

Solar Panel Energy Modeling by using Matlab Simulink

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Abstract: New and renewable energy is one of the research priorities in Indonesia and even the world today. This is to answer the limitations and the high cost of using conventional energy sources such as petroleum for generators. By using new and renewable energy, we can save costs and also help governments and the world to keep the air clean from the dangers of pollution. For Indonesia we have abundant natural resources including constant and high intensity sunlight. This encourages us as researchers to make maximum use of one of these renewable energy sources. Solar Panel, which is the application of new and renewable energy technology that comes from solar insulation. In its use to the community, an analysis must be carried out in advance of the intensity of sunlight in a certain area. This is to calculate the number of solar panels that will be used to meet the energy needed by the community. Therefore, this study aims to create a solar panel model with input in the form of light insulation data using Matlab Simulink. So that by modeling and analyzing the amount of energy produced by a certain type of solar panel, it can determine how many solar panels are needed for a certain area.

1 INTRODUCTION

Renewable energy is one of the most well-known energy problems today. There are several potential sources of renewable energy. One of the common and simple renewable energies is solar energy. The big problem with the current availability of energy is the limited conventional energy sources such as fuel. These all energy sources have a lot of problems because they have a finite amount of energy. It is important to create models and analyzes based on the availability of energy sources. Solar energy is the most preferred renewable energy in equatorial countries today. It depends on the production of solar energy in a particular area to have a good solar energy design and analysis. To have a good analysis of that, in this paper we make a predictive model of solar energy based on solar irradiation data.

Solar Panel, which is the application of new and renewable energy technology that comes from solar insulation. In its use to the community, an analysis must be carried out in advance of the intensity of sunlight in a certain area. This is to calculate the number of solar panels that will be used to meet the energy needed by the community. Therefore, this study aims to create a solar panel model with input in

the form of light insulation data using Matlab Simulink. So that by modeling and analyzing the amount of energy produced by a certain type of solar panel, it can determine how many solar panels are needed for a certain area.

2 RESEARCH LITERATURE

Modeling of Solar Panel/Photo voltaic Energy System:

The output of PV-arrays is DC Power and this output can be directly used to the DC load/appliances. Hence, if the load is AC appliances, the DC power has to be changed into AC form using power electronic inverters (DC/AC). In the SOPRA HAN system, the type of load is AC appliances. Hence, the PV-arrays are connected to the battery pack via ESI converter (AC-DC) which is a bi-directional DC/AC converter. There are many mathematical models developed to describe the behavior of PV. In this project, the model reepresents the power output of PV. Hourly power output from PV system with an area A_{pv} (m²) on an average day of j th month, when total solar radiation of IT (kW h/m²) is incident on PV surface, so the equation 1 of the system:

$$P_{pv - AC bus} = I_{Tj} \cdot \eta \cdot A_{PV} \quad (1)$$

where system efficiency η is given by

$$\eta = \eta_m \cdot \eta_{pc} \cdot Pf$$

and, the module efficiency (η_m) is given by

$$\eta_m = \eta_r [1 - \beta(T_c - T_r)]$$

$$T_c = T_a + \frac{(NOCT - T_a, NOCT)}{IT, NOCT} \cdot I_T \quad (2)$$

Where

IT = The total solar radiation is incident on PV surface (W/m²)

Apv = Area of a single PV-panel (m²)

η = System Efficiency

η_m = module efficiency

η_{pc} = Power converter efficiency

Pf = Packing Factor

η_r = Module reference Efficiency

β = The array efficiency temperature coefficient

Tr = The reference temperature for the cell efficiency (°C)

Ta = The instantaneous ambient temperature (°C)

NOCT = Normal operating cell temperature (°C)

IT,NOCT= The irradiation in NOCT (W/m²)

Ta,NOCT= The ambient Temperature in NOCT (°C)

There are 2 types of PV Panels (SI185N and FS225) used the system and their parameter which are used for the calculation of powers from a PV panel can be seen in the datasheets. Based on the equations, the simulation model for the PV array is shown in fig 1 below:

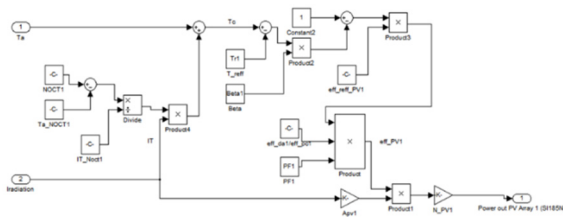


Figure 1: Simulink Matlab model for output power of PV Array SI185N.

