The International Journal of Engineering and Science (IJES)
|| Volume || 10 || Issue || 4 || Series I || Pages || PP 37-48|| 2021 ||
ISSN (e): 2319-1813 ISSN (p): 20-24-1805

The Efficiency Analysis of Solar Home System 200Wp

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ABSTRACT
West Borneo have many potentials energy of sun, which is can make as arouse Solar Power Electric Generator (SPEG). In this research the specification of solar home system we use 200 WP with 90 watt household's load. Maximum efficiency of sun energy to be electrical energy at solar cell 100 WP is as big 14,84%. The results of PVsyst also indicate efficiency that produce is 14,74% that same approach with result of calculation where the efficiency as 14,84%. This case mean that the information system status first specially battery, then the capacity of solar charge have ESL indicator at 3 color lamp charging LED (red < 30%, yellow < 70%, green 100%) and red LED. With attention indicator battery lamp obtained at solar charge lower is 30% then we need to save battery from damage. From the usage duration energy 1680 watt/ hour so obtained result of calculation load energy that used 90 watt is 18,67 hours with condition remaining battery energy 30%. At this research inverter 1000 Watt can't be used above 1000 Watt because it can destroy the battery.

Keywords:_Solar home system, PVsyst, SHS efficiency_

Date of Submission: 27-03-2021 Date of Acceptance: 10-04-2021

I. INTRODUCTION

Electrical energy is urgently needed by people in remote and underdeveloped areas in West Kalimantan that have not been reached through the electricity network from the State Electricity Company (PLN). The area actually has many potential energy sources that can be used as alternative energy sources to generate electrical energy, one of which is solar energy. When viewed geographically, West Kalimantan has a lot of potential for solar energy which can be used as an energy source for Solar Power Plants, namely the solar home system.

The main problem with the development of a solar home system lies in the quality of the power of the 200 Wp solar home system with a load of 90 watts for the household, especially household lights, which is the reference for planning the construction of a solar home system [1]. Regarding the energy potential in the area of West Kalimantan which is located on the equator, it is necessary to provide information for the design and construction of a solar energy generator, in this case the solar home system for remote and underdeveloped areas [2]. With the analysis of the efficiency of the 200 Wp solar home system, it is hoped that this area has the potential for solar energy for solar home systems which is a theoretical reference and calculation for other areas that have the same potential and become an alternative energy source to solve the problem of electrical energy needs in remote and disadvantaged areas.

II. METHOD

The research focus is in the environment of the Faculty of Engineering, University of Tanjungpura Pontianak with literature study used to obtain theoretical sources as a reference in the problem approach. The data taken in this study are data on a 200 Wp solar home system and a 90 Watt load based on current and voltage data on the entry and exit lines of the solar cell, solar charge, battery, inverter. 200 Wp solar home system design and 90 Watt load. Tests and evaluations were carried out to determine the characteristics and performance of a 200 Wp solar home system built at a load of 90 watts. Measurements are carried out without load and with a load of 90 watts, as well as the calculation and analysis as a whole as a comparison of the calculation results with the results

III. RESULTS

1. Solar Home System

The solar home system is a way of utilizing solar energy by converting the intensity of sunlight into electrical energy which is used for household loads. From Figure 1 below we can see a diagram of the solar home system installation.

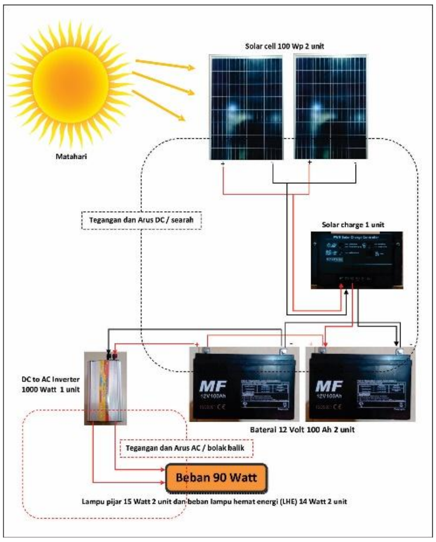

Figure 1 Solar home system installation diagram

Solar cell generates DC / direct current and voltage, which is passed on by the solar charge to charge the battery. To convert solar energy from the battery it is converted to an inverter used by AC / alternating loads. In general, solar cells of a certain size produce a certain amount of power too, by paying attention to components such as solar charge, batteries and inverters based on the specified load. [3,4,5,6,7]

2. Solar Cell

The main tool used to capture, convert and produce electricity from the sun / solar is photovoltaic or what is generally called a solar cell module. As an area located on the Equator, Pontianak and its surroundings receive 5.40 W / m2 sunshine. In the solar energy production spec, a 1000 W / m2 solar cell can be calculated with the following equation:

$$P_{in} = J \times A \quad (1)$$
$$= 1000\ W/m^2 \times 0{,}6834\ m^2$$
$$= 683{,}4\ Watt$$

