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Performance Analysis OFF GRID Solar Power Plant through Characteristic of Current – Voltage (I–V) Installation of Solar Power Plant OFF GRID PPSDM KEBTKE

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ABSTRACT:
In photovoltaic solar cell system, solar radition energy is converted into deirect current electrical energy based on the photovoltaic effect. The solar cell is then assembled into asolar module that us arranged in series and parallel to produce a greater voltage and Current. The performance of solar cell-modules can be recognized through the Characteristic of Current to Voltage (I – V). I-V Characteristic describe the Current and Voltage generated and the power generated. The solar module is designed to operate according to a standard test of temeperature and conditions of 100 W/m^2 and a temperature of 25^0 C. in other conditions, the solar module will produce different performance. An increase in temeperature in the module can result in reduce power and efficiency of the photovoltaic module. This paper will analyze the result of Current and Voltage measurement at operating conditions at 12.45 PM, solar cell temperature 49^0 C and cloudy sky. The Schneider soalr module is designed at irradiation of 1000 Watt/m2 at a cell temperature of 25^o C to produce a short circuit Current Isc 9.02 Amperre (string) and an open circuit Voltage Voc 102.2 V (string). At the irradiation of 1000 Watt/m^2 at a cell temperature of 25^o C, the power generated in array 1 (3x4) 3.687.376 Watt and array 2 (3x3) 2.765.532 Watt and efficiency of 14.5%. The efficiency of this calculation results in accordance with the design of the single crystal sislicon module (15-18)%. The results of the measurement of string Current and Voltage in array 1 obtained data flow 0.3 A and Voltage 102.5 V and irradiation of about 33.3 Watt per m^2. There needs to be an examination of the low module output by examining the top layer of Ethylene Vinyl Acetate (EVA) cells and the bottom layer (Polyvinyl Flouride Film) and it is necessary to check the connection of the solar cells (sting) in the module is not broken/loose.

KEYWORDS: I-V Characteristics, PV module performance

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I. INTRODUCTION

Energy needs as a driver of life are increasingly. This is driven by a surge in the number of human populations especialy in developing countries. Primer energy sources that is widely used at this time is fossil energy whose reserves are increasingly decresing, Moreover, the adverse effect of the use of energy in the form of gases that can damage the environment, one of which is the CO^2 that causes greenhouse effect. With this reason we are expected to seek and utilized new energy resources (*Non Conventional Energy*) that are more efficient anda have limited existence, so that it can be utilized contonuosly like utilizing solar energy by photovoltaic soalr cells, because solar energy is a limited source of energy available, it is very efficient, environmentally friendly anda reduces pollution to the environment.

PPSDM KEBTKE as an educational institution has utilized of solar power plant for own utilization and training facilities. Solar Power plant installed are 15 KW On Grid and 15 KW Off Grid.

In Photovoltaic solar cell system, solar radiation energy is converted into direct current electrical energy based on the photovoltaic effect. In the process solar cell serves as semiconductor diode that commonly made from silicon. Solar cell are then assembled into solar modul whit seri and parallel to produce greater voltages and currents under certain environment conditions. A solar cell-Modul designed to produce performance at temperature 25° C and radiation 1000 Watt/m^2. But another condition solar cell-Modul performance can be known through current characteristic of voltage.

Based on the problem above we can identify the problem are:

a. Effect of environmental conditions (temperature, weather time) on the performance of PV – VP Curent, Voltage, power, efficiency);
b. Effect the light intensity with respect to the current and output Voltage of the Module.;
c. Relationship between Solar power plant (Power) output with Current and Voltage.

By knowing identify th problem from solar Module, then the formulation of the problem raised are:

a. Does the light intensity have a significant effect on the terminal Voltage?
b. Does the decrease in the intensity of the lighy causes a linear change in the current?
c. Is the power generated by solar cells/Modules proportional to the amount of current?
d. Do environtmental conditions (temperature, weather, time) of operation of the cell/solar module cuase change in Current and Voltage output?
e. What is the Efficience of Solar Modules?

Purpose and Benefits from this paper are:

a. By knowing values of Voltage and Current of a Module under certain operating conditions, it can determine the performance of the module;
b. As part of Solar power plant performance evaluation to determine the technical steps if solar power plant performance below standard;

II. SOLAR ELECTRIC COMPONENT

Solar electricity is a source of electrical energy derived from the sun. With photocell technology, sunlight can be converted into electrical energy. To be able to convert sunlight into electrical energy requires a device called a solar electric component. This solar electric component forms a unified which is organized in such a way that it can work optimally. If one of these components is damaged or cannot be used, then the process of changing light energy into electrical energy can be disrupted.

Circuit of Photovoltaic Module

A Circuit of Photovoltaic Module or also called Array, Array consists of several modules that are connected in series and/ or parallel. This circuits convert sunlight radiation that hits the entire surface of the circuit into electricity.

