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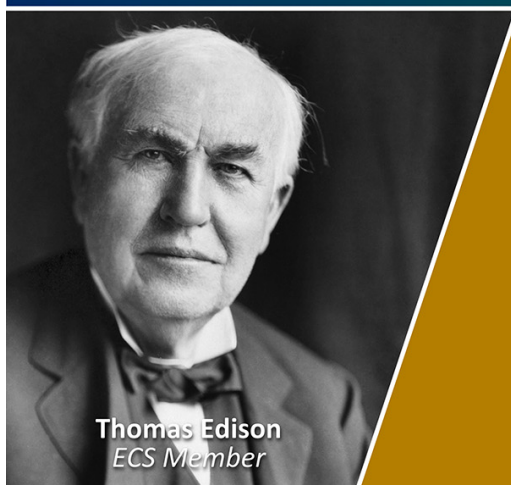
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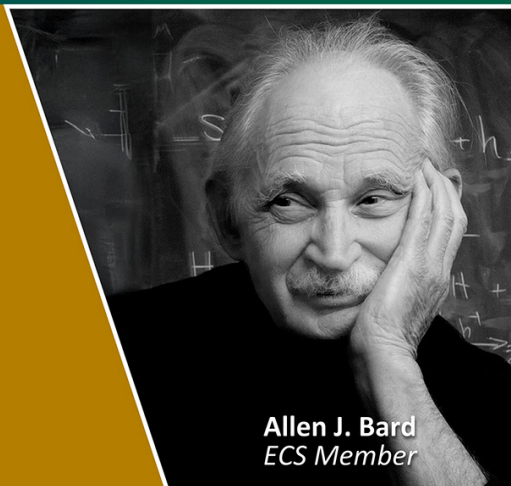


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A Design of Building Prototype of Micro Hidro Hybrid Electricity and Solar Cell as A Learning Media for Electrical Engineering Practicum

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Abstract. *Abstract*—In the Department of Electrical Engineering Islamic University "45" Bekasi, it does not have a laboratory of Renewable energy. In this research, a hybrid power plants have been designed and combined with hydroelectric power plants and solar power plants. From the results of the design of the Solar Cell Power Plant, the results obtained for 1 to 4 pieces of 100wp solar panels obtained the generation voltage of 21.12 volts generating power of 18.80 Watts on average for 7.8 hours. Whereas, for MHP the average voltage is 10.81 Volt and the generation power is 41.48 Watts for 8 hours of use.

Keywords: Generator, Hybrid Electricity, Solar Cells and Micro Hydro

1. Introduction

In the Department of Electrical Engineering, Islamic University "45" Bekasi, there is still no complete laboratory equipment especially for the laboratory of electricity generation engineering. This becomes the background of this research.

The need for electricity is currently increasing and the source of reserves of oil, gas, coal as fuel for electricity generation is decreasing. It is known that almost all sectors of society use electricity and energy sources. Then, the excessive consumption and dependence on one energy source such as the use of petroleum fuel is very large, while to form petroleum energy sources, gas takes hundreds of millions of years.

The declining reserves of fuel oil, gas and coal as fuel for electricity generation and increasing consumption trigger the experts to find alternative energy sources, explore and create new technologies that can replace petroleum, gas, coal and others as fuel for electricity generation.

The utilization of solar energy and water as an alternative energy source for electricity generation is a very remarkable breakthrough. Besides, since the sun is obviously a very large energy source, the use of solar energy does not have a negative impact on the environment. This tool is called a solar cell in the form of a semiconductor device that conducts electricity which can absorb solar thermal energy to supply electrical energy. Then, the proper management of energy resources will be able to provide welfare for the general public.



2. Theoretical Review

2.1 Hybrid Power Plants

A hybrid power plant is a power plant that utilizes more than one energy source, such as the Solar Power Plant (solar power) and Micro Hydro Power Plant (hydropower)

2.1.1 Definition of Solar Cells

Solar cells or photovoltaics can be electrically conductive semiconductor devices that can convert solar energy directly into electric power efficiently. This photovoltaic effect was discovered by Becquerel in 1839, where Becquerel detected a photo voltage when sunlight hit the electrode in an electrolyte solution.

