroleum gases / LPG), 0.5 L of gasoline and 0.5 L of diesel oil. Biogas can generate electricity of 1.25 - 1.50 kilo watt hour (kwh).

The design of a solar PV-biogas electric energy generating unit in rural areas in East Java aims to meet the electricity needs in rural areas. The PV-biogas hybrid solar power generation model requires a study and analysis of its potential in rural applications.

ISSN 2055-0197(Print), ISSN 2055-0200(Online)

International Journal of Energy and Environmental Research
Vol.7, No.1, pp.18-25, September 2018
Published by European Centre for Research Training and Development UK (www.eajournals.org)

Solar PV power plants

Energy released by sunlight is actually only received by the earth's surface by 69% of the total solar emission energy.energy supply *Solar cell* from sunlight received by the earth's surface is very large, reaching 3 x 10 joules per year, this energy is equivalent to 2 x 10^{17} Watts.

Solar module PV power capacity is denoted in watt peak (Wp). This standard refers to the intensity of solar radiation of 1000 W / m² which is perpendicular to the solar cell at a temperature of 25 ° C. The photovoltaic module has a relationship between current and voltage represented in curve IV. When the variable resistance is infinite (open circuit), the current is worth a minimum (zero) and the voltage in the cell is at the maximum value, known as open circuit (Voc) voltage. In other circumstances, when the variable resistance is zero (short circuit), the maximum current is known as short circuit (Isc). If the variable resistance has a value that varies between zero and infinity, the current (I) and voltage (V) will get a variable value as shown in Figure 1, known as the IV characteristic curve in solar cells.

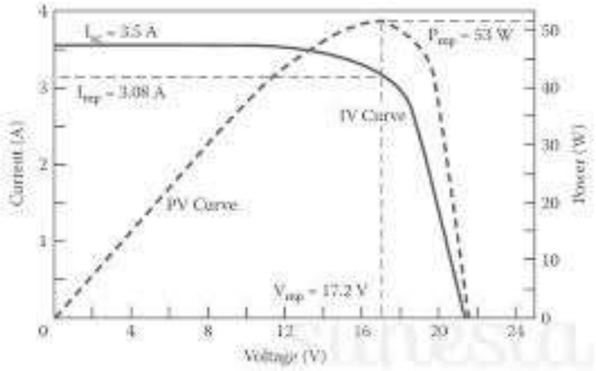

Figure 1. Characteristic curve of IV solar cells in STC

The working principle of Solar PV if the sun's light affects the solar panel, then the electrons in the solar cell will move from N to P, so that at the output terminal of the solar panel will produce electrical energy. The amount of electrical energy produced by solar PV varies depending on the number of solar cells. Output from direct current solar panels (DC) whose voltage outflow depends on the number of solar cells installed in the solar panel and the sunlight's intensity illuminating solar PV.

Solar PV input power is the multiplication between the intensity of solar radiation which is widely accepted by PV modules.

Pin = Ir x A (1)

with:

Pin: Input power due to solar irradiance

Ir: Solar radiation intensity (Watt / m2)

A: The surface area of the photovoltaic module (m2)

While solar PV output is an open circuit voltage (Voc) , Short circuit current (Isc), and Fill Factor (FF) produced by Photovoltaic cells.

Pout = Voc x Isc x FF (2)

With,

Pout: Power generated by solar cell (Watt)

Voc: Open circuit voltage in solar cell (Volt)

Isc: Short circuit current on solar cell (Ampere)

ISSN 2055-0197(Print), ISSN 2055-0200(Online)

FF: Fill Factor
Value FF can be obtained from the formula: FF = Voc-ln (Voc + 0.72) / Voc + 1 (3)
Efficiency of solar PV is a ratio of power that can be generated by solar PV with input energy obtained from solar irradiance. The efficiency used is the instantaneous efficiency of data retrieval.
η = Output / Input x 100% (4)

Figure 2. Model of solar PV power generation

The electrical energy produced by solar panels can be used directly to a load that requires DC voltage source with a small current consumption. Electrical energy produced by solar PV can be used in cloudy or night conditions, where solar PV cannot be sunlight. Solar PV is connected to electrical energy storage media using batteries. Stability of the storage of electrical energy in the battery is installed a regulator that serves to regulate the charging voltage and control the charging of the battery automatically (Automatic charger).

