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Identification of the Influence of the Use of Thermoelectrics Against the Decrease in the Temperature of Solar Modules

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Abstrat:- The solar heat absorbed by the solar module can raise the temperature and lower its output voltage. Efforts are needed to lower the temperature of the solar module so that it is in standard condition so that its performance remains optimal. The installation of heat-absorbing materials in the form of thermoelectrics is used as an effort to cool the solar module. Thermoelectric is able to reduce the average temperature of solar modules by 7.24°C and increase the average output voltage of solar modules with a difference of up to 3.65 Volts. This condition can be seen from the average Voc output voltage of solar modules added by thermoelectric can reach 18.22 Volts compared to those without thermoelectric additions of 14.57 Volts. The results of the study can be concluded that the addition of thermoelectric heat-absorbing materials is more effective for lowering the temperature of solar modules than without the use of thermoelectric.

I. INTRODUCTION

A solar module or photovoltaic module is a combination of a number of photovoltic cells that work to convert sunlight radiation into electrical energy based on the photovoltic effect. Solar cells are active elements that utilize the photovoltaic effect to convert solar energy into unidirectional electrical energy without the use of moving mechanical parts and also fuel. Combining a number of cells to form a solar module and several modules forming an array. Generally, solar cells are categorized into three types, namely monocrystalline (mono-Si), polycrystalline (poly-Si), and thin film [1].

The efficiency of solar cells varies, depending on the type such as monocrystalline and polycrystalline can reach 30%, while thin film can reach 20%. The sunlight absorbed by solar cells can raise the temperature of solar cells and other residual energy is wasted in the form of heat. This condition greatly affects the performance of solar cells especially monocrystalline and polycrystalline types and this can cause a decrease to voltage which is quite drastic when the temperature rises. The normal working temperature of the solar cell is in the range of 25 ± 10C, and if the solar cell temperature exceeds the normal working temperature, it will affect the output voltage. For a rise in temperature every 1 serajat celsius only (from 25 degrees) can reduce 0.5 % of the total power generated [2],[3].

In contrast to voltage, the short circuit current (Isc) will slightly increase with a rise in temperature.The characteristics of highly non-linear photovoltaic (PV) cells are also influenced by a number of other external factors such as solar irradiation, temperature, wind speed which are environmental factors that strongly affect solar cells. The thermoelectric cooling method is the use of the Peltier effect to create a heat flux between the junction of two different types of material [4].

Cooling with air, cooling with liquids, immersion, Thermoelectric and Thermoelectric heat pipes are types of methods to improve the efficiency of solar modules.

The purpose of this study is to reduce the working temperature of the solar module to be close to its normal condition, namely the temperature of 25°C so that the output voltage increases [5][9].

II. RESEARCH METHODS

This research is divided into several stages that are carried out sequentially, including

A. Preparation of research materials consisting of:

- *Solar modules*

The solar module used in this study is a polycristalline type 10 Wp Brand Yunde Chinese product as many as 2 pieces with dimensions of 36 x 23.5 cm. Before use the solar module must be checked first to make sure it is functioning properly or not. The figure of the measured output voltage is 16.79 Volts with a module temperature of 48°C, an ambient temperature of 37°C [5][6]. The specifications of the solar modules used in this study are as shown in Table 1, and their physical form as shown in Figure 1.

Rated maximum power	10 Wp
Voltage at Pmax (Vmp)	17,40 V
Current at Pmax (Imp)	0,58 A
Open - Circuit voltage (Voc)	22,04 V
Short – Circuit (Isc)	0,63 A
Maximum sytem voltage	700 vdc
Cell technology	Poly – si
Weight	1,2 kg
Dimension	350*235*18

Table 1:- Solar Module Specifications

Fig 1:- Physical Form of Solar Module mounted on frame

- *Thermoelectric*

This component can absorb heat, and the type used in this study is of type TEC 12706 as many as 4 pieces [7]. This component has sides of the same length as the side of the width of 4 cm. The specifications of these components are as shown in Table 2. The physical form of the thermoelectric as shown in Figure 2.