3 RESEARCH METHODS

This study uses statistical modeling based on data on wind speed, sunlight insulation and the amount of electricity used. MATLAB application software is used as a simulator to obtain the amount of power generated by solar panels. Wind speed data is

obtained from secondary data in the form of data from a certain area. Likewise, the type of solar panel used is the type ES225 / SI185N. This statistical modeling uses physical formulas based on mathematical and physics models with the input of sunlight insulation excel data. The variables and system equations will be simulated in the MATLAB application software.

Solar panels are devices that consist of solar cells that convert light into electricity. They are called solar or sun or "sol" because the sun is the strongest light source that can be utilized. Solar panels are often called photovoltaic cells, photovoltaic can be interpreted as "electric light". Solar cells rely on the photovoltaic effect to absorb energy. In general, a solar cell is a semi-conductor expanse that can absorb photons from sunlight and convert it into electricity. These solar cells are made of tiny pieces of silicon coated with a special chemical to form the basis of the solar cell. Solar cells generally have a minimum thickness of 0.3 mm and are made of slices of semiconductor material with positive and negative poles. In a solar cell there is a connection (function) between two thin layers made of semiconductor material, known as "P" type semiconductors (positive) and "N" type semiconductors (Negative), respectively. P type silicon is a surface layer that is made very thin so that sunlight can penetrate directly to reach the junction.

This part P is given a ring-shaped nickel coating, as the positive output terminal. Below the P section, there is a type of N section coated with nickel as a terminal. The process of converting or converting sunlight to electricity is possible because the material that makes up solar cells is a semiconductor. More precisely, it consists of two types of semiconductors, namely the n type and the p type. An n-type semiconductor is a semiconductor that has an excess of electrons, so that the excess is negative, (n = negative). Meanwhile, p type semiconductors have excess holes, so it is called p (p = positive) because of the excess positive charge. Initially, the manufacture of these two types of semiconductors was intended to increase the level of conductivity or the electrical and thermal conductivity of natural semiconductors. In this natural semiconductor, the electrons and holes have the same number. Excess electrons or holes can increase the electrical and thermal conductivity of a semiconductor. These two types of n and p semiconductors, when put together, form a p-n connection or p-n diode. negative output.

Solar energy is the most preferred renewable energy in equatorial countries today. It depends on the production of solar energy in a particular area to have a good solar energy design and analysis. To have a

good analysis of that, in this paper we make a predictive model of solar energy based on solar irradiation data. We are modeling solar energy using Matlab and Simulink.

```

1 % Model of a single PV-panel within 1 Year
2
3 % Monthly irradiation data
4 load('data.mat');
5 % Monthly Data Load For one year (365 Days)
6 data=load('data.mat');
7
8 % The monthly average irradiation [W/m2] for 1 year
9 load('yearload.mat');
10
11 %
12
13 % The model for one PV-panel type SI185N
14
15 % Area of PV-panel in [m2]
16 Ppv_SI185N_Area=1.7664; % (1.2*1.45)
17
18 % Efficiency of PV-panel in [%]
19 Eff_PV_SI185N=14.5;
20
21 % Power for a single PV-panel type SI185N [W]
22 Ppv_SI185N_Max=Power_Ppv_SI185N(Ppv_SI185N_Area, Ppv_SI185N_Eff);
23
24 % Power for N number of PV-panels type SI185N [W]
25 Ppv_array_SI185N_Max=N*Ppv_SI185N_Max;
26
27 % The maximum Power of a single PV-panel type SI185N during a year
28 Ppv_max_SI185N_Max=Power_Ppv_SI185N;

```

Figure 2: Solar Panel Power Matlab Script.

At the figure 2 we transform the mathematical equations of the PV Model into matlab script. It is a statistical model. So, we get the input from the excel file consist of solar insulation data sheet as the input of the model.