In this case, the solar cell used is a polycrystal type solar cell with a capacity of 100 Wp, the Greentek brand, the PSP 100W model, as many as 2 units. The solar cell produces a voltage of 12 to 18 VDC and a current of 0.5 to 7 Ampere. Solar cells are connected in parallel. This solar cell behaves like a semiconductor component in general, that is, when the temperature changes, the voltage tends to decrease. The voltage and current curves depend on changes in solar radiation received by the solar cell. The amount of output power of the solar cell (Vout), namely the multiplication of the open circuit voltage (Voc), short circuit current (Isc) and fill factor (FF) contained in the solar cell can be connected with the following equation:

$$Pout = Voc \times Isc \times FF \quad (2)$$
$$= 22\ V \times 6.05\ A \times 0{,}761853\ W$$
$$= 101{,}4027\ Watt$$

The FF filler factor is the value of the voltage and current ratio at the maximum power state of Vmax and Imax obtained when observing measurements from the solar cell to the solar charge, while the open circuit voltage (Voc) and short circuit current (Isc) are found in the solar cell spec. with the following equation:

$$FF = (Vmax \times Imax) / (Voc \times Isc) \quad (3)$$
$$= (13{,}29\ V \times 7{,}63) / (22\ V \times 6.05\ A)$$
$$= 101{,}4027\ W / 133.1\ W$$
$$= 0{,}761853\ Watt$$

The maximum output efficiency (n) is defined as the percentage of optimum power output to the light energy used, we can see it with the following equation:

$$\eta = Pout / Pin \times 100\% \quad (4)$$
$$= 101{,}4027 / 683{,}4 \times 100\%$$
$$= 14{,}84\%$$

The maximum efficiency of converting light energy into electrical energy in a 100 WP solar cell is 14.84%.
To see the characteristics of solar cells in this study, the PVsyst software is used, which is a photovoltaic system software designed to simulate the planning of a solar home system.

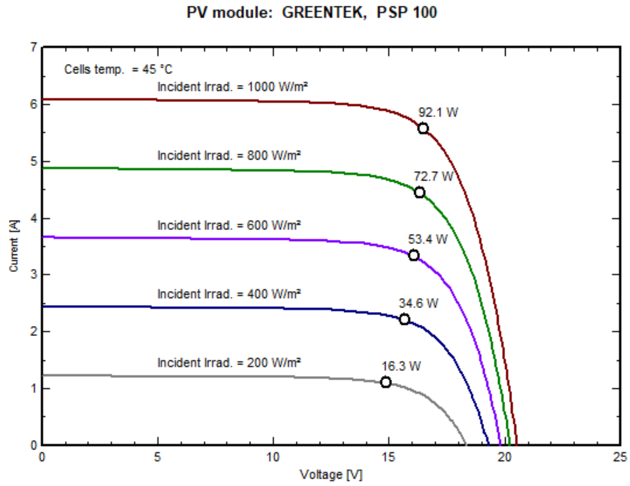

Figure 2 Graph of currents and voltages to solar radiation

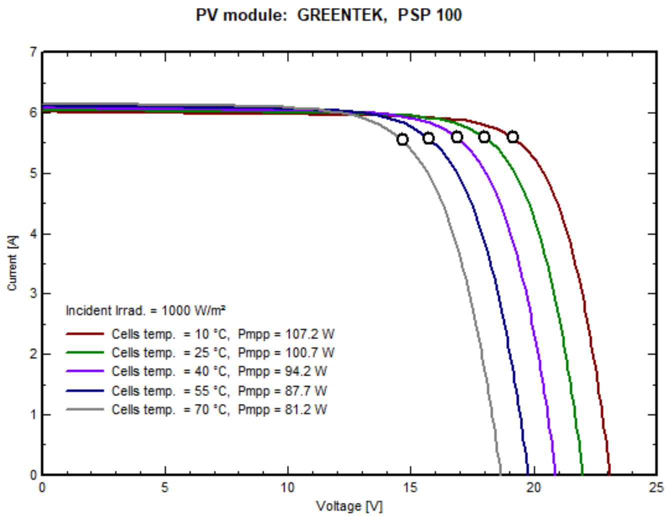

Figure 3 Graph of current and voltage with respect to temperature

Figure 2 shows that the current and voltage in the solar cell are strongly influenced by the amount of solar radiation. So that it can be seen that the 100 Wp solar cell shows that the solar radiation of 1000 W / m2 will produce a current of 6.05 A and a voltage of 22 V which is the same in the overall specifications of the solar cell. In Figure 3, it can be seen that temperature also affects the current and voltage produced by solar cel, the higher the temperature, the lower the current and voltage that will be generated.

In the PVsyst software you can also see the output graph for the parameter of the relationship between efficiency and temperature to solar radiation and vice versa, by using the Voc and Isc input data from the specifications of the solar cell used.