Power Supply:	0 - 15.2V (max.)
The input current:	0 - 6A (max.)
Power:	60W
Operating temperature:	-55 - 83 ° C
Dimensions:	40 x 40 x 4mm
one side generates heat and the cold side generating	
Modul should be used in conjunction with the termoelektrik	

Table 2:- Thermoelectric Specifications

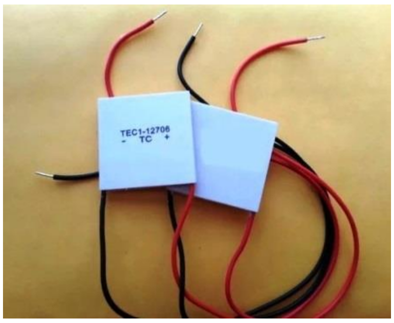

Fig 2:- Thermoelectric Physical Form

B. *Preparation of research equipment consisting of:*

- *Laser thermometer*

The tool for measuring temperature used is in the form of a Benetech GM320 Non-Contact Laser Brand laser thermometer with the aim that there is no hand touch that can affect the measurement results later. The physical form of the laser thermometer used as shown in Figure 3

Fig 3:- Physical Form of Laser Thermometer

- *Digital luxmeter*

The solar light intensity measuring instrument used is HS1010/HS1010A LCD Digital Light Meter Illuminance 1-200000LUX. This tool is already in digital form, and is equipped with various features including automatic measurement level selection, maximum and minimum reading resistance functions and automatic data recording. The physical form of the digital Luxmeter used as shown in Figure 4.

Fig 4:- The physical form of a digital Luxmeter

- *Digital multimeter*

This measuring instrument is used to measure various electrical parameters such as current, voltage and resistance and is already in digital form. The MASDA DT830B brand multimeter can also test diodes and transistors. The physical form of the digital Multimeter used as shown in Figure 5.

Fig 5:- Physical Forms of Digital Multimeters

C. Installation of Research Devices

Before installing all the devices needed, the positioning of the solar module placement is first carried out correctly according to the location coordinates so that the solar module does not experience shading so that it gets the effect of heat from the sun to the maximum. The steps of the research carried out:

a) The first step that needs to be done is to make a solar module placement mounting place or frame. The mount is made in such a way that the solar module can be placed appropriately and the legs must be the same length so that there is no tilt in the position of the solar module.
b) The second step is the installation of a heat-absorbing device or component on each solar module. Thermal paste is used to glue the component with a solar module. Each of these components is attached to the bottom or back of the solar module.
c) The third step ensures the proper functioning of all measuring instruments by testing the measuring instruments one by one. After being tested proceed to the measurement process.

D. Measurement of Temperature, Irradiation and Output Voltage

After the steps mentioned above, then take measurements of the temperature and output voltage of the solar module as shown in Figure 6a, b.

(a) (b)

Fig 6:-a,b Measurement of Temperature, Irradiation and Output Voltage.

The measurement process is carried out from 12.00 to 13.40 WIB. This time was chosen because the intensity of sunlight is at its highest point. The measurement time span is taken once every 10 minutes, and the data taken are in the form of temperature and voltage where the two parameters are indicators of the performance of the material attached to the solar module. The results of these measurements were carried out for two conditions, first for the condition of the solar module without cooling (not using thermoelectric) as shown in Table 3. For conditions using a cooler (using thermoelectric) as shown in Table 4.

