Solar-diesel hybrid power plant battery charging systems

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Abstract. This study aims to examine the charging current of a solar energy hybrid generator with a Genset / Diesel and the time used to fill the accumulator in conditions without load and load conditions. The results showed that the solar energy hybrid generator and Genset / Diesel prototypes were able to produce electrical power at 08.00 - 17.00 in the average sunny weather of 290.7 Wp without loading and at the time of load of 236.4 Wp. At night, the energy stored in the battery is converted into electrical energy to supply the load. Thus it can save electrical energy.

1. Introduction

Today, the source of electrical energy that is of concern is solar energy and vegetable energy because it is easy to obtain and environmentally friendly. This situation helps the government in saving electric energy, especially in offices, hospitals, housing, and so on, because the electricity produced does not use fuel oil.

Indonesia's large enough area separated by land and sea is one of the factors of inequality in PLN electricity services so that the archipelago uses electricity generation separate from the interconnection system. Thus, PLN must build a PLTD or GENSET in serving customers or people who live in rural areas, especially in the islands. This situation is very influential in the development of current technology and rural economic growth. Seeing this condition, the available electric power capacity certainly cannot be sufficient anymore, so that another power plant is needed that is able to serve the needs of the community. However, the current conditions are no longer possible because of the investment costs of generation and the price of fuel oil, which is high enough so that the parties concerned are trying to save electricity.

1.1. The working principle of photovoltaic solar cells

Solar or in the international world, better known as a solar cell or photovoltaic cell, is a semiconductor device that has a wide surface and consists of a series of diodes of type p and n, which can convert the energy of sunlight into electrical energy [1,2].

Solar cells are arranged by combining p and type n silicon. P-type silicon is positive silicon due to lack of electrons, while n-type silicon is negative silicon due to excess electrons when it receives (charged) solar radiation (in the form of photons) in both (silicon p and n) forms positive (holes) and negative (electron). This causes polarization where the hole moves toward silicon type n. by connecting both types of silicon (type p and type n) through an external conductor, there is a potential difference between the two and direct current flows. This illustration is presented in Figure 1.

The definition of photovoltaic itself is the process of converting light into electrical energy [1,3]. Therefore the field of research related to solar energy is often also known as photovoltaic research [4].

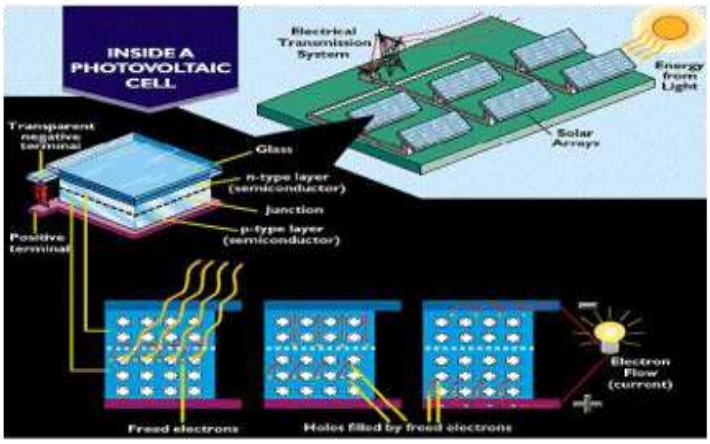

Figure 1. Working principle of photovoltaic cells.

1.2. Diesel / Genset Power Plant

The Diesel Power Plant in this study is stated as a generator set that works using fuel oil. Genset is a device that produces electrical power, which is obtained from the conversion of mechanical energy into electrical energy. Genset consists of two main devices, namely engine, and generator (G1), and is supported by a starter motor (M1), battery, and other control devices, as shown in Figure 7 [4,5]. If the start button is pressed, the starter motor M1 works and starts the engine, if the engine is working then the start button is released, then about 10 seconds the generator (G1) works then the MCB can be turned on to supply power. When the stop button is pressed, the engine will stop (Off).