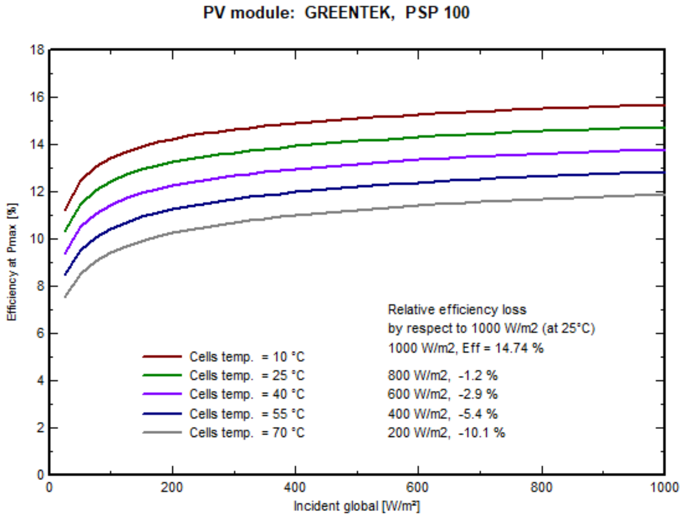

Figure 4 Graph of efficiency and temperature for solar radiation

From Figure 4, it can be seen that the three elements are related to one another. The PVsyst software also shows that the resulting efficiency is 14.74% which is close to the calculation result in equation (4) where the efficiency is 14.84%.

3. Solar Charge

Solar charge functions to maintain the energy balance in the battery by regulating the maximum and minimum voltage of the battery, this tool also serves to provide security for the protection indicator system against overcharging or over-charge of the battery which can damage the battery life and solar cell components. The 12 Volt solar cell generally has an output voltage of 16-20 Volt. When the solar cell voltage is high, there is a very big difference between the solar cell and the battery voltage found in the solar cell spec. The potential power obtained from the MPPT and which will be used by solar charge, can be seen with the following equation:

With a PV controller other than MPPT

$$P = VDC \times Imp \quad (5)$$
$$= 12\ V \times 11{,}40\ A$$
$$= 136{,}8\ Wp$$

With MPPT PV controller

$$IC = Pmax / VDC \quad (6)$$
$$= 200\ Wp / 12\ V$$
$$= 16.67\ A$$

Solar charge capacity of 20 A which can accommodate solar cell power of 136.8 Wp to 200 Wp which has a voltage of 12 V to 24 V, at currents below 16.67 A. To see the characteristics of solar charge using the PVsyst software, solar cell used is solar cell 20 A with the brand Solarland as shown in Figures 5, 6, and 7.

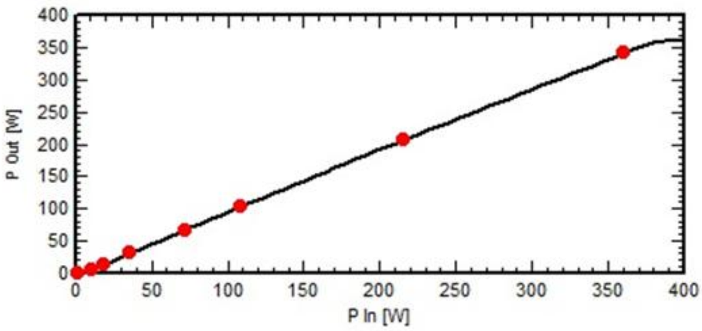

Figure 5 Graph of input power and output power in solar charge

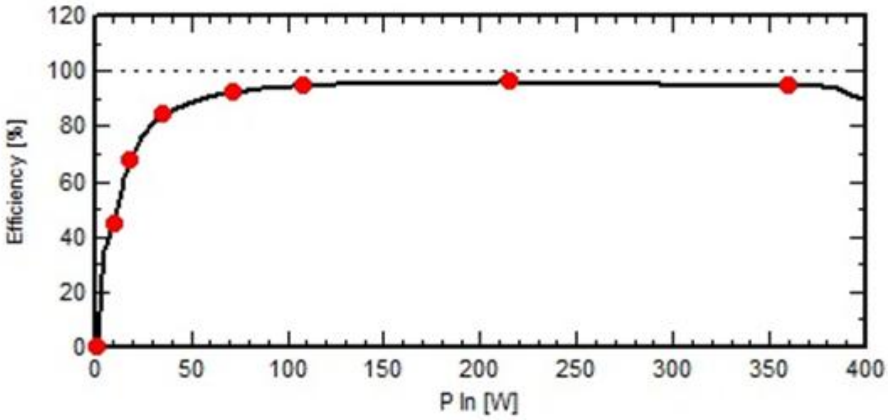

Figure 6 Graph of efficiency and input power in solar charge

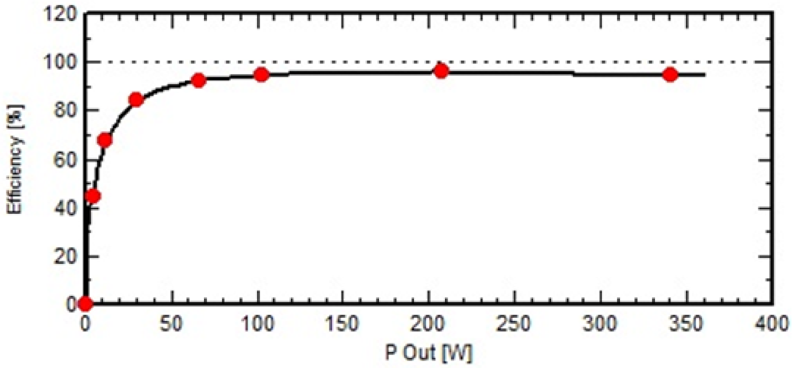

Figure 7 Graph of efficiency and output power in solar charge

Figure 5 shows that the input power and output power are directly proportional to the input of the solar cell and forwarded by the solar charge to the battery. So that, it can be seen that the solar charge shows the battery power to be charged according to the 2400 Watt battery required. Figures 6 and 7 show that the resulting solar charge efficiency is 98% based on the input power and output power generated in the VPsyst software.