This material is made of single crystalline silicon. This material is still at the top of the sequence of manufacturing costs compared to the electrical energy produced by conventional aircraft.

A. Types of solar cell panels

Solar cell panels convert the intensity of sunlight into electrical energy. These solar cell panels produce currents used to charge the batteries.

The solar cell panel consists of:

1. Photovoltaic, which produces electricity from the intensity of light, when the intensity of light decreases (cloudy, rainy, cloudy) the electricity generated will also decrease. By adding solar cell panels (expanding), it means increasing solar power conversion. Generally, the panels of solar cells of a certain size also give certain results. For example, the size of a cm x b cm produces electricity DC (Direct Current) of x Watt per hour / hour.
2. Polycrystalline (Poly-crystalline)
Is a solar panel that has a random crystal arrangement. This polycrystalline type requires a larger surface area than the monocrystal type to produce the same electrical power, but it can produce electricity on cloudy days.
3. Monocrystal (Mono-crystalline)
It is the most efficient panel producing the highest total electricity power up to 15% efficiency. The disadvantage of this type of panel is that it will not function properly if it is in the place with limited sun shines (shade), its efficiency will drop dramatically in cloudy weather.

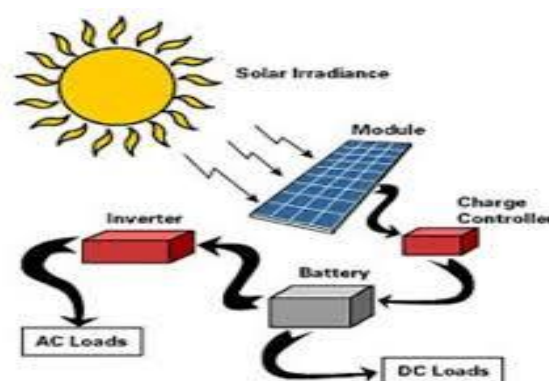


Figure 2.1 Instalation Scheme of PLTS



Figure 2.2 Solar Cell Panel

A single photovoltaic silicon crystal with a surface area of 100 cm^2 will produce about 1.5 W with a voltage of about 0.5 V in the same direction (0.5 V-DC) and around about 2 A under full heat (about $1000 \text{ W} / \text{m}^2$).

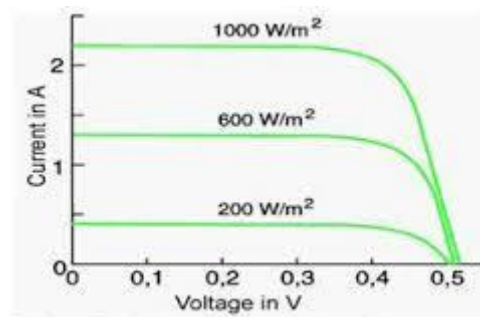


Figure 2.3 Characteristics of Photovoltaic Cells

2.1.2 Working Principles of Solar Cells

The working principle of silicon solar cells is based on the concept of semiconductor p-n junctions. The cells consist of doping-n and -p of semiconductor layers which form pn junction, antireflection layer, and metal substrate as the place where current flows from the n-type layer (electron and p-type (hole)). N-type semiconductors are obtained by doping silicon with elements from group V so that there is an excess of valence electrons compared to surrounding atoms. On the other hand, the p-type semiconductors are obtained from doping by group III so that valence electrons are deficit of one compared to surrounding atoms. When the two types of material are in contact, the excess electrons of the n-type diffuse on p-type so that the doping-n area will be positively charged while the p-doping area will be negatively charged. The electric field that occurs in both of them pushes the electron back to the n-region and the hole to p-region. By adding metal contacts to the area p and n, a diode has been formed.

2.1.3 Solar Cell Performance

The electrical power produced by solar cells when they get light and it is obtained from the ability of the solar cell device to produce voltage when given a load and current through the load at the same time. When a cell in the short circuit condition, the maximum current or short circuit current (I_{sc}) is generated, whereas in the open circuit condition there is no current which can flow so that the voltage is maximum, it is called open-circuit voltage (V_{oc}). Whereas, the point on the I-V curve that produces maximum current and voltage is called the maximum power point (MPP).