Time (minutes)	**Irradiation (W/m^2)**	**Ambient temperature (^0C)**	**Uncooled (Thermoelectric)**	
			Temperature (^0C)	**Voc (Volt)**
12.00 - 12.10	1137	36	53,3	14,42
12.10 - 12.20	1129	33,2	52	14,36
12.20 - 12.30	1188	37,2	54,8	11,24
12.30 - 12.40	1173	37,1	51,2	14,47
12.40 - 12.50	1042	35,7	50,8	14,59
12.50 - 13.00	1037	34,9	48,3	15,7
13.00 - 13.10	1034	33,6	45	15,4
13.10 -13.20	1028	32,3	43,6	15,26
13.20 -13.30	1033	33,8	41,4	15
13.30 -13.40	1031	33,2	44,5	15,34
Rata – rata	**1083**	**34.7**	**48.49**	**14.57**

Table 3:- Irradiation Value, Ambient Temperature, Module Temperature and Output Voltage (Voc).

Time (minutes)	Irradiation (W/m^2)	Ambient temperature (^0C)	Temparatur Thermoelectric (^0C)	Solar module temperature (^0C)	Voc (Volt)
12.00 - 12.10	1137	36	31,3	45,9	17,6
12.10 - 12.20	1129	33,2	31,9	40,7	18,7
12.20 - 12.30	1188	37,2	32,6	41,5	17,5
12.30 - 12.40	1173	37,1	29,8	43,7	18,6
12.40 - 12.50	1042	35,7	30,5	41,4	18,8
12.50 - 13.00	1037	34,9	30,8	41,9	17,5
13.00 - 13.10	1034	33,6	31,1	38,7	18,3
13.10 - 13.20	1028	32,3	30,8	39,3	17,9
13.20 - 13.30	1033	33,8	30,4	39	17,7
13.30 - 13.40	1031	33,2	33,7	40,4	19,6
Rata - rata	**1083**	**34.7**	**31.29**	**41.25**	**18.22**

Table 4:- Irradiation Value, Ambient Temperature, Module Temperature and Output Voltage (Voc).

III. RESULTS AND DISCUSSION

The average temperature measurement result of a solar module without thermoelectric refrigerant reached 48.49°C and at this value produced an average output voltage of 14.57 Voc. The value is based on an average irradiation of 1083 W/m^2 with an average ambient temperature of 34.7°C. When compared to modules that use thermoelectric heat-absorbing materials, the average temperature value parameter reaches 41.25°C and at this value produces a Voc output voltage of 18.22 Volt. The value is calculated based on an average irradiation value of 1083 W/m2 with an average ambient temperature of 34.7°C. Something interesting about solar modules that use thermoelectric heat-absorbing materials is that the average temperature on the material reaches 31.29°C. This condition indicates that the thermoelectric heat absorbing material can really work as a good heat absorbent material. From the irradiation values, ambient temperature, module temperature and output voltage (Voc) presented in the table above, you can see the comparison to each parameter in a graph. The graph presents an overview of the performance of solar modules to which heat-absorbing materials are added with which no heat-absorbing materials are added. The comparison is as shown in chart 1.