4. Batteries

The battery is a store of electrical energy when the sun is not there. Batteries suitable for PV are deep cycle lead acid batteries that can accommodate a capacity of 100 Ah, 12 V, with an efficiency of around 80%. Charging time for the battery / battery for 12 hours - 16 hours [1,3,4,5,6,7,16].

The calculation of battery power in energy units in Watts / Hours is converted to Amperes / Hour which corresponds to the battery voltage, so that the battery power capacity can be calculated by equation (7) as follows:

$$Battery\ Power = Ampere/Hr \times Voltage$$
$$= 200A/Hr \times 12\ V$$
$$= 2400\ Watt/Hr$$

So that the power consumption of a clean battery can be used with equations (8) and (9) as follows:

$$Usage\ Power = Battery\ Power - (Battery\ Power \times\ 30\%)$$
$$= 2400\ Watt/Hr - (2400\ Watt/Hr \times\ 30\%)$$
$$= 2400\ Watt/Hr - 720\ Watt/Hr$$
$$= 1680\ Watt/Hr$$
$$Duration\ of\ power\ consumption = Usage\ Power /\ Load\ Power$$
$$= \frac{1680\ Watt}{Hr} /\ 90Watt$$
$$= 18{,}67\ Hr$$

The maximum amount of electrical power is not all used by electrical equipment because approximately 20% will be used by the inverter to operate [3,4,5,6,7,14]. By paying attention to the battery indicator light found at the lowest solar charge is 30%, it is necessary to do calculations based on the lowest indicator light to secure the battery from damage. From the duration of the power consumption of 1680 Watt / hour, the calculation results of equation (9) the load power used by 90 Watts is 18.67 hours with a 30% battery power test condition. To see the characteristics of the battery using the PVSyst software, the battery used is a 100 Ah battery with a 12 Volt DC voltage with the MF maintenance free brand. The graph of the battery voltage at the time of charging the battery is shown in Figure 8, the graph of the battery voltage at the time of discharge of the battery is shown in Figure 9 and in Figure 10 the graph of the battery voltage at the time of charging and discharging the battery.