At the figure 3 we make a simulation based on the time series excel input into the simulator. I will display the power produced by the PV Array in the system. So, the output of power produce the pattern based on the various time series input of the solar irradiation. All of the Matlab Script is written with the explanation to have a good understanding for the analysis for the power.

```

25 % The maximum Power of a single PV-panel type FS225
26 Ppv_max_FS225_Max=Power_Ppv_FS225;
27
28 % The maximum Power of PV-arrays type FS225
29 Ppv_array_FS225_Max=N*Ppv_max_FS225_Max;
30
31 %
32
33 %
34
35 %
36
37 %
38
39 %
40
41 %
42
43 %
44
45 %
46
47 %
48
49 %
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74
75 %
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81 %
82
83 %
84
85 %
86
87 %
88
89 %
90
91 %
92
93 %
94
95 %
96
97 %
98
99 %
100

```

Figure 3: Solar Panel Energy Graph Matlab Script.

Validation of Power Output Model of Solar Panel/ Photo Voltaic

This section describes the procedure to validate or

verify the power output model of components of SOPRA HAN. The first plan before the project will be done, the validation will use the measurement data. However, until this report is written the SOPRA plant still has some technical problem so that it is not possible to validate with it. Hence, the verify or validation the power output components are done by comparing it with information or data from datasheet components.

As explained in section 3.2.1, there are two models of solar panel that represents two types of Solar panel that used in SOPRA as model of PV SI185N and FS225. To see the performance of the model simulation of solar panel, we generate the artificial dataset of weather input that represents the normal operating condition of PV SI185N and FS225. For the type PV SI185N, the max power output for a single PV panel with the test condition with temperature ambient (Ta) 20oC and the maximum input irradiation 1000 W/m2 is 185 Watt with efficiency module 14.5%. While the type PV FS225 the max power output for a single PV panel is 225Watt with efficiency module 14.5% in test conditions with 20oC and the maximum input irradiation 1000 W/m2. The figures below show the simulation power output of a single PV panel for both type of PV panel.

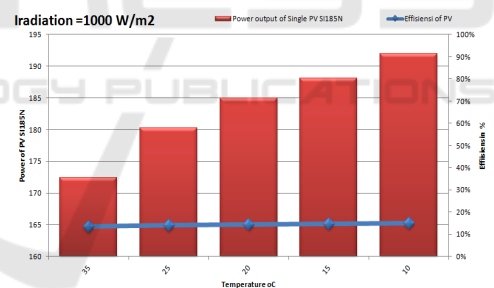


Figure 4: The output Power of a single of PV SI185N with constant Irradiation 1000 W/m².

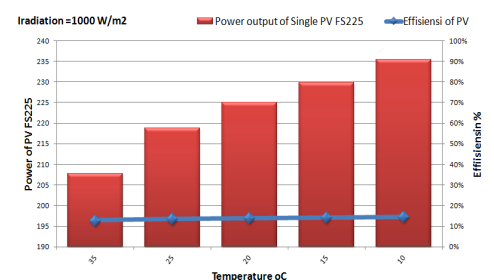


Figure 5: The output Power of a single of PV FS225 with constant Irradiation 1000 W/m².

Figure 4 and Figure 5 show the simulation of PV model with keep the irradiation in 1000 W/m² and

variance of temperature ambient (T_a). It can be seen the output power of PV affected by T_a . It will affect the temperature cell of PV which there is a decrease of efficiency of PV if there is an increase T_a surround the PV panel. Both of the simulation result of PV SI185N and PV FS225 show that for the irradiation 1000 W/m² and T_a 20°C, then the power output of both PV are 185 W and 225 W respectively.

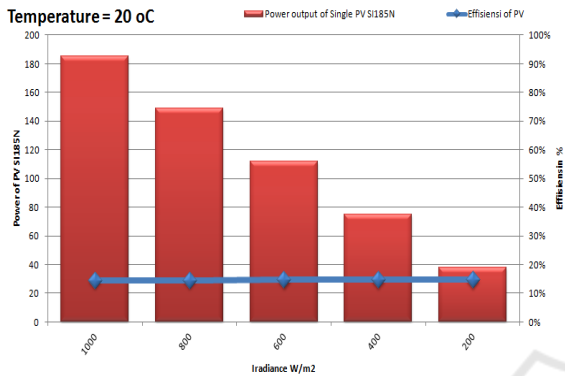


Figure 6 :The output Power of a single of PV SI185N with constant T_a 20°C.

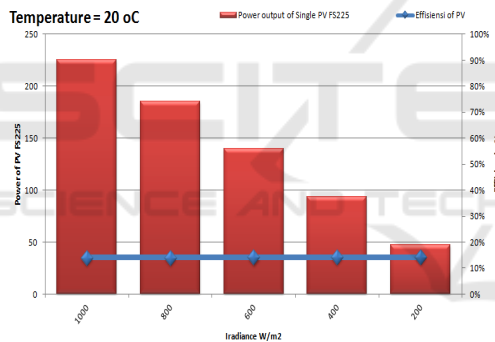


Figure 7: The output Power of a single of PV FS225 with constant T_a 20°C.