2.1.4 Components of a Solar Power Plant in lighting

The solar cell for lighting lamps has several components including:

A. Solar module (photovoltaics module)

As discussed above, solar cells or photovoltaic cells are devices that can convert solar radiation energy directly into electrical energy. Basically, the cell is a type of diode that is composed of P-N junction. Photovoltaic solar cells are made from semi-conductor materials which are processed in such a way that can produce direct current electricity (DC). On its use, solar cells are connected to one another, parallel or series, depending on their use to produce power with a combination of the desired voltage and current.

B. Battery

Batteries are devices that store the power produced by solar panels which are not immediately used by a load. The stored power can be used during periods of low solar radiation or at night. The components of the battery are sometimes called accumulators. Batteries store the electricity in the form of chemical power. The battery most commonly used in solar applications is a maintenance-free lead-acid battery, which is also called a recombinant or VRLA battery (valve regulated lead acid).

C. Inverter

Inverters are electrical devices used to convert direct current (DC) into alternating electric current (AC). Inverters convert DC from devices such as batteries, solar panels / AC cells. The use of an inverter from a solar power plant (PLTS) is for devices using AC (Alternating Current). Several things to consider in choosing an inverter; load capacity in Watts, try to choose an inverter whose workload is close to the load we want to use so that the work efficiency is maximum. DC input is 12 Volt or 24 Volt, Sinewave or square wave output AC.

D. Load (Load)

Load is an equipment consuming the power generated by your power system. The expenses may include wireless communication equipment, street lights, home or building lighting, TV, radio, and others. This research focuses the discussion on lighting. Although it is impossible to accurately calculate the exact amount of equipment consumed, it is very important to make a good estimation.

E. Types of Solar Cell Implementation Methods

Solar energy power plants are divided into 4 methods, including:

1. With a photovoltaic system,
2. With a photoelectrochemical conversion system,
3. With a solar thermal distribution receiving system,
4. With a solar thermal receiver system centrally.

F. Solar Charge Charge Controller is an electronic equipment used to adjust the direct current that is added to the battery and taken from the battery. The charge controller solar cell is also overcharging (excess charging - because the battery is 'full') and overvoltage from the solar panel, which will reduce the battery life. The charge control solar cell implements the Pulse width modulation (PWM) technology to regulate the battery charging function and release the current from the battery to the load. Some functions of the charge controller solar cell are as follows:

1. Setting up the current for charging to the battery, overcharging, overvoltage.
2. Interpreting the current released / taken from batteries so that the battery is not full discharge, overloading.
3. Monitoring battery temperature

2.2 MicroHidro Power Plant (PLTM)

2.2.1 Components of Electric Power Plant Micro Hydro (PLTM)

To make Micro-Hydro Power Plant (PLTM), supporting components are needed such as:

A. Waterfall

Most waterfalls are found in Indonesia, so they are very large potential generators for driving and it can be used for community interests.

The clarification of water related to the production capacity of the hydro produced is as follows:

Table 1 Clarification of the High Level of Collaboration on Capacity (Power Terms of the 2002 ESDM Candy Output);

1. Pico Hydro <500 W
2. 500 W Micro Hydro up to 100 kW <1 MW
3. 100 kW Hydro Mini to 1 MW 1 MW-10 MW
4. 1 MW Small Hydro to 10 MW
5. Full-scale (large) Hydro > 10 MW

Electricity generation for Microhydropers for the principle of utilizing high water and the amount of water discharge per second is there irrigation water channel, river or waterfall. This water flow will rotate the export turbine to produce a mechanical generator. The energy continues to drive generators and generate electricity.

B. Turbine

A turbine is a rotating machine that takes energy from a fluid stream. A simple turbine has one moving part, "rotor blade assembly / runner".