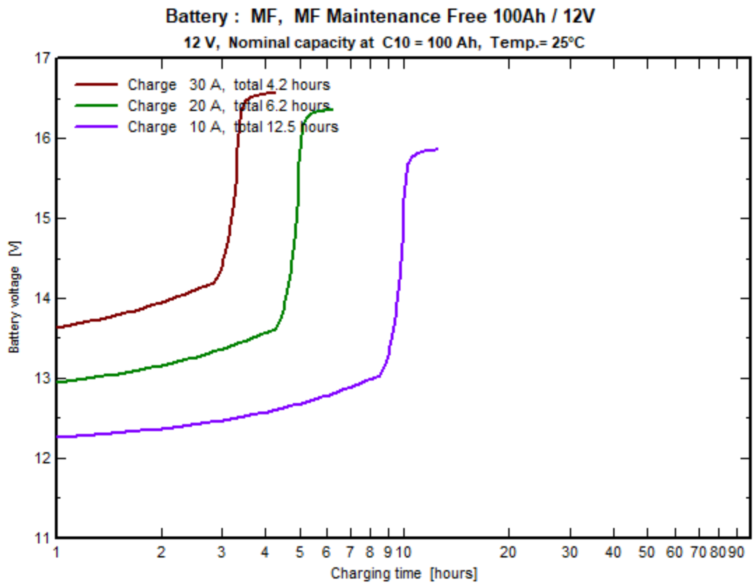

Figure 8 Graph of battery voltage at the time of charging the battery

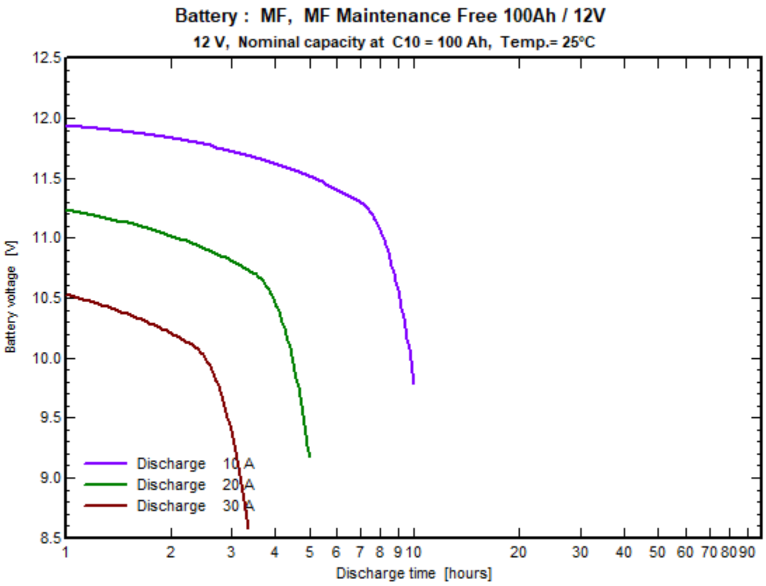

Figure 9 Graph of battery voltage at the time of discharge of battery power

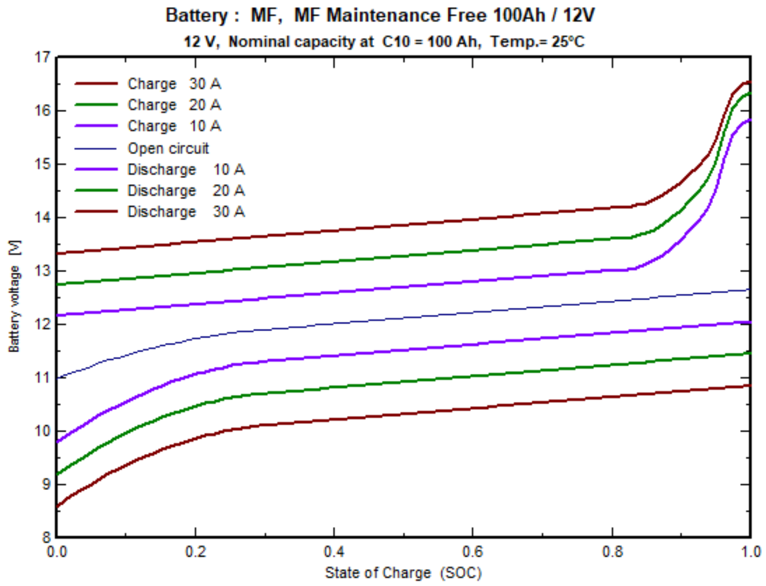

Figure 10 Graph of battery voltage open current at charging time and discharge of battery power

In Figure 8, the resulting VPsyst software shows the battery voltage at the maximum battery charge time of 30 A with a charge time of 4.2 hours having a voltage of 13.6 V. Figure 9 graph of battery voltage at maximum battery discharge time with current 10 A with a usage time of 10 hours with a voltage of 11.94 V. In Figure 10 the graph of the open current of the battery voltage at the time of charging and discharging the battery, it can be seen between the charging and discharging currents of 30 A and 10 A with a voltage of 12 V. 2 units of battery power 100 Ah 12 V is 2400 Watt / Hour. The battery efficiency produced by the VPsyst software is 97% at 2328 Watt / hour.

5. Inverters

Inverters are electronic devices that are used to convert 12 Volt DC voltage to 220 Volt AC voltage. Inverters in the process of converting DC voltages to AC voltages. Inverters are electronic devices that function to convert direct current (DC) electricity to alternating current (AC). Alternating alternating current electricity can vary in voltage and frequency depending on the switching transformer, and the control circuit used [1,3,4,5,6,7,17]. In this study, the 1000 Watt inverter used is an inverter whose use must not be above 1000 Watt of the load used because it can damage the inverter to maintain its useful life, the tolerance used is with equation (10) as follows:

$$\begin{aligned}\text{Inverter power} &= \text{inverter power} - (\text{inverter power} \times 30\%)\\ &= 1000\ \text{Watt} - (1000\ \text{Watt} \times 30\%)\\ &= 700\ \text{Watt}\end{aligned}$$

From equation (10) it is found that the usable power capacity is below 700 Watt while the load used is 90 Watt. By using the PVsyst software to view the input power and output power graphs on the battery power consumption inverter, it is shown in Figure 11, the efficiency graph and the input power on the inverter in Figure 12 and in Figure 13 the efficiency and output power of the inverter.