Bogas power plant
Biogas is a gas produced from anaerobic (fermentation) processes of organic materials such as human waste, household waste and animal waste. Materials that are needed in making biogas are methane and carbon dioxide contained in organic matter. The process of making biogas is organic impurities mixed with clean water, a ratio of 1: 1 water and dirt or can use a ratio of 1: 1.5. The temperature that takes place during the process is 27-38^0 C. The source of the suitable biogas raw material is used in Indonesia, such as; animal and human waste, organic waste, and liquid waste. Biogas generating equipment. There are two types of biogas or digester generating equipment, namely floating type and fixed dome type.

ISSN 2055-0197(Print), ISSN 2055-0200(Online)

The process of making biogas with the following steps:

1. Mixing cow dung with water until it forms a slurry with a ratio of 1: 1 in a temporary reservoir.
2. Flowing the sludge into the digester through the intake hole. In the first filling the gas faucet above the digester is opened so that the input is easier and the air inside the digester is pushed out. In this first filling, a large amount of cow manure is needed until the digester is full.
3. Adding a starter of 1 liter and fresh rumen contents from cow dung for digester 3.5 - 5.0 m^3. After the digester is full, the gas faucet is closed so that the fermentation process occurs.
4. Disposing of the first gas produced on days 1 to 8 because COis formed$_2$. Whereas on the 10th to 14th days methane is formed (CH_4) and CO_2 begins to decline. At composition CH_4 54% and CO_2 27%.
5. On the 14th day the gas formed can be used to light a fire on a gas stove or other necessities. Starting on the 14th day, we have been able to produce biogas energy which is always renewable. Furthermore, the digester continues to be filled with cow manure continuously so that an optimal biogas is produced.

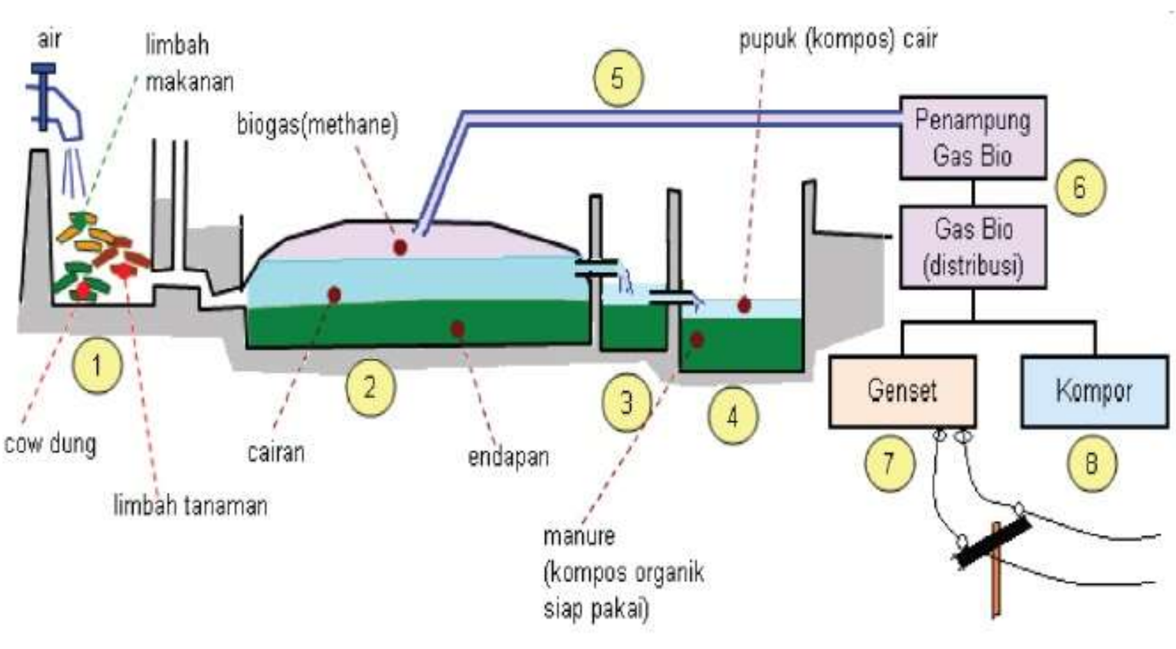

Figure 3. Model of biogas power plant

The conversion of biogas energy to electricity generation can be done using gas turbine, microturbines and Otto Cycle Engine. The choice of this technology is strongly influenced by the existing biogas potential such as methane gas concentration and biogas pressure. While the conversion of 1 Kg of methane gas is equivalent to 6.13 x 107 J, while 1 kWh is equivalent to 3.6 x 107 Joule. For methane gas density 0.656 kg / m3 so that 1 m^3 of methane gas produces 11.17 kWh of electricity.