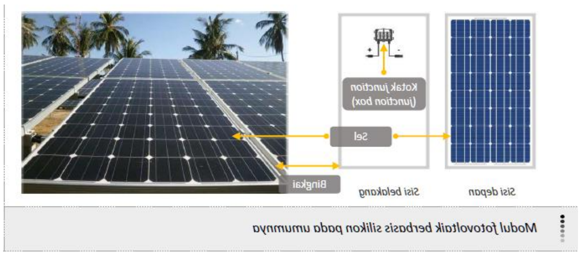

Figure 1. Circuit of Photovoltaic Module

Combiner Box combining multiple solar module strings or soalr modules in a parallel configuration. This Box also features a protection device to protect each string of photovolataic modules.

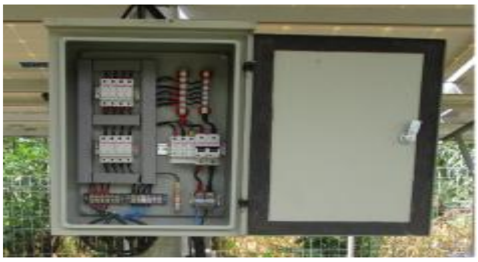

Figure 2. Combiner Box

Wiring connects the output from Combiner box to the Solar Charge Controller located in genaertor house. Cables are generally installed underground and must be weatherproof or ultraviolet (UV) resistant.

Solar Charge Controller (SCC)

SCC changes the output of the solar module to reach the battery Voltage level and control the battery charging process.

Figure 3. *Solar charge controller* (SCC)

DC Distibution Panel

This panel used as aconection point (Bus) for DC Voltage. This panel connects SCC, battery bank, and inverter.

Figure 4. DC Distibution Panel

Battey Bank

The bank battery stores the energy produced by the solar modules during the day and is used when the load is increased and the energy from photovoltaic module is insufficient to supply energy.

Figure 5. Bank Battery

Inverter

The battery inverter converts the battery bank's DC Voltage (around 48 V DC) to an AC Voltages of 230 V AC. This inverter also maintains the battey so that the energy in the battery is not used up.

Figure 6. Inverter

AC Distribution Panel

This panel used to conection several battery inverters in parallel as well as also conecting to distribution grid/ network. This panel consist of several connection points or busbars, protections systems, energy meters, and operational indicators.

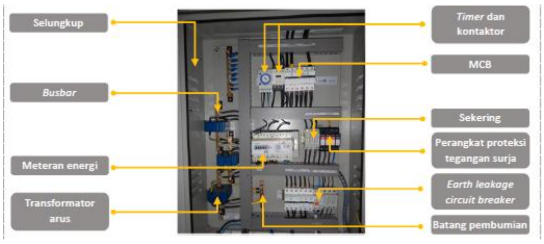

Figure 7. AC Distribution Panel

Monitoring System and Pyranometer

Remote monitoring system (RMS) and pyranometer are instrument to monitor complete system performance and solar irradiation in certain network is available and working properly, monitoring can be done remotely as long as the system is connected GSM.

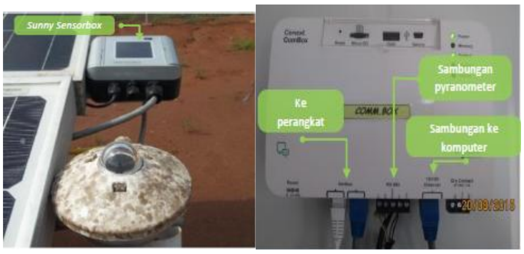

Figure 8. Monitoring System and Pyranometer

Power House

A Power hoiuse is a building where most electronic components are installed including battery inverters, AC distribution panels, SCC, and battery banks., The power house protect component that are sensistive to bad weather or other environmental conditions that can damage the solar power system.

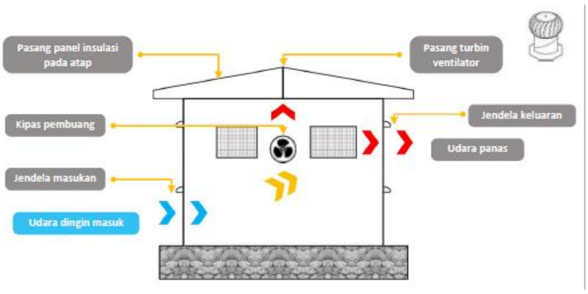

Figure 9. Power house

Lightning Rod

Lightning rods are used to catch lightning strikes to avoid strikes directly to parts made of other conductors in the area of the generating system. Solar power plant must also be supported by good earthing and additional surge Voltage protection devices to protectect the devices electronics of the indirect effect of lightning strikes.

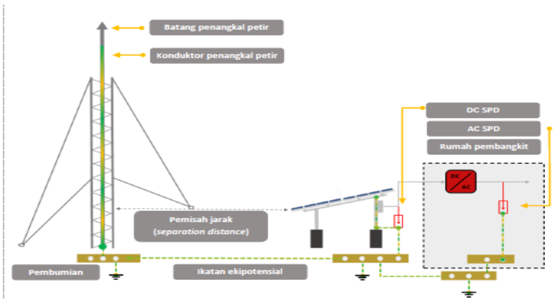

Figure 10. Lightning Rods

The Intensity of solar radiation

The energy particles in sunlight are called photon energy. The amount of photon energy wil determine the amount of electrical energy produced at the time of photovoltaic effect.