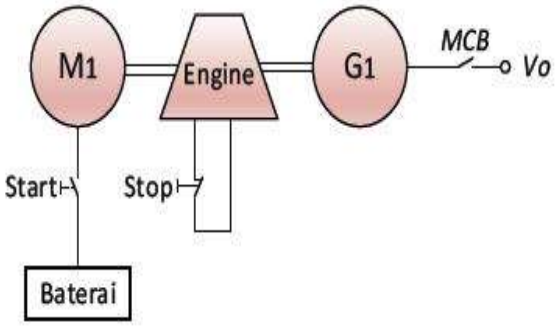

Figure 2. Single line Genset

1.3. Hybrid PLTS – Genset / Diesel (PLTD)

The term Hybrid is defined as the use of 2 or more power plants with different energy sources, generally used for captive generators, so that a synergy that provides economic and technical benefits means the reliability of the supply system.

The main purpose of a hybrid system is basically to try to combine two or more energy sources (generating systems) so that they can cover each other's weaknesses and can achieve supply reliability and economic efficiency on certain load profiles.

Type load (load profile) is an important keyword in a hybrid system. For each different load profile, a hybrid system with a certain composition is needed, so that the optimum system can be achieved. Therefore, system design and sizing systems play an important role in achieving the target of a hybrid system. For example, a relatively constant load profile for 24 hours can be supplied efficiently and economically by the generator (with the appropriate capacity), but the load profile

where electricity usage during the day differs greatly compared to night time, will make the generator use not optimum. Hybrid PV-Genset [6] combination will reduce the generator operating hours (for example from 24 hours per day to only 4 hours per day at peak load only) so that O & M costs can be more efficient, while PLTS is used to supply base loads, so no initial investment is needed big. Thus Hybrid PV-Genset will be able to save O & M costs, reduce inefficiency in the use of generators, and at the same time, avoid the need for large initial investments.

Hybrid system modeling can be expressed in the form of a centralized AC and DC relationship, as shown in Figure 3.

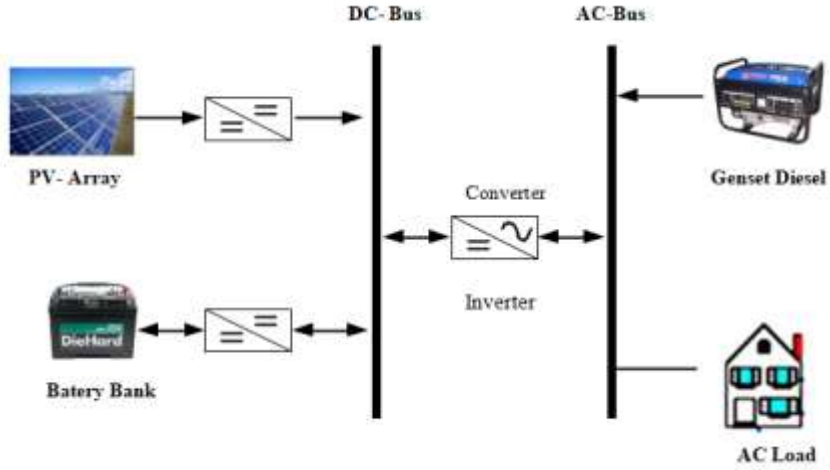

Figure 3. Centralized AC and DC coupled hybrid generating systems (Centralized AC and DC-coupled Hybrid Power Systems)

2. Research Method

This research was carried out in 3 stages:

2.1. Hybrid system

The making phase of a hybrid system prototype Experimental prototype for hybrid PLTS system with PLTD as in Figure 4 below:

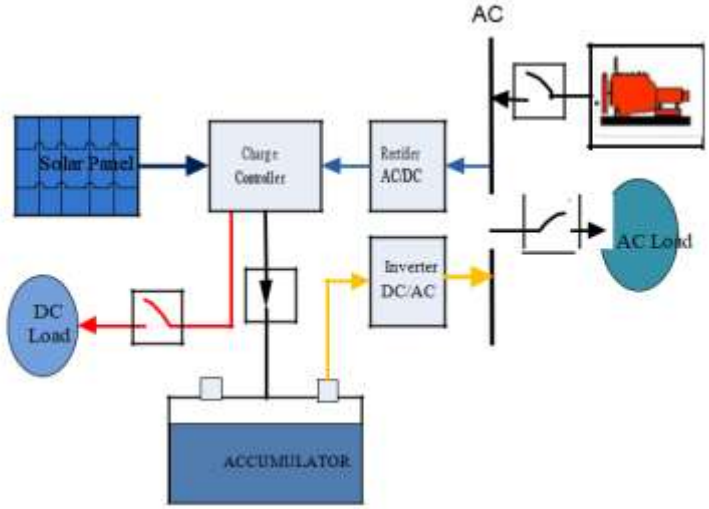

Figure 4. Hybrid system scheme for PLTS and PLTD/Genset

2.2. Testing and measurement phase

Based on the prototype of the solar energy hybrid generator and Genset / PLTD that has been made, it is tested with two conditions as follows:

a. Hybrid system between PLTS and Genset (PLTD) is operated in no-load conditions. Tests are carried out during the day by
   1. Solar energy is converted into electrical energy and then stored in the Accumulator while the electrical energy from the Genset is aligned using an AC-DC converter and dihybrid on the charge controller.
   2. DC load and AC load in the OFF position
   3. Measuring current and voltage from solar energy (PLTS and from Genset / PLTD 4. Measure the hybrid current and voltage in the charge controller

b. Hybrid systems between PLTS and Genset (PLTD) are operated in heavy conditions
   1. Solar energy is converted into electrical energy and then stored in the Accumulator while the electrical energy from the Genset is aligned using an AC-DC converter and hybridized on the charge controller
   2. DC load and AC load are ON
   3. Measuring current and voltage from solar energy (PLTS and from Genset / PLTD
   4. Measure the hybrid current and voltage in the charge controller. Measure current and voltage in the AC clutch

2.3. Analysis phase

At this stage, the results of the tests that have been carried out are then analyzed to find out the total power supplied and the total load that can be served by the hybrid system.

3. Results and Discussion

Prototype of a hybrid solar power generator and generator / PLTD system as shown in Figure 5.

Figure 5. Prototype of hybrid PLTS system testing with Genset

3.1. Testing the Hybrid (PLTS – Genset) on Conditions without Loads

Table 1. The Current and Voltage of Hybrid PLTS systems with Genset for time during sunny days

Times	V Hybrid (V)	I Hybrid (A)
08.00-09.00	19	8.0
09.00-10.00	19.2	10.4

10.00-11.00	19.4	16.8
11.00-12.00	19.5	18.4
12.00-13.00	20.2	19.2
13.00-14.00	20	18.6
14.00-15.00	19.1	18.2
15.00-16.00	19	12.8
16.00-17.00	19	12.6

Based on the test results data in table 1, it can be seen that the relationship between the voltage and current of the Hybrid system is a no-load condition. At 12.00 - 13.00 West Indonesia Time, seen from the current Hybrid PLTS system output with the largest generator. This happens because the solar panel is perpendicular to the sunlight it absorbs

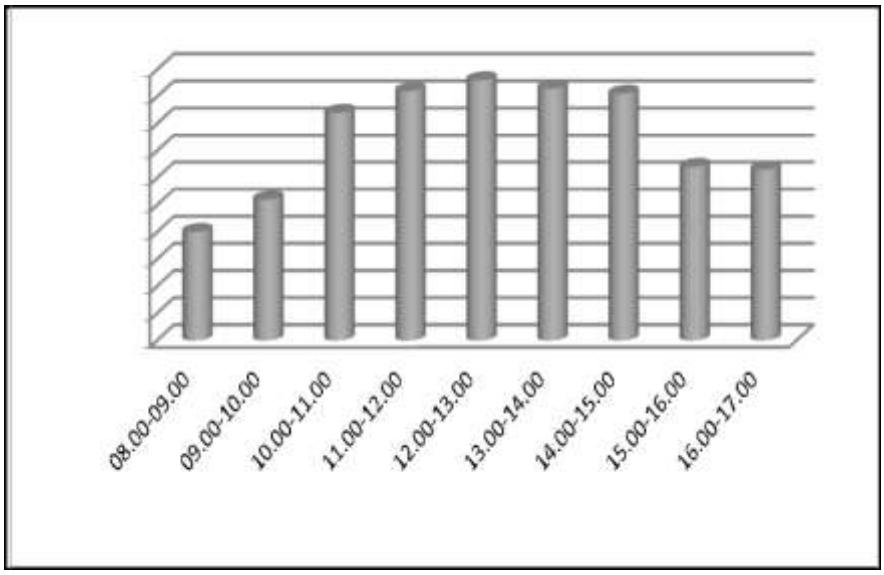

Figure 6. The current of the Hybrid PLTS system with Genset

3.2. Testing the Hybrid (PLTS – Genset) on Load Conditions

Table 2. The Current and Voltage of Hybrid PLTS systems with Genset for time during sunny days

