Impact of Integration of Solar Blocking Film and Color Filter on Photovoltaic Performance Under Meteorological Condition in Timor Island, Indonesia

Ade Manu Gah, Sumartini Dana and Maychel G. Pae
Electrical Engineering Department, State Polytechnic of Kupang, Kota Kupang, Indonesia

Keywords: Color Filter, Solar Blocking Film, Kupang.

Abstract: Beside solar radiation, a factor that most influences the performance of a PV cell is temperature. When there is an increase in temperature, the short circuit current (Isc) will increase partially but the value of the open circuit voltage (Voc) will decrease which then results in the low output power of the PV cell itself. Some method used to control the surface temperature of solar panels is to use Color Filter and Nano blocking Film. This method passes visible light with a certain wavelength to hit the cell and at the same time reflects other light. Regarding to these method, the latest research used a Light Simulator in the laboratory, where the Filter and Blocking Film impacts on solar panel are tested separately, found that the use of Nano Film was effective in increasing the efficiency of PV Panels up to 14%. However, there has not been a similar application carried out in real conditions (outdoor/outside the Lab) and there has been no integration research under conditions where the two filters are combined. This research aims to analyse the performance of a Photovoltaic System with integration of Solar Blocking Film and Color Filters under Real conditions, namely the climatic conditions of Timor Island lndonesia. The method in this research is an experimental method where the performance of photovoltaic without solar Filters is compared with the performance of photovoltaic that has been integrated with solar blocking film rate of 40% and Color Filters yellow, purple and red. The results show that the performance of PV panels by using a combination of 40% Solar Blocking Film and Yellow Color Filters has succeeded in increasing the output power by up to 7,81% compared to PV panel without filters.

1 INTRODUCTION

Solar Cell is a semiconductor technology that converts solar energy into electrical energy. When sunlight (photons) hit the surface of the solar cell, electrons are separated from the semiconductor material which then creates a flow of electrons known as electric current. In addition to electric current, electric voltage also appears as a result of conversion. The amount of light absorbed by the solar cell is directly proportional to the amount of current produced while the voltage produced depends on the temperature and the type of material used in its manufacture (Ahmad Manasrah, 2019).

One of the things that most affect the performance of a PV cell is temperature. When there is an increase in low temperature, the short circuit current (Isc) will increase partially while the value of the open circuit voltage (Voc) decreases which results in the output power of the PV cell itself which then impacts on the low efficiency of the PV cell performance. On the other hand, if the PV temperature is reduced to near the nominal operating temperature, the PV efficiency will be higher (Teo, Lee, & Hawlader, 2012).

One solution to prevent the increase in temperature is to use a light filter. The use of light filters on solar panels is intended so that sunlight hitting the surface of the panel is a spectrum of light with a longer wave and less energy (Sudhakar, Jain, & Bagga, 2013). In addition, studies on the use of 20%-80% blocking film and color filters have also been used to reduce the temperature of the PV panels and the efficiency results obtained are quite good compared to not using filters (Ahmad Manasrah, 2019). However, the use of color filters and film blocking in this study was tested on the Light Simulator in the Laboratory.

Indonesia's position on the equator has made Indonesia as one of the countries with the largest solar energy absorption in ASEAN. The average intensity

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of solar radiation in Indonesia can reach up to 4.8 kilo watt hour per meter square per day (EBTKE, 2020). East Nusa Tenggara (NTT) is one of the provinces in Indonesia with longer summer season than the rainy season. Summer season in NTT can last 7-8 months while the rainy season lasts 4-5 months. Due to the long duration of summer for 1 year, NTT is considered to be quite rich in sunlight. The highest intensity of solar radiation in Indonesia is in NTT, especially in Sumba Island and Timor Island can reach up to 60 GW (Bere, 2020). This potential later became the government's project to make NTT a solar barn (EBTKE, 2020). Despite having the best solar energy potential in Indonesia, the electrification ratio in NTT is still lower than many other regions in Indonesia. Utilization of solar energy through the technology of converting solar energy into electrical energy is still very low compared to its potential.