ISSN 2055-0197(Print), ISSN 2055-0200(Online)

The procedure for determining the capacity of a biogas power plant begins with determining the potential data of Biogas Raw Materials (Ton / day or Kg / day) and measuring total solid (TS) and volatile solid (VS) in the Anaerobic Digestion process, using equations;

$TS = 3.095\% (4) \times P_s$ (kg) (5)

$VS = 85\% (4) \times TS$ (kg) (6)

P_s= Potential Data Biogas raw material (Kg / day)

TS = total solid (Kg / day)

VS = volatile solid (Kg / day)

3. Calculation of the amount the volume of methane gas

$Vgm = 0.417 \times VS\ m^3$ (7)

Vgm = Total volume of gas Metan (m^3)

VS = volatile solid (Kg / day)

4. Calculation of electrical energy potential

$E = Vgm \times FK$ kWh (8)

E = Production of Electrical Energy (kWh)

Vgm = Total volume of gas Metan (m^3)

FK = Conversion Factor (kWh / m^3)

RESEARCH METHOD

The research method of the solar PV-biogas hybrid power plant is carried out in several stages to assess the potential for the application of hybrid power plants in rural areas in eastern Java, including; (a) analyze the potential intensity of solar energy that can be converted into electrical energy with a photovoltaic module, (b) analyze the potential of biogas energy sources in the area of East Java, (c) design a solar PV-biogas power plant model, solar PV design using solar modules PV 50 Wp is 2 pieces, so the total power generated is 100 Wp, with a 10 ampere battery charging control. Whereas to convert DC current to AC current for the use of load with an DC / AC 12V / 220V inverter with 900 watts of power capacity (d) design a biogas power plant system, using a digester capacity of 600 M^3 with biogas raw material for cow dung waste. Composition of a mixture of water mixture: cow dung using a ratio of 1: 1 with a temperature of the digester room between 20-45$^{0\,C}$. Biogas products are converted to using biogas generators with a power capacity of 1000 watts. (e) analyzing the electrical energy produced by solar PV-biogas power plants.

RESULTS AND ANALYSIS

The use of a hybrid PV-biogas diesel power plant model in the countryside, with a 100 watt solar PV capacity can produce an average of 1.26 KW of electricity per day. Electric power value of peak power of 65.63 watts produced at hours (12.00-1230)

ISSN 2055-0197(Print), ISSN 2055-0200(Online)