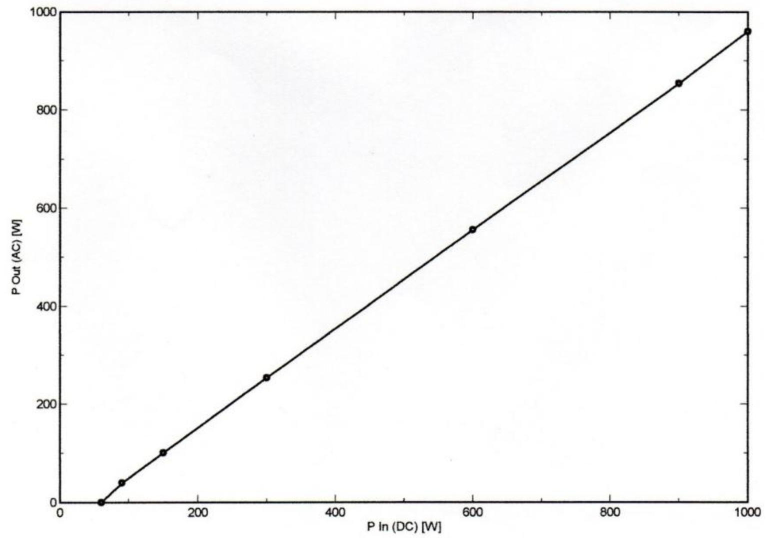

Figure 11 Graph of input power and output power in battery consumption inverter

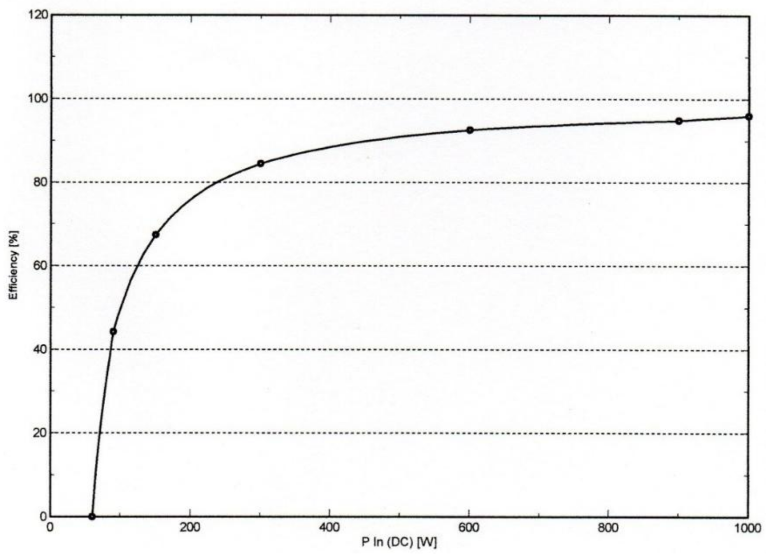

Figure 12 Graph of the efficiency and input power of the inverter

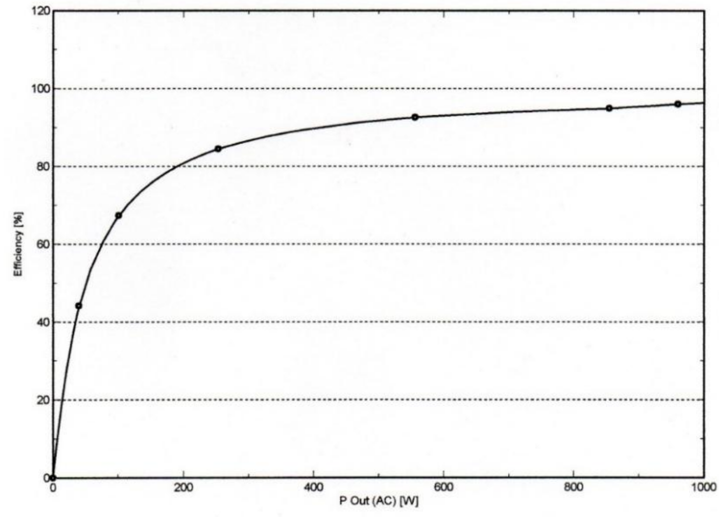

Figure 13 Graph of the efficiency and output power of the inverter

The VPsyst software shows the inverter in Figure 11 a graph of the input power and output power of the inverter, battery power consumption is directly proportional to battery power usage using an inverter. Figure 12 and Figure 13 have an efficiency of 96% of the input power and output power of the inverter respectively

6. No-Load Battery Charging

Charging the battery without load in this study was carried out only on the battery and was not connected to the load, only charging from the solar cell circuit, solar charge, to the battery only. This no-load charging is also carried out when the battery still has 30% charge, as seen in the red LED indicator on the solar charge. At no-load charging, current and voltage measurements are also carried out for 7 days from solar cell to solar charge and from solar charge to battery, starting from February 25, 2018 to March 3, 2018.