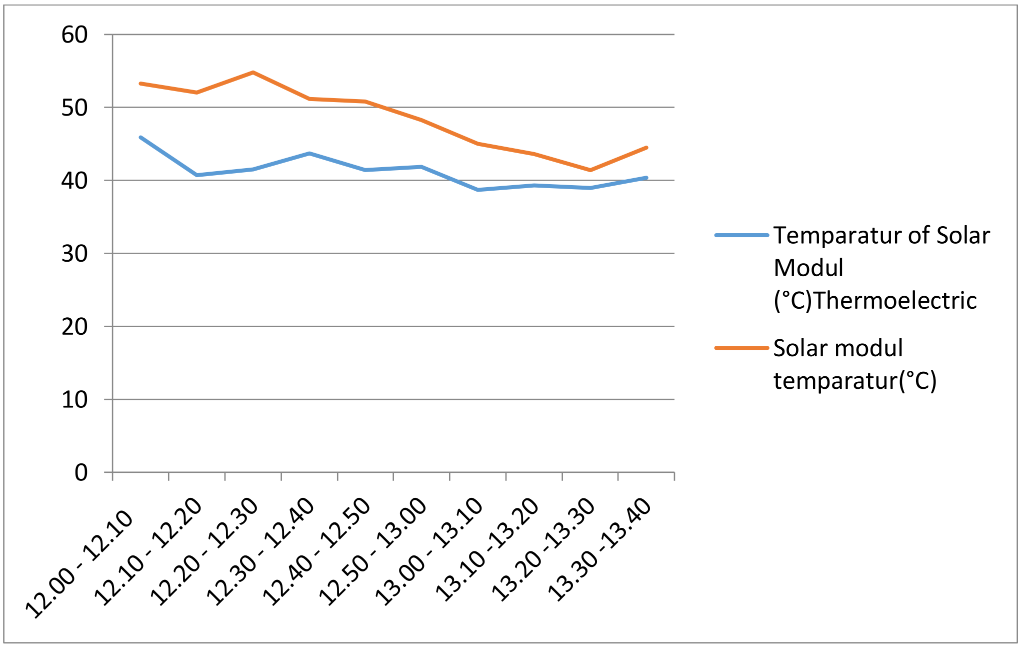

Chart 1.:- Temperature comparison of solar modules with and without coolant

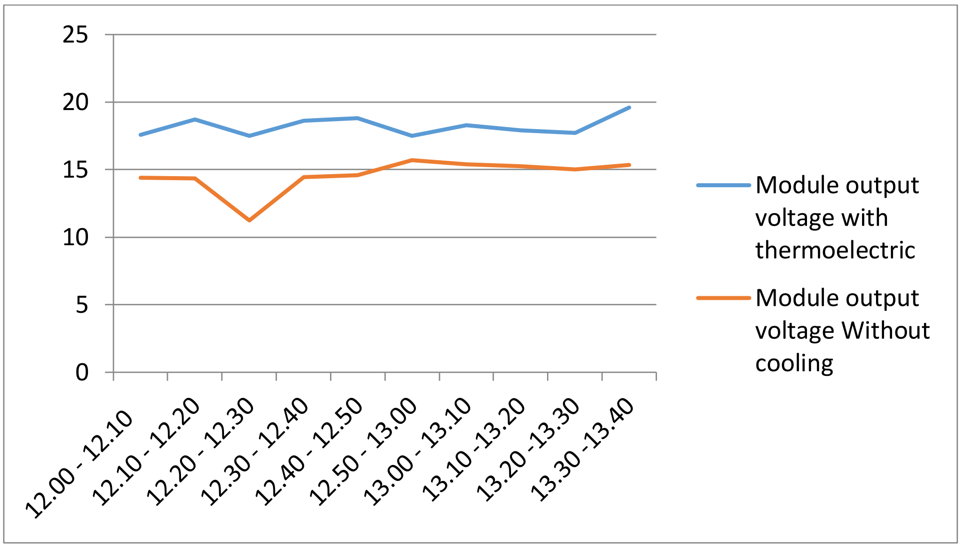

Chart 2:- Voltage comparison of solar modules with and without cooling

Based on the comparison of the two data presented in the graph above, it shows that the greater the temperature drop that occurs, the greater output voltage generated by the solar module. From this phenomenon, it can be concluded that the addition of thermoelectric to the solar module can absorb heat and successfully lower the temperature of the solar module so that the performance of the solar module becomes better compared to those that do not use heat-absorbing materials.

IV. CONCLUSION

The solar module to which the thermoelectric heat-absorbing material is added has an average temperature value of 41.25°C with a Voc output voltage of 18.22 Volts. This value is much higher when compared to solar modules that do not add thermoelectric heat absorbent materials which only produce an average voltage of 14.57 Volts at an average module temperature of 48.49°C. From the two temperature and voltage values, it can be seen that there is an increase in the average output voltage value of 3.65 Volts. To maintain the output voltage so that it is always at the optimal value, it is necessary to add devices from various kinds of absorbent and heat-releasing materials. The addition of Thermoelectric to lower the temperature of solar modules turned out to be more effective when compared to without heat-absorbing additives. However, it is hoped that in the future this research can be continued by comparing the addition of heat absorbers other than thermoelectric materials.

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