Times	V Hybrid (V)	I Hybrid (A)
08.00-09.00	19	6.0
09.00-10.00	19.2	8.2
10.00-11.00	19.4	14.6
11.00-12.00	19.5	15.4
12.00-13.00	20.2	17.0
13.00-14.00	20	15.2
14.00-15.00	19.1	14.4
15.00-16.00	19	10.0
16.00-17.00	19	9.0

Based on the test results data in Table 2 shows the current and voltage of the Hybrid system are directly proportional. In overloaded conditions, there is a decrease in hybrid currents, this is because

part of the current flows into the load. Thus, the charging time to the accumulator will be longer than the no-load condition.

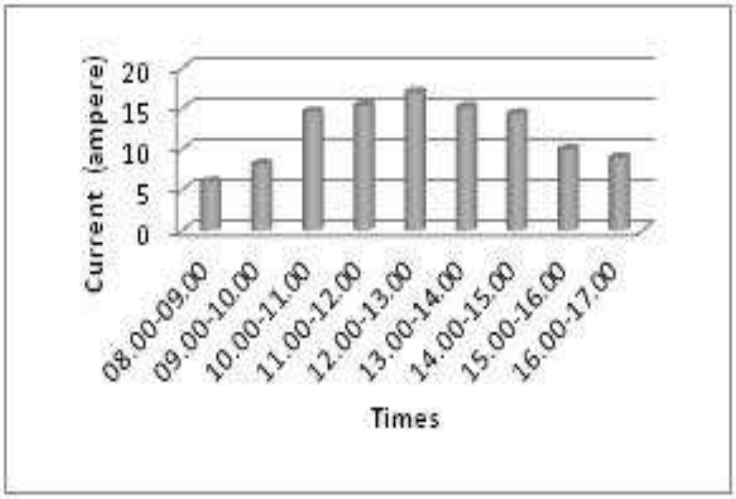

Figure 7. The current of the PLTS Hybrid system with Genset

3.3. Discussion

On average, the voltage for charging a hybrid system of PLTS with Genset for the time period 08.00 to 17.00 is 19.4Volt. The average for the hybrid system output of PLTS with Genset for the time range 08.00 to 17.00 is 15 Ampere. If this power is used to turn on the lamp load of 7 x 18 Watt or 126 Watt it can last for 2.31 hours while the average for charging voltage of hybrid systems with Genset PLTS for the time range 08.00 to 17.00 uses a load of 7 x 18 Watt of 19.4Volt, the average for the output current of the hybrid PLTS system with Genset for the time range 08.00 to 17.00 is 12.2 Ampere. If this power is used to turn on the lamp load of 7 x 18 Watt or 126 Watt, it can last for 1,876 hours. So charging from a Solar Power Plant and Genset for one hour produces an average voltage of 19.4 Volts with a current of I = 12.2 Ampere, capable of turning on a 126 Watt lamp load for ± 1,876 Hours Both conditions above show that the power stored in the accumulator at no-load conditions will longer turn on the lamp with 126 Watts of power compared to the conditions when charging accumulator while being loaded with a power of 126 Watt.

The test results show that the Genset directly supplies to the load and simultaneously fills the battery, while the PLTS only fills the battery; this is in accordance with the function of the tool made. So the batteries function as backup energy and store electricity from the two plants. If at any time the supply from the generator (Genset) goes out, then the source of supply to the load uses the battery.

4. Conclusion

Based on the results of prototype testing for conditions without and with a load it can be concluded that the prototype solar energy hybrid generator and Genset / Diesel are able to produce electrical power at 08.00 - 17.00 on a sunny average of 15 Ah at a voltage of 19.4 Volts or 290.7 Wp without loading and at an average load of 12.2 Ah at a voltage of 19.4 Volts or 236.4 WP. At night, the energy stored in the accumulator is converted into electrical energy to supply the load. Thus it can save electrical energy.

Acknowledgments

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