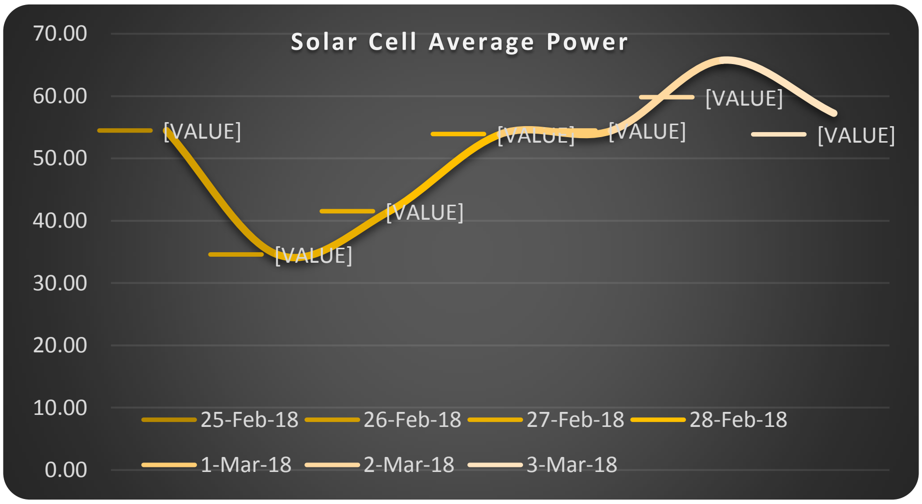

Figure 14 Graph of the average power of the solar cell at no load measurement

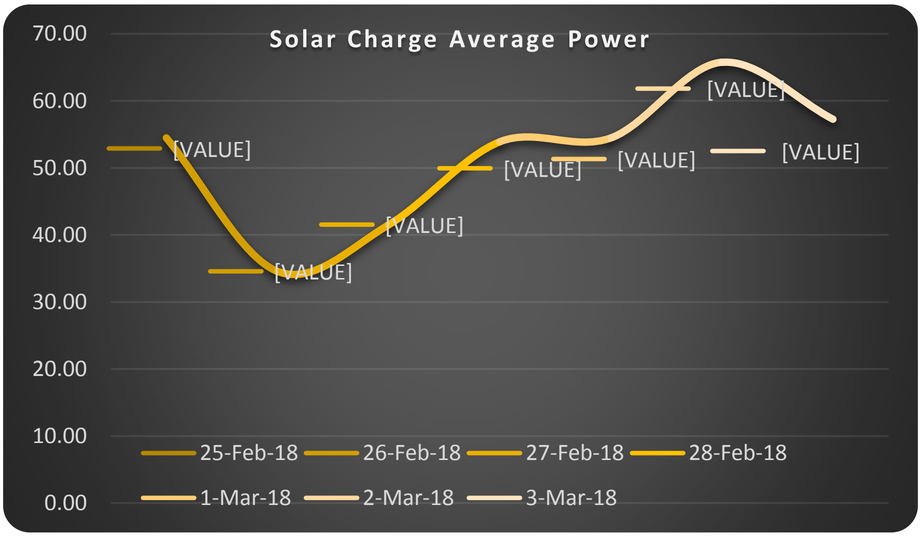

Figure 15 Graph of average power of solar charge measurement without load

Table 1 Power calculation data (Watt) of average solar cell and solar charge

Item	Daya rata - rata (Watt)						
	25 Feb 2018	26 Feb 2018	27 Feb 2018	28 Feb 2018	1 Mar 2018	2 Mar 2018	3 Mar 2018
Solar cell	54.46	34.56	41.49	53.88	54.46	65.76	57.26
Solar charge	30.72	23.69	24.66	28.54	31.91	30.42	30.14

Table 2 Data for calculating the average efficiency of solar cells and solar charges

Item	Efisiensi						
	25 Feb 2018	26 Feb 2018	27 Feb 2018	28 Feb 2018	1 Mar 2018	2 Mar 2018	3 Mar 2018
Solar cell	8%	5%	6%	8%	8%	10%	8%
Solar charge	56%	69%	59%	53%	59%	46%	53%

7. Charging the Battery With Load

After making observations of measurements without load, it will be carried out testing and observing the whole measurement where all the components that have been tested one by one become the solar home system. The test is carried out to see whether a battery that is 100% full can supply a lamp load for 10 hours, simultaneously when charging the battery. Charging loads are 2 units of incandescent 15 Watt 2 units on March 9, 2018, 15 Watt energy saving lamp (LHE) 4 units on March 11, 2018 and 2 units 15 Watt incandescent lamp load, energy saving lamp (LHE) 15 Watt 4 units on March 14, 2018. The light load will turn on (on) from the morning at 07.00 WIB, then will be turned off (0ff) manually at 17.00 WIB. At the time of observation, the measurement was carried out for 30 minutes with the battery 100% charged.

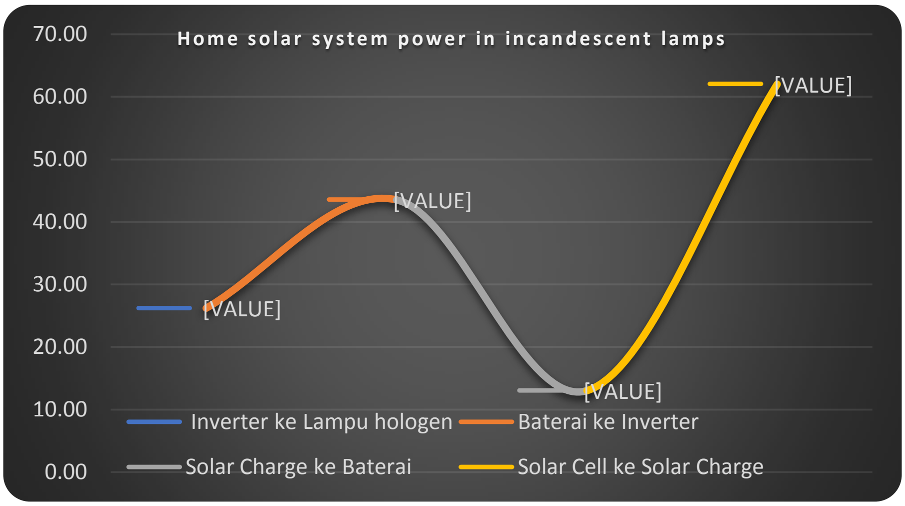

Figure 16 Graph of the average power of the solar home system in incandescent lamps