As mentioned above, Timor Island is one of the islands in Indonesia with the best light intensity and the average temperature on Timor Island is around 26-32 degrees Celsius (Basuk, Lidjang, & Nulik). With such a high ambient temperature, it is important to consider the use of Filters in the Solar Cell system built around Timor Island. Considering this, this research will conduct a study on the performance of the Solar System by involving the use of Solar Blocking Film and/or Color Filters.

This research will take a case study in Bioba as one of the villages located in Kupang Regency. The reason for choosing Bioba Village is because this village is still not being electrified even though the potential power plant through PV system is great. This area has a fairly high light intensity, reaching 7.3 KW with a fairly high average temperature of 30 degrees Celsius (Weather Spark, 2022).

2 METHOD

The stages of this applied research are as follows:

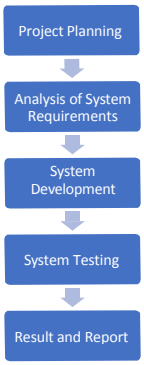

Figure 1: Research Stages.

A. Project Planning

The main purpose of this plan is to get the design and testing method of the Photovoltaic system that was built and integrated with Solar Blocking Films and Spectrum Color Filters. Block diagram of the system that was built is shown below.

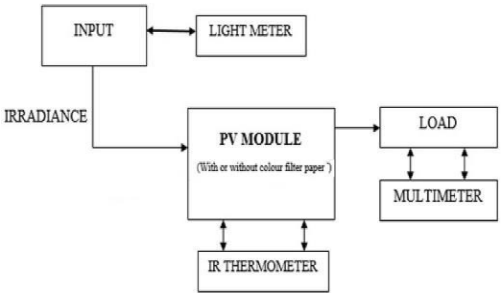

Figure 2: System's Block Diagram.

B. System Requirements

At this stage, an analysis is carried out to determine the requirements for the system development and system testing Some of the main components of the System are:

- Solar Panels,
- Charge Controller,
- Inverters,
- Battery
- AC and DC loads,
- Thermocouple
- Temperature Recorder
- IR thermometer
- Irradiance Meter
- Multimeter
- Solar Blocking Film with a blocking rate of 40%
- Spectrum Color Filter (red, violet, and yellow).

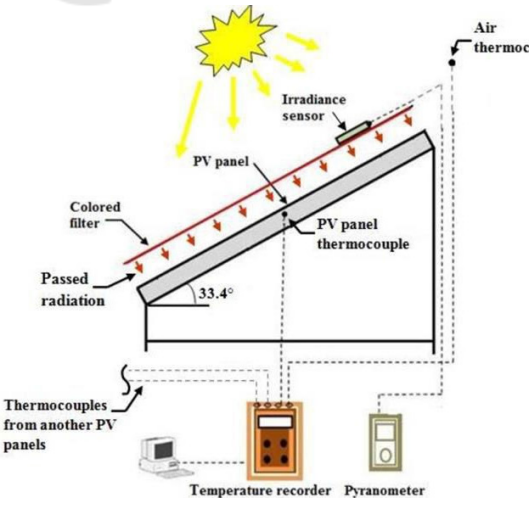

Figure 3: Systems Design.

C. System's Testing

This stage serves to determine the performance of the PV system built under the climate conditions of Timor Island in Bioba Village, Southwest Amfoang. Performance indicators of the PV system built are current, voltage, power, panel temperature, and system efficiency. Some of the tests to be carried out:

a. PV System Performance without integration with Solar Blocking Film and Color Filter
b. PV System Performance with Solar Blocking Film integration with blocking rates of 40%
c. PV System Performance with Integrated Solar Blocking Film and Color Filter

3 RESULT

The performance of the system are measured continuously from 09.00 to 14.00 where the intensity of the sunlight in Timor is considered high. The average temperature of the environment is around 35 degree Celcius.