The amount of radiation energy that falls on a particular array surface is called the power density or intensity of solar radiation expressed in a Watt/ m^2 or KW / m^2.

The other unit used to measure solar radiation is to state the average price of the Peak Sun Hour each day at a particular location stated in KWh / $m^{2.}$

The magnitude of the intensity of light emitted by the sun when entering the atmospheres is approximately 1367 Watt/ m^2 , and when it penetrates the earths's atmosphere with its fading it will decresase due to the process of absoption, difuusion anda reflection. So that when reaching the surface of the earth the maximum sun's intensity will be approximately ± 1000 Watt/m² or 1 KW/m² in the midle of the bright sun. the typical characteristics of solar horizontal surface intensity with respect to the time when the day is sunny with a day that has been set at 3 different months in 1 year can be seen in figure below.

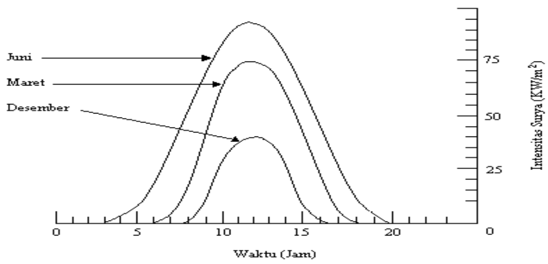

Figure 11. Characteristics of solar intensity over time (hours) in 1 day

Solar Cell

Type of solar cell or photovoltaic cell (PV) which is currently commonly used is crystalline silicon type and thin film solar cell. Crystaline silicon type consist of semiconductor like mono-crystaline and poly crystalline. Thin film solar cell consist of cadmium telluride (CdTe), Copper Indium Gallium Diselenide (CIGS), and amorphous thin-film silicon (a-Si, TF-Si) that can change in sunlight irradiation to electric. When soalr cell absorp sunlight there will be a transfer of free electrons in the negative and positive connections of the cells. If the psositive and negative connection form solar cell connect to load direct current will flow (a series of electrical equipment). On prosess of photovoltaic effect an solar cell, silicon produce voltage about 5 Volt and Cureent 2 Amperre with solidity of current dipend on intensisty of sunlight radiation. Current and Voltage output an solar cell module can be seen in figure below.

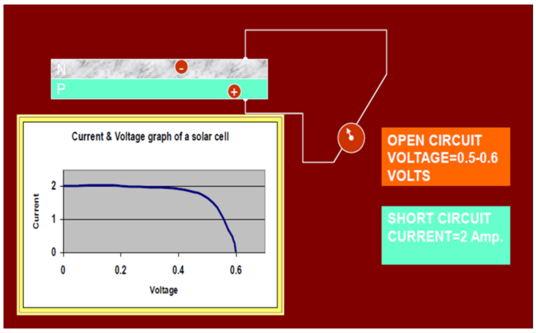

Figure 12. Current and voltage output of silicon solar cell module

A solar module is a group of solar cells arranged anda connected in series or parallel.
The solar module is packaged in protective laminate against the environment. The silicon cells themselves do not experience damage or degradation even after decades of use.
However, the module output will decrease with time. This degradation is caused by two main factors, namely the damaged to the top layer of Ethylene Vynil Acetate (EVA) cells and the lowe layer (Polyvinil Flouride Film) slowly, the information contained in the tabel contain at least the parameter as the table 1.

Table 1. Solar Module labels

The brand and type of photovoltaic module	Module manufacturer and product type pV module
Type	Type of cell (monocrystalline, polycristalien, etc
Module nominal power P_{MAX} (Wp)	Nominal power of PV module with can be from standardized tests (STS, standardized conditional tests) STS includes test condition with sunlight radiation about 1000 W/m2, temperature of module 25 ^{o} C, and air mass1 (AM –air mass) about 1.5 AM
Open Circuit Voltage, Voc (V)	Voltage output from PV module if no load
Short Circuit current, Isc (A)	Current through the PV module when a short circuit occurs
Maximum Power point Voltage (Ump)	Operational voltage in maximum power
Maximum power point current (Imp)	Operational current in maximum power
Maximum Voltage (Umax)	Maximum Voltage when PV module can be operate safely

Solar Cells

A Solar cells are agroup of solar modul es arranged on a buffer structure that will form building blocks in a single string anda as the basis formation of PV Array. In a centralized solar cell system the maintenance of a soalr panel circuit is the wiring of one module with another module. So that the solar module circuit can continue to function s to keep the series of solar cells (strings) in the module uninterrupted, because if the strings in this module are disconnected then the electric currnet cannot flow. The cycle of formation of solar modules, solar panels, solar arrays.