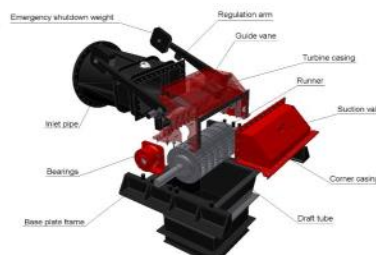


Figure 2.4 Parts of a micro hydro turbine

1. Level of Turbine Efficiency

The total efficiency of mini crossflow features with a small height is 84% throughout the stream. The maximum efficiency of the intermediate and standard features with the highest Quality, is 87%.

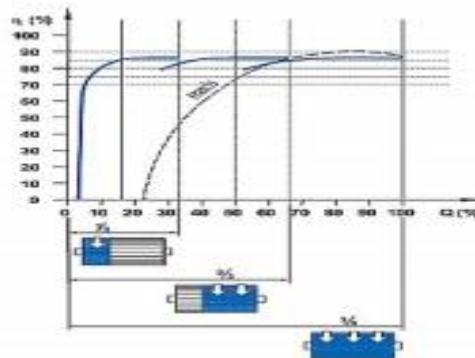


Figure 2.5 Curve Efficiency of Cross Flow Turbine

2. Turbine power

The amount of the PLTMH at the maximum discharge condition is as follows:

$$P = g \times Q \times H \times \eta$$

C. Generator

The generator is a tool for changing the mechanical mechanism of electricity generators. The type of generator that will be used in the MHP is a horizontal shaft synchronous generator with a rotation of 1000 rpm. At the synchronous generator TM using a speed of 1000 rpm so that it is closed in the generator amount,

$$P = \frac{120 f}{N}$$

Where:

N = Generator Turnover (rpm)

f = Frequency (Hz)

P = Number of poles

2.2.2 Calculation of the Amount of Generator Expenditure at the PLTMH

1) Calculation of Water Discharge: Debit is one of the important parameters in PLTMH planning. The size of the water discharge will determine the amount of energy that can be produced. To calculate the flowing water flow, it uses the formula:

$$\text{Debit} = \frac{\text{Vessel Volume}}{\text{Time or duration to fill the vessel}}$$

2) Falling Water (Head): To get the height of falling water (h) a measurement is carried out using the water-filled tube method where it is measured from the surface of the water on the side of the water until water touches the surface of the water.

3) Calculation of Input (P_{in}) Power: After obtaining the amount of discharge and head, it can be determined the amount of input power (P_{in}) generated by the formula [3]:

$$P_{in} = \rho \cdot Q \cdot g \cdot h$$

Where :

P_{in} = Input power

ρ = Water density (1000 kg / m³)

Q = Water discharge (m³ / s)

G = Gravity (9.81 m / s²)

H = Height of falling water (m)

4) Calculation of Efficiency of Each Turbine: Efficiency is calculated by dividing the power coming out of the generator with the power of entry, or mathematically can be formulated as follows [5]:

$$\eta = (P_{out}) / (P_{in})$$

3. Methodology

In the first year of the research, it was the design of a solar cell generator prototype. Furthermore, in this research, the work stages were carried out systematically and continuously until the output of the Solar Cell electricity generation practicum learning media is created. The research stages were as follows:

1. Field survey
2. Preparation of tools and materials
3. PLTH design
4. Manufacture and Assembly of Solar Cell Plant Installation (Year I)
5. Manufacture and Assembly of Micro Hydro Power Plants (Year II)