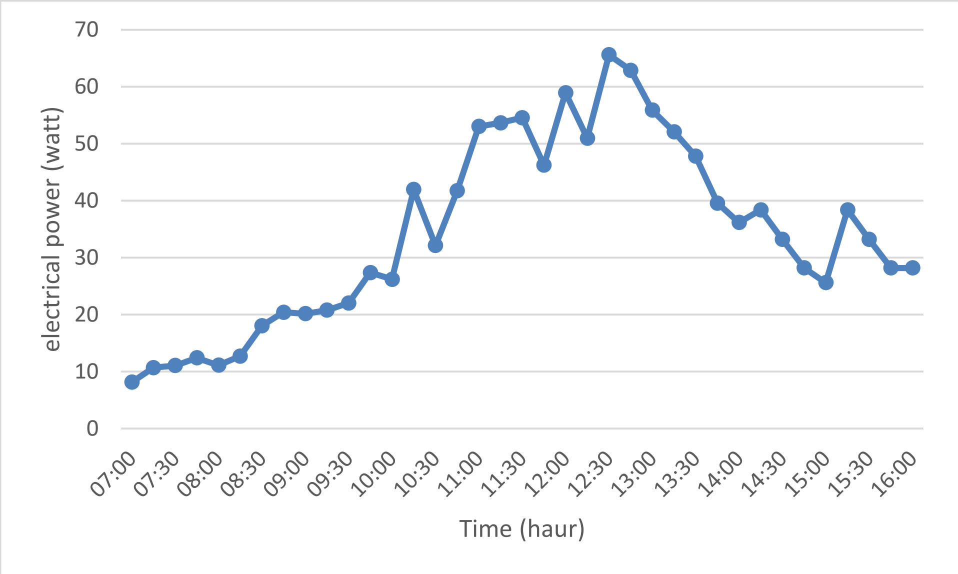

Figure 4. Solar PV power

The results of the trial of biogas production as a fuel for 1 KW biogas generators were produced from raw materials for cow manure compared to cow manure and water (1: 1). Resulting in a slurry of 0.106 m^3. The resulting slurry is fed into the digester. After 1 hour biogas production was measured for 12 hours with an average biogas production of 0.06 m^3/ hour. Biogas production per day is 0.06 m^3/ hour x 24 hours = 1.68 m^3. While the results of the generator test need a consumption of biogas 0.018 m^3. ' Use of 800 watt electricity load, so that hourly spent on biogas is 60 minutes x 0.018 m^3/ minute = 1.08 m^3. from biogas production per day if it is used to supply a hybrid PV-biogas hybrid power plant, it can generate electrical energy of (1.68 m^3/ 1.08 m^3) x 800 Wh = 1.244 KWh

Configuration of a power plant generating a hybrid PV-biogas diesel generator with solar PV input power of 1.26 KW per day and power supply from 1.244 KW biogas generator can produce 2.50 KW of electrical power. The minimum power of the hybrid PV-biogas model is very effective and efficiently applied as a model for small-scale power generation in rural areas. Electric energy consumption per family head is an average of 1 KWh / day with the application of solar PV-biogas hybrid power plants still surplus energy.

CONCLUSION

100 watts of solar PV can produce an average of 1.26 KW of electricity per day. The electric power value of the peak power is 65.63 watts produced at hours (12.00-1230), while the 1 KW biogas generator requires the consumption of biogas fuel 1.08 m^3/ hour by generating 1,244 KWh. The power plant model configuration of diesel PV-biogas hybrid generator is generated by 1.26 KW of solar PV power per day and 1.244 KW of biogas generator with a total electrical energy of 2.50 KW / day. Electric energy consumption per family head is an average of 1 KWh / day with the application of a solar PV-biogas hybrid power plant still with a surplus of 1.50

ISSN 2055-0197(Print), ISSN 2055-0200(Online)

KW of energy, so the model of solar PV-biogas hybrid generator has a good effective and efficient level to be applied in rural Java east

6. REFERENCES

[1]. https://www.republika.co.id/berita/nasional/daerah/17/10/27/oygprw423-kumsi-listrik-masyarakat-jatim-naik-152-persen, accessed on August 18, 2018.
[2]. Farmer analyst in East Java. Directorate General of Livestock and Animal Health Ministry of Agriculture, Livestock Service, East Java province, 2017. Surabaya. 2017
[3]. (teknik-kimia2003.blogspot.com/2008/04/biogas.html, accessed on July 16 2018).
[4] http://ardyprasetyo.wordpress.com/2007/09/12/utilizing-biogas-sebagai-energi-alternatif/, accessed 16 July 2018
[5] Muchammad, Yohana. Eflita, "Effect of Surface Temperature Photovolaicmodule 50Wp on the output power produced using Reflectors with variations of 00, 500, 600, 700, 800", ROTATION (2010), 14-18.
[6] Tanim, M., Chowdhury, NA, Rahman, MM, Ferdous, J., others, 2014. Design of a photovoltaicbiogas hybrid power generation system for Bangladeshi remote area using HOMER software, in: Developments in Renewable Energy Technology (ICDRET), 2014 3rd International Conference on the. IEEE, pp. 1–5
[7] NJOROGE, DK. 2002. Evolution of biogas technology in South Sudan; current and future challenges. Proc. Biodigester Workshop. March 2002. http) / www mekarn.org/procbiod/kuria .htm. (April 13, 2006).
[8] Forrest, AK, Hernandez, J. Holtzapple, MT, 2010. Effects of thermophilic microorganisms. Bioresour. Technol. 10, 7510-7515.
[9] Su, H., Tan, F., Xu, Y., 2016. Enhancement of biogas and methanization of citrus 500 waste via biodegradation pretreatment and subsequent optimized fermentation. Fuel 501 181, 843–851.

ACKNOWLEDGMENTS
This research is supported by the national research incentive research program, funded by the Ministry of Research, Technology and Higher Education (No. 000001.57 / UN38.11-P / LT / 2018).