Most manufactures produce solar panels based on a standard test of temperature and conditions (STC) with an iiradiation of 1 kW.m^{2}; a temperature of 25 ^{o}C with in open Voltage (Voc) and a maximum Voltage (Vpm). PV arrays with crystalline modules on average, the Voltage will drop by 0.5 V every 10 ^{c}C. The formation of a solar array or PV Array consists of two or more soalr panels which are connected together in series and parallel series. Pv array electrical cables are electrically connected together to form a PV array installation and in general the greater the surface area of the PV array, will produce greater electrical power.

Characteristic of Current - Voltage

This curve is plotting Cureent and Volatege, from short circuit Current (Isc) to open circuit Voltage (Voc). The performance of solar modules can be calculated by multiplying Current and Voltage at the points on the curve.

I – V curves are produced from solar cell experiments or solar modules subject to irradiation exposure. Curves I – V pass through 2 (two) main points, namely short circuit Current (Isc) and open circuit Voltage (Voc). Short-circuit Current is the current generated when the positive and negative terminals are directly connected. The zero value on the resistance makes th Volatge value also zero value. Conversely, an open circuit voltage occurs when the positive and negative terminals are open, so there is no current flowing. The Current-Voltage charaecteristic in figure below is the operation of the cella t a light intensity of 1000 W/m^2 with an operating temperature of 20 ^{o}C. for different light intensities the current-voltage characteristic will change. From fugure below (current –Voltage characteristics at fdifferent light intensisties) it is seen that for decreased light intensity it turn out that the terminal Voltage does not change too much, on the contrary for the decreased light intensity the current changes linearly. Therefore it can be conclude that the surface area of a solar cell does not greatly affect the terminal voltage, on the contrary the surface area of a solar cell largely determines the amount of current.

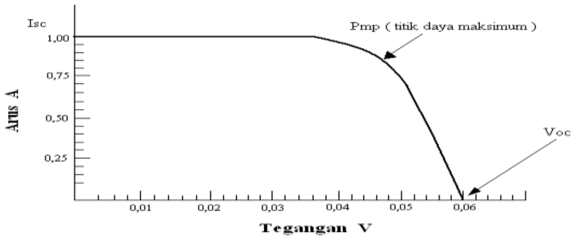

Figure 13. Characteistic Current –Voltage of 10 m^2 silicon solar cell at an intensity of 1 KW/m^2 temperature 20 ^{o}C

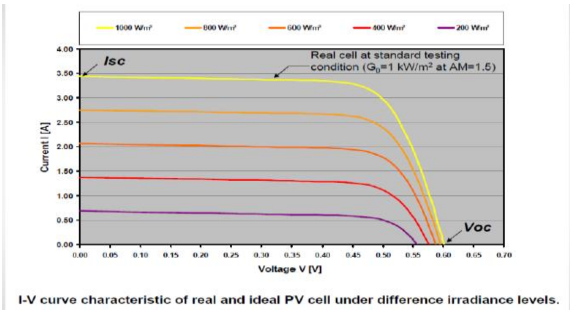

Figure 14. Characteistic Current –Voltage solar module at various irradiation levels

Power Generated

Based on the Voltage formula, the load resistance will make the clel work at the point of the current-Voltage characteristic curve, namely by dividing the Volatge and the amount of Current from the Current – Voltage charactersitics so that maximum solar cell operating point can be determined ar the load. This is shown in figure below.

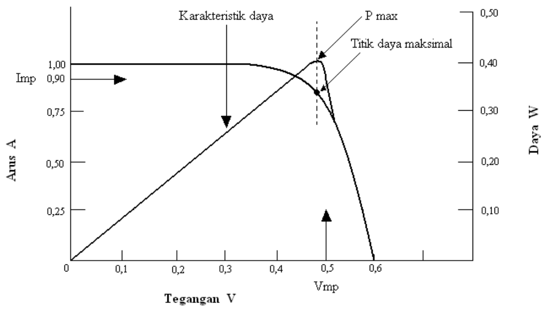

Figure 15. Current and power characteristics as a function of Volatge

As explained if figure 13, it can be seen from the characteristic curve in figure 15 that the knee shape of curve is the same for different light intensities, where the terminal Voltage does not change much, only the Current will change linearly. Because the terminal Voltage does not change too much, it can be concluded that the power generated by solar cells is proportional to the amount of Current and the power generated is almost maximum at light levels except at the lowest level.

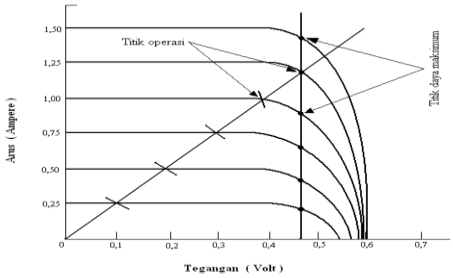

Figure 16. operating point of load resistance and maximum power point at changing intensity.