Based on the figure 6 and Figure 7, it can be seen the output power of both type PV depends on the solar irradiation. The output of PV will decrease when the amount of solar irradiation is become smaller. The changing of amount of solar irradiation gives high impact to the power output of PV. Otherwise, the effect of temperature to the output power of PV is in small amount.

All of the simulation result above is represented to see the performance of the power output models of a single PV panel of both type PV. And one of must be considered that each region has typical weather. For instance, in tropical region like thailand has a high average solar irradiation and also high average temperature where the last give decrease impact to the power output. Otherwise the west region has the

opposite condition. The next chapter (chapter 4) will shows the result of solar panel as a PV array and the effect of this power output by teh real weather condition.

4 RESULTS AND DISCUSSION

The simulation and analysis of the system design above is to use statistical modeling based on wind speed data, sunlight insolation and the load of a certain area. The data is analyzed into the Matlab application using the physical equations of the system components. The following is modeling using the Matlab Editor:

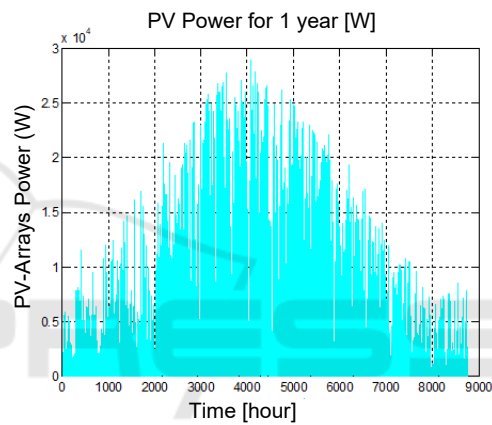


Figure 8: Power Produced in 1 Year.

Based on the Figure 8, the various output as the power of PV Array in a year. It describe a maximum power in the middle of the year. I caused by the solar insolation has a pattern in every year.

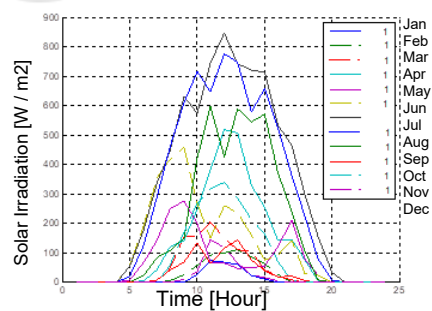


Figure 9: Simulation of Sunlight Insulation per Month in 1 Year.

Based on the Figure 9, it describe the pattern of every month power produced by the PV Array. I shows that July is the maximum power produced every year.

Because the position of the earth toward the sun namely aphelium and perihelium.

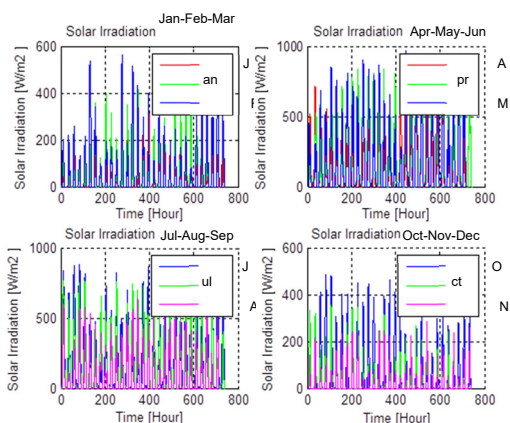


Figure 10: Irradiation in 1 Year.

From the figure 10 above, it describes the various solar irradiation in 3 serial months. At the middle of the year from July to September produced more power because the distance between the sun and the earth.

5 CONCLUSION

From these results it can be concluded that the value of solar irradiation varies each month. This determines the amount of energy produced by the solar panels. The more renewable components available, the greater the value of the power. However, this will result in an even greater cost. Therefore, it is necessary to find the ideal amount of these components to produce energy as efficiently as possible. Likewise, the graphs taken in this study look too large, resulting in unstable power. The value of the power generated to be efficient must be in accordance with the amount of load and data on sunlight insulation in the area.

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