Table 1: PV System Performance without integration of Solar Blocking Film and Color Filter.

Time	Voltage (Volt)	Current (Ampere)	Power (Watt)
08.00	19,35	1,77	34,23
09.00	19,01	1,72	32,62
10.00	18,78	1,70	31,93
11.00	18,03	1,67	30,27
12.00	18,45	1,70	31,42
13.00	18,70	1,72	32,25
14.00	18,35	1,68	30,95

Table 2: PV System Performance with Solar Blocking Film integration with blocking rates of 40%.

Time	Voltage (Volt)	Current (Ampere)	Power (Watt)
08.00	19,50	1,86	36,27
09.00	18,93	1.80	34,07
10.00	18,81	1,80	33,85
11.00	18,63	1,79	33,34
12.00	18,43	1,76	32,52
13.00	18,40	1,77	32,56
14.00	18,70	1,75	32,72

From the table we can see that the Power output of the system with solar blocking film is better than the PV power output without addition of the Blocking Film

Table 3: PV System Performance with Solar Blocking Film integration with blocking rates of 40% and Yellow Color Filter.

Time	Voltage (Volt)	Current (Ampere)	Power (Watt)
08.00	20,24	1,93	39,14
09.00	20,24	1,95	39,56
10.00	18,52	1,79	33,16
11.00	18,38	1,78	32,82
12.00	18,17	1,76	32,03
13.00	18,20	1,76	32,12
14.00	18,31	1,77	32,55

Power output of the system with the integration of 40% blocking Film and Color Filter Yellow shows better result compared to the previous treatments.

Table 4: PV System Performance with Integration of 40% Solar Blocking Film and Violet Color Filter.

Time	Voltage (Volt)	Current (Ampere)	Power (Watt)
08.00	19,55	1,66	32,57
09.00	18,87	1,60	30,26
10.00	18,94	1,60	30,47
11.00	18,62	1,58	29,43
12.00	18,14	1,53	27,91
13.00	18,15	1,54	27,96
14.00	18,29	1,55	28,42

Table 5: PV System Performance with Integration of 40% Solar Blocking Film and Red Color Filter.

Time	Voltage (Volt)	Current (Ampere)	Power (Watt)
08.00	19,85	1.67	33,15
09.00	18,66	1,59	29,66
10.00	18,27	1,55	2835
11.00	18,02	1,53	28,31
12.00	18,05	1,53	27,61
13.00	17,9	1,52	27,21
14.00	18,05	1,54	27,79

The results shows that the best performance is shown by the PV system with the integration of 40% Solar Blocking Film and Yellow Collor Filter.

The comparison with the system without any Filters is presented in the table below:

Table 6: Comparison with the system without any Filters.

Time	Without Filter	With 40% Blocking Film + Yellow Collor Filter	
	P	P	Δ P (%)
08.00	3.423,02	3914,42	14,36
09.00	3.262,12	3956,92	21,30
10.00	3.193,91	3316,93	3,85
11.00	3.027,24	3282,67	8,44
12.00	3.142,04	3203,37	1,95
13.00	3.225,75	3212,30	-0,42
14.00	3.095,65	3255,52	5,16
Average			7,81

From the table, we can see that there is 7,81% of increase in Power Output if the system integrated with the 40% solar blocking Film and Yellow Color Filter.

4 CONCLUSION

The research is aiming to measure the performance of the PV system with and without addition of Blocking films and Color Filter under the meteorological condition of Timor Island. The results shows that the best performance is shown by the system with the integration of 40% of Solar Blocking Films and Yellow Color Filter where there was an increase around 7, 81 % of its power output compared to the system without integration of any Filter. On the contrary, the addition of the different colors (Violet and Red) integrated with 40% blocking Film in this research show reduc the performance of the panel.

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