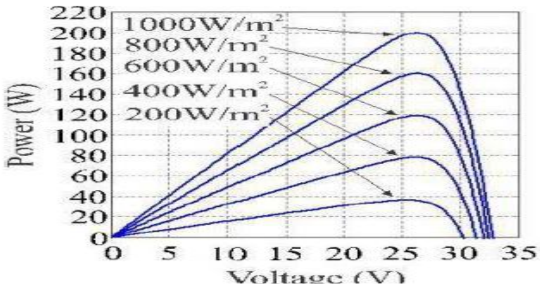

Figure 17. Curve of Solar module power against irradiation

Efficiency of Solar Energy Conversion

The efficiency of solar energy conversion is actually determined by the process of making solar cells and the materials used in making these solar cells. These factors that influence the reduced efficiency of solar cell energy conversion are due to the presence of an anti-reflection thin layer and an electrical contact layer on the N-type surface that prevent sunlight from penetrating into the P-N connection. Another factor that influences the efficiency of solar cells is due to the reflection of light ont the surface of the solar cell layer that does not penetrate the N layer and also because of the excess photon energy that is not utilized by the solar cell.

The efficiency of solar energy conversion is defined as the ratio of electrical output power and solar energy input.

$$\eta = \frac{\text{Daya Output listrik}}{\text{Daya Input Matahari}} = \frac{P_{out}}{P_{in}}$$

Where:

$P_{out} = V_{mp}\, I_{mp}$ dan ; $P_{in} = H \,.\, A$

Vmp : Voltage at maximum power

Imp : Current at maximum power

H : The intensity of solar radiation

A : Surface area of solar cells

So that efficiency can also be written as follows:

$$\eta = \frac{H.\ A}{V_{mp} \,.\, I_{mp}}$$

If the fill factor of the current-voltage characteristic is defined as follws:

$$F_F = \frac{Voc.\ Isc}{V_{mp} \,.\, I_{mp}}$$

Then the efficiency can be written as follows

$$\eta = \frac{F_F \,.\, V_{oc} \,.\, I_{sc}}{H\ A}$$

Where:

Voc: Voltage in open circuit state

Isc: short circuit current
Ff: fill factor which amounts to about 0.6 -0.8 for Si solar cells.
The efficiency of monocrystalline solar cells is around 15 – 28%, polycrystalline solar cells have efficiency (12-14%), efficiency of thin film solar cells (5-6%).

Effect of Temperature on solar cells

For Temperature which is different in the operation of solar cells, the current and Voltage output will change, as well as the magnitude of the short-circuit current, the open circuit current Voltage and the maximum power will change linearly. This can be seen ini the characteristics of currnet –
Voltage at different temperatures and graphs Voc, Isc and Pmax as a function of temperature.

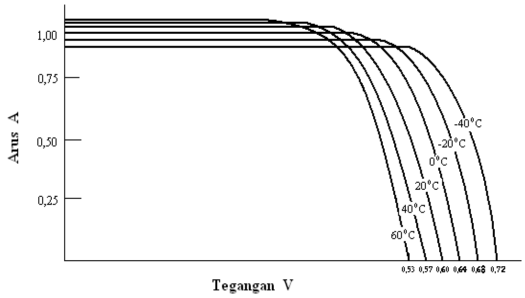

Figure 18. Current – Voltage characteristics as a function of temperature changes

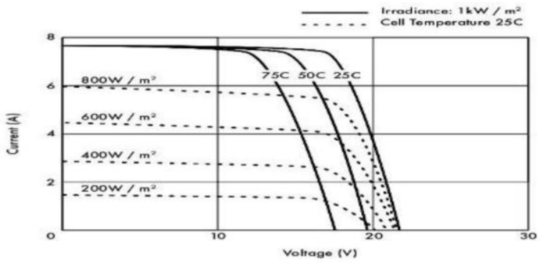

Figure 19. Effect of Temperature, Irradiation on Current and Voltage

Generally, in sunny and hot conditions (the equator), photovoltaic temperature can reach 40- 50 ^{o}C and it is not impossible that the temperature can be higher than that.

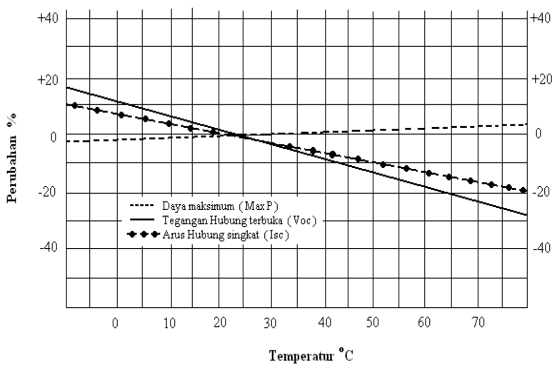

Figure 20. Graph of Voc, Isc, Pmax as a function of temperature.

From the curve above it canbe seen that at temperatures below 25 ^{o}C the output power increases, whereas at even higher temperatures the output power decreses. With the change in output power due to temperature changes, the conversion efficiency also changes. This is shown in the efficiency characteristics of solar cells as a function as shown in figure bellow.