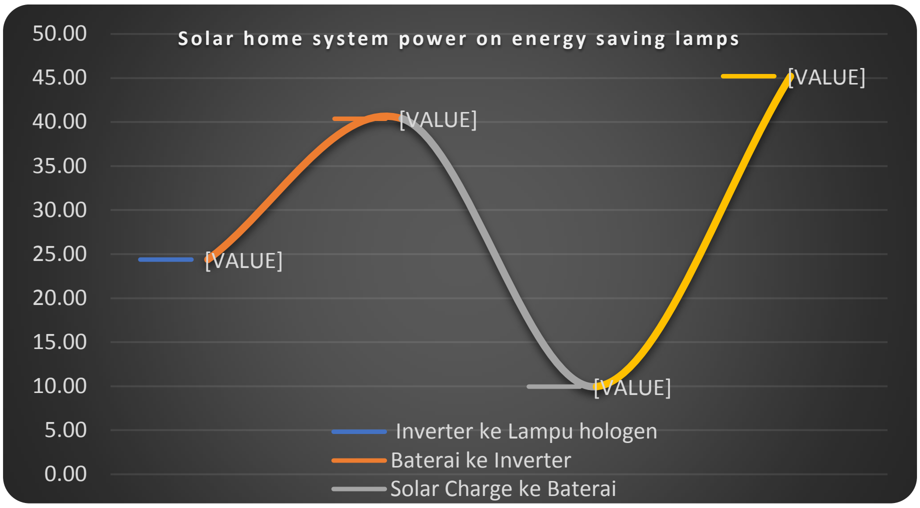

Figure 17 Graph of the average power of the solar home system on energy efficient lamps

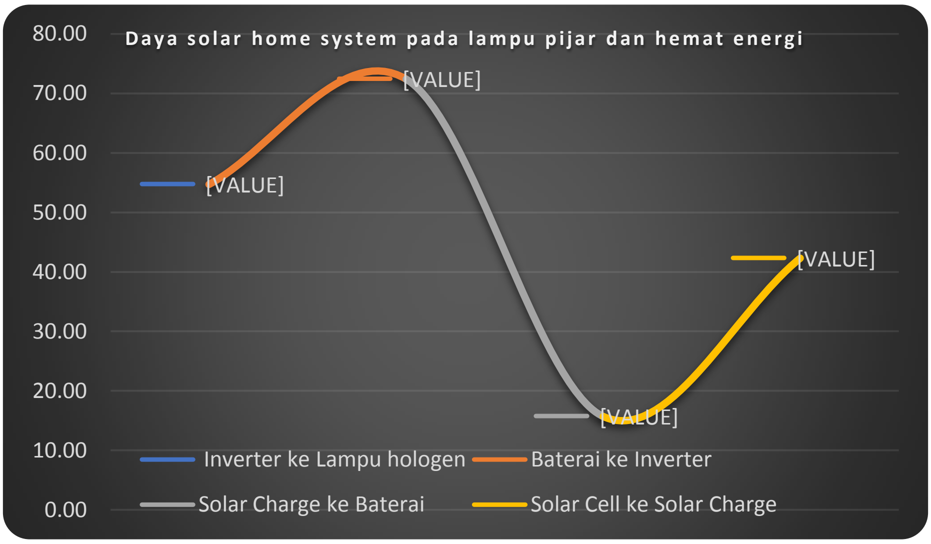

Figure 18 Graph of the average power of the solar home system in incandescent and energy-saving lamps

Table 3 Efficiency data from solar home system components

No	Date/Time	Efficiency			
		Inverter	*Battery*	*Solar charge*	*Solar cell*
1	9 Mar 2018	60%	18%	21%	9%
2	11 Mar 2018	60%	17%	22%	7%
3	14 Mar 2018	76%	30%	37%	6%

Table 4 Data faktor daya selama pengukuran dengan beban

No	Item	Date/Time	Power Factor
1	Incandescent Lamps	9 Mar 2018	0.87
2	Energy Saving Lamps	11 Mar 2018	0.41
3	Incandescent Lamps& Energy Saving Lamps	14 Mar 2018	0.61

IV. CONCLUSIONS

Based on the results of research on the 200 Wp solar home system, it can be concluded that it functions well with a predetermined design of the load that is 90 watts. The best conditions are when charging the battery from the solar cell via solar charge at 10.00 WIB until 14.00 WIB and the use of 70% battery power can be used for ± 18 hours with 100% battery condition and 30% battery power is not used. The solar cell used has an efficiency with the observed measurement results of 14.84% when charging the battery and the results shown by the PVSyst software are 14.74%. By using the PVsyst software, see the specifications and efficiency of the solar home system components. When charging a battery from a solar cell via solar charge, the smaller the current and the greater the voltage on the solar charge, it will indicate that the battery will be full. The efficiency of the solar cell affects the type of solar cell on the overall system performance. The surface area and type of solar cell also affect the charging of electrical energy for battery charging. Determination of the type of load power greatly affects the consumption of battery power from the inverter. The determination of the inverter is very much needed for the use of battery power at the load power to be borne. To get the efficiency of the solar home system from the PVsyst software, first, you must first obtain the specification data of the solar home system components from the model and manufacturer. It is advisable to carry out simulations with different conditions such as models of the types of solar home system components, altitude, temperature and humidity, and other environmental parameters. This research should be followed up by increasing the load power capacity used for the solar home system so that we know the extent of its development.

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