6. Testing the performance of Solar Cell Generators and Micro Hydro Generators
7. Make a report

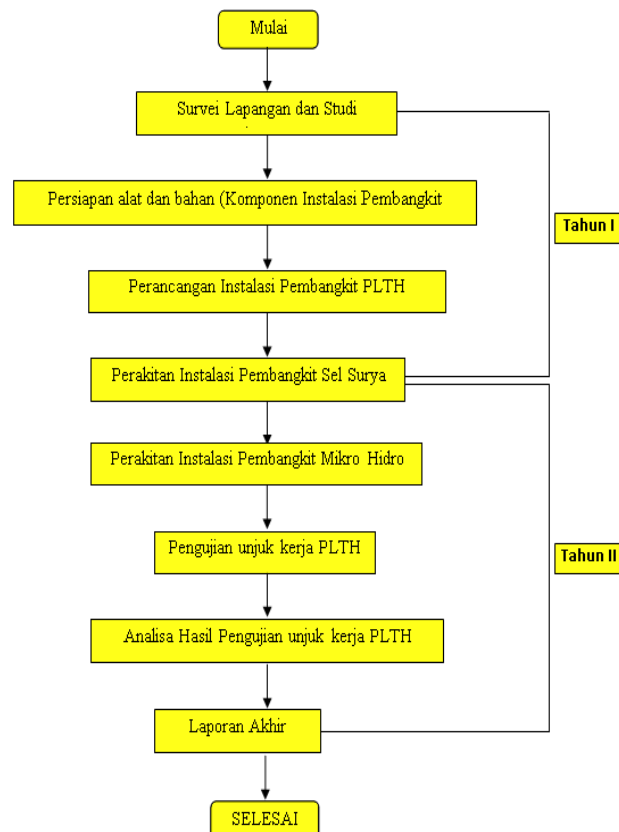


Figure 3.1 Research Flow Chart

4. Results And Discussion

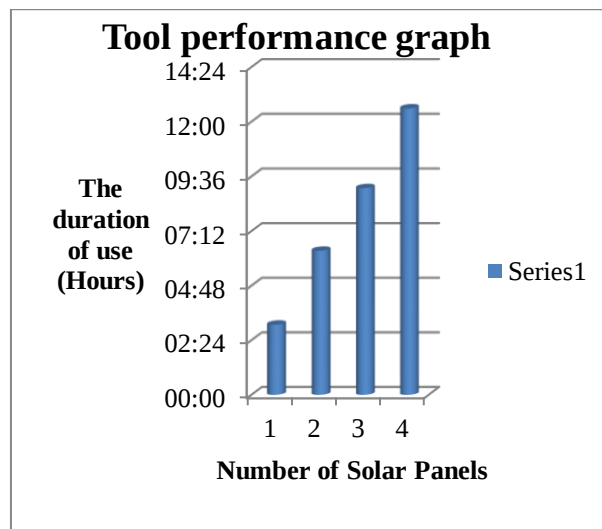
4.1 Results of Testing Tool Performance

Specifications of the construction of the Generating Tools Electric PowerSurya:

- a. 100WP Solar Panel (4 Pieces)
- b. Output Voltage 21.12 V
- c. Voltage Battery 100 AH

Table 4.1 Data on PLTS Testing Results

NO	Number of Panel	Teg.(Volt)	Stuffing	Usage Time	Load
1	1 Unit	21.12	8 hours	3,5	0,89
2	2 Unit			6,2	0,88
3	3 Unit			9,5	0,88
4	4 Unit			12,35	0,87
The Average power consumption of 18.80 Watts					

**Figure 4.1** Tool Performance Graph

4.2 Results of Testing The Performance of Mhp

1. Specifications of the construction of the Power Plant Equipment Electric Micro Hydro:

a. Pelton Turbine Model

b. Pump type: Jet pump with 125 watt input power, head pump m, 98 rpm rotation.

c. 12 VA generator power, 98rpm rotation and frequency ... Hz.

d. Runner Specifications: total of 20 pieces

Table 4.2 The Data on MHP Testing Results (8 Hours)

No	Volt	Speed (rpm)	Watt
1	09.01	120	34,5
2	09.05	135	36,5
3	11.06	185	44,6
4	11.08	200	44,6
5	11.02	170	42,5
6	12.01	210	46,8
7	11.08	200	44,1
8	10.09	150	42,9
9	09.03	130	36,7
The average of power consumption 41,48 Watt			

5. Conclusion

From the design of Solar Cell Generators, the results for 1 to 4 panelsurya100wp obtained a generation voltage of 21.12 volts for generation of 18.80 Watts on average for 7.8 hours. While for MHP, the average voltage is 10.81 volts and generating power of 41.48 watts for 8 hours of use.

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