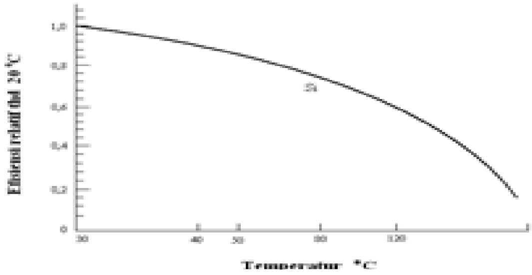

Figure 21. Efficiency characteristics as a function of temperature.

Formation of Photovoltaic Modules and Arrays

In application we can connect severl soalr cells in a series and parallel relationship to from a power plant that provides the desired Current and voltage at a load.

In application we can connect severl soalr cells in a series and parallel relationship to from a power plant that provides the desired Current and voltage at a load.

In the connection of solar cells in series as shown in figure bellows, it is known that the total Voltage of solar cells in the series is the result of the total Volatge of each soalr cell. While the amount of current produced is the same as the current of a single solar cell. Therefore it can be concluded that the connection of solar cell series wil determine the desired amount of current.

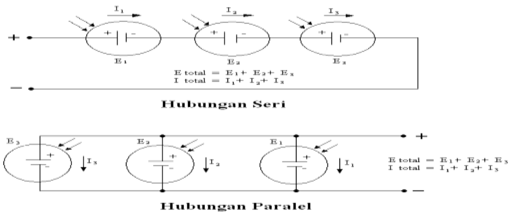

Figure 22. Conection of solar cells in series and Parallel

The Current –Voltage characteristic curves of several solar cells connected in series – parallel, and combination of series and parallel are shown in figure below.

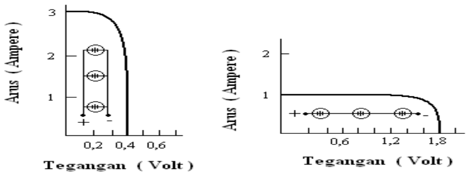

Figure 23. Current –Voltage characteristic curves in series and parallel

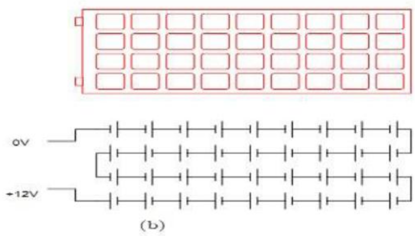

Figure 24 Series connection on Solar cell modules

Array of Photovoltaic Arrays

In amodule the solar cell circuits in series are called often, and parallel circuit are called blocks. The modules that have been formed are reconnected in series call Branch-circuits which are then several Branch-circuit solar modules assembled into a Photovoltaic Array. In the assembly the module can be first connected in series first, then later in parallel or can also be done vice versa. This can be seen in figure below.

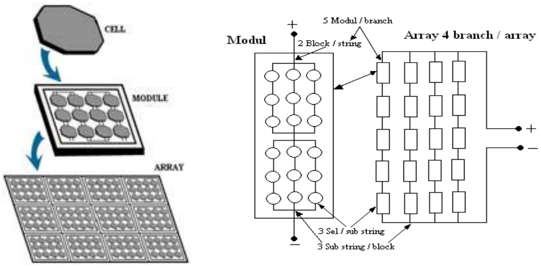

Figure 25. Arrangement of cells in modules and modules in arrays

Direct Current Circuits

Basically, direct Current-Voltage sources for both batteries and solar modules can be arranged in series or in parallel. The outputs of the two circuits will be different.

The series of solar modules will increase the output Voltage while the electric Current will be the same. The series of solar modules can be seen in figure below.

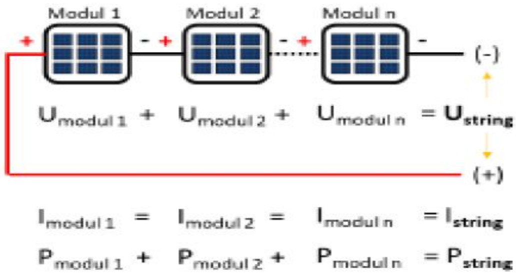

Figure 26. Series

The parallel circuit of the solar module will increase the ampere but output Voltage will remain the same. The parallel electrical circuit of the solar modul can be seen in figure below.

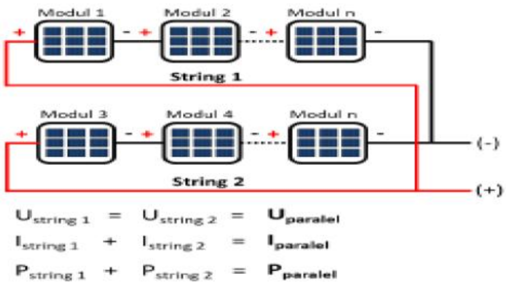

Figure 27. Parallel

III. RESULT AND DISCUSSION

The guidelines issued by PT. LEN state that the measured Voc value must match or approach the value listed on the solar module label. Likewise, the Isc value listed in the module listed in the table must be at least 1.25 times the value of each measurement result.

3.1. Off Grid Solar Power Plant in PPSDM KEBTKE

Solar power plant in PPSDM KEBTKE has 3 different installation units namely Scneider, Leonic and SMA instalations as shown in figure below.

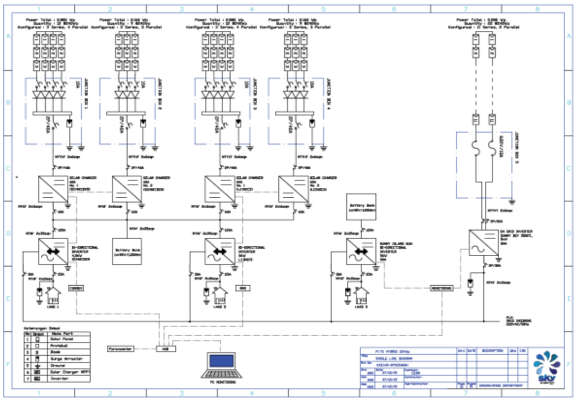

Figure 28 instalation Off Grid Solar power plant in PPSDM KEBTKE

From figure 28 above it can be seen that the Scneider and leonic installation has 2 array modules with 3 series x 4 parallel (3x4) and 3 series x 3 parallel configuration (3x3) as well as SMA 21 (22) parallel x 2 series (21 922) configuration x 2).

The module technical data consist of:

1. Maximum power (Pmax) 240 W;
2. Voltage at maximum power (Vmp) 28.4 V;
3. Curent at maximum power (Imp) 8.47 A;
4. Open Circuit Voltage (Voc) 34,0 V;
5. Short circuit Current (Isc) 9.02 A;
6. Maximum system Volatge of 1000 V;
7. Temperature range of -40 ^{o}C to + 85 oC;
8. Test at STC 1000 W/m2/AM 1.5 / cell temp / 25 ^{o}C;
9. Nominal operation Cell temperature (NOCT) 45 ^{o}C + - 2 oC (43 ^{o}C – 47 ^{o}C);
10. Dimension: 14.99 x 9.90 cm;
11. Monocrystalline.

Figure 29. technical data of solar modules

3.2. Calcualtion of Open Circuit Voltage (Voc)

To calculate Voc, you need to know the configuration of the PV array module and its technical data. From the single line diagram if the solar power plant off grid PPSDM KEBTKE Scheider is known to have 3 series (string) and 4 parallel configurations on the PV array modules 1 and 3 series (string) and 3 parallel on the PV module array 2. From the technical data the values of Voc and Isc are known is 34.0 V and 9.02 A.

3.2.1. Array PV Module 1

Series circuit calculation:

a. Voc String 1:= Voc modul 1 + Voc modul 2 and Voc modul 3 = 34,0 V x 3 = 102, 2 V
b. Voc String 2:= Voc modul 1 + Voc modul 2 and Voc modul 3 = 34,0 V x 3 = 102, 2 V
c. Voc String 3:= Voc modul 1 + Voc modul 2 and Voc modul 3 = 34,0 V x 3 = 102, 2 V
d. Voc String 4:= Voc modul 1 + Voc modul 2 and Voc modul 3 = 34,0 V x 3 = 102, 2

Parallel circuit calculation

e. Voc String 1:= Voc String 2:= Voc String 3 = Voc String 4= **102, 2** V

1.1.1. Array PV modul 2

Series circuit calculation:

a. Voc String 1:= Voc modul 1 + Voc modul 2 and Voc modul 3 = 34,0 V x 3 = 102, 2 V

b. Voc String 2:= Voc modul 1 + Voc modul 2 and Voc modul 3 = 34,0 V x 3 = 102, 2 V
c. Voc String 3:= Voc modul 1 + Voc modul 2 and Voc modul 3 = 34,0 V x 3 = 102, 2 V

Parallel circuit calculation

a. Isc Paralel = Isc Paralel 1 + Isc Paralel 2 + Isc Paralel 3 = 9,02 x 3 = **27,06** A

From the calculation result above can be made a PV module characteristic chart as shown below.

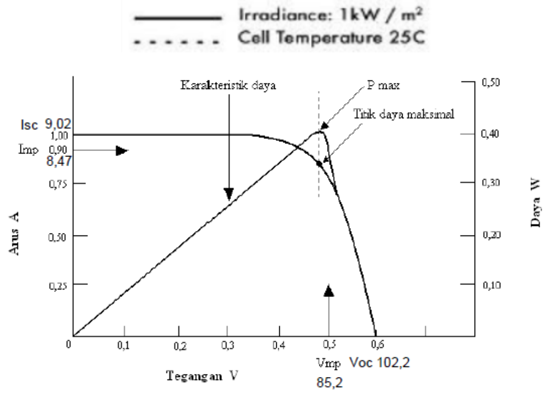

Figure 30. Characteristic of I – V Solar Module String in PPSDM KEBTKE (Schneider)

3.3. Power Output

Power output of solar modul is obtained from the formula P = V x I, so P = 102.2 V x 36.08 A = 3,687. 376 Watt (array PV module 1), and P = 102.2 V x 27.06 A = 2,765. 532 Watt

3.4. PV module Efficiency

From the formula:

$$\eta = \frac{F_F \cdot V_{oc} \cdot I_{sc}}{H\,A}$$

And by using the values: Fr = 0.7, Voc 34.0 V, Isc 9.02 A, H = 1000 Watt/m^2 and A = 148.4 cm^2 or 1.48 m^2, then:

η = 102.2 V x 9.02 A x 0.7 / 1000 W/m^2 x 1.48 m^2

η = 214.7 / 1.480

η = 14.5 %

3.5. Measurement of Solar module Strings (Schneider installation)

Measurement are made of the amount of Voltage, current and temperature of the cell module with the following result:

1. Temperature data: 49. 5 oC – 52.1 oC;
   Cloudy weather, 12.45 WIB;

Figure 31. Temperature data

2. Voltages:
    a. Voltage of String 1 : 103 V
    b. Voltage of String 2 : 102.5 V
    c. Voltage of String 3 : 102 V
    d. Voltage of String 4 : 102.5 V

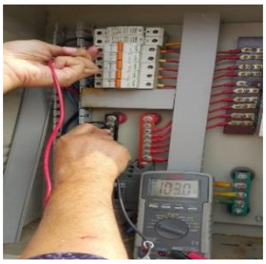

Figure 32. Measuremttn Data of Open circuit Voltage (Voc)

The open circuit Voltage (Voc) measure 102 – 103 V, close to the Voc table (34.0 V/module) or at 102.2 V / string (3 modules). This Voc measure complies with LEN requirement.

3. Current
a. Current String 1, 3 and 4: 0.3 A
b. Current String 2: 0.2 A
LEN requirement Isc listed in the module
table must be able least a.25 times the value of the measured current (7.216 A). with Isc measrumen 0.3 x 1.25 =0.375 A or 5.2% from the required Isc value measuring value 97.216 A).

Figure 33. Short Circuit Current Measurement data (Isc)

3.6. Form the Short Circuit Current Measurement and open circuit Voltage can describe the characteristic I – V string solar Module in PPSDM KEBTKE.
Power generated:
P = 102.5 V x 0.3 A = 30.75 Watt
Efficiency:
η = 0.7 x 102.5 x 0,3 A / 1000 watt/m^2 x 1.48 m^2
η = **1.5** %.

By using the reference light intensity of 1000 Watt/ m^2 for a current 9.02 A, then at current 0.3 A the intensity of sunlight is 33.3 Watt/m^2

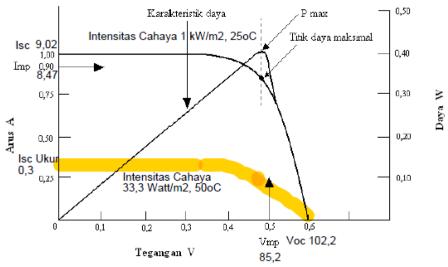

Figure 34. Characteristic I –V String solar module calculate and measurement

Table 2. Voltage, Current, Power and Efficiency

No	Scale	Calculated	Measurement
1	Voc Series	102.2 V	103 V 102.5 V 102 V 102.5 V
2	Isc Series	9.02 A	0.3 A 0.2 A 0.3 A 0.3 A
3	Voc Paralell	102.2 V	
4	Isc Paralell 4 strings 3 strings	 36.08 A 27.06 A	
5	Power 4 strings 3 strings	 3.687 W 2.765 W	30.75 W
6	efficiency	14.5 %	1.5 %

IV. CONCLUSION

The Schneider solar module is designed at irradiation of 1000 Watt/m^2 at a cell temperature of 25 ^{o}C to produce a short circuit current Isc 9.02 A (string) and an open circuit Voltage Voc 102.2 V (string);

At the irradiation of 1000 Watt/m^2 at a cell temperature of 25 ^{o}C, the power generated in aaray 1 (3x4) 3.687.376 Watt and array 2 (3x3) 2.765.532 Watt and efficiency of 14.5%. the efficiency of this calculation result in accordance with the design of the Single crystal sislicon module (15-18)%.;

The results of the measurement of string current and Voltage in array 1 obtained data flow 0.3 A and Voltage 102.5 V and irradiation of about 33.3 Watt/ m^2.;

From the measurement results it can be seen that the value of the string Voltage is still around 102.2 V which indicates that the decrease in the intensity of solar radition does not cause a significant change in th trade output;

From the measurement results, it can be seen that the current value of the string A 0.3 changes (decresses) very dramatically in line with the decrease in the intensisty of solar radiation;

The decreses in output current causes a deacrease in output power which is only about 30.75 Watt and efficiency is only 1.5%;

At higher temeperatures in the power output decresases and with changing output power du to changes in temperature and irradiation, the conversion efficiency also changes.

There needs to be an examination of the low intensity of sunlight PV module, It is necessary to examine the low module output by examining the top layer of Ethylene Vynil Acetate (EVA) cells and the bottom layer (Polyvinyl Fluoride film) and It is necessary to check the connection of the solar cells (string) in the module is not broken/loose.

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