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Technology Sun Tracking System for Solar Power Plants Base on Recurrent Neural Networks

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ABSTRACT

Solar energy is one alternative of renewable sources of energy that can be used as a substitute for fossil fuel, which will be eventually depleted. Since Indonesia is located at the equator with abundant supply of sunlight all through the year, the use of solar energy as an alternative source of energy is considered the right decision. However, the movement of the sun throughout the day may reduce the absorption of the solar energy. Thus, the solar panel needs to be equipped with a tracking system to be able to track the sun and get the highest solar energy as possible. There are several steps to trace in this problem the first is detecting the absorption of energy in the solar panel, the second is moving the solar panel in the direction of the sun, and the third is making an estimation if there is a change in time of the day or season. The method that is used to optimize the sun tracking is Recurrent Neural Network (RNN). This method is implemented to help making the best decision for the solar panel movement.

Keywords: *Solar Panels; Sun Tracking; Recurrent Neural Network.*

1. INTRODUCTION

Indonesia, as the part of international community, shares the concern on the issue of renewable sources of energy. Since Indonesia is a tropical country that lies at the equator and rich in sunlight, the use of solar energy to produce electricity is considered a reasonable option. There is an emerging trend regarding the solar power plant, that is the implementation of smart technology for the solar plant's control system, monitoring system, and tracking system. The solar power plant is predicted to come a future source of energy in Indonesia, beside micro hydro, and wind power generator [1]. Several solar power plants have provided electricity in the certain areas, that are not yet covered by PLN. However, the power plants have not implemented optimally due to various problems, such as its efficiency, the battery life, maintenance cost, and power plant maintenance. The low level of solar panel's efficiency, the lack of maintenance personnel, to expensive installation costs can be future research topics in the field of renewable energy. The focus of this paper is the optimization of solar panel by sun tracking so that the solar panel can be move towards the sun [2]. In comparation between solar panels with no tracking system and solar panels with tracking system, the former shows lower energy absorption [3][4]. As for the purpose of this paper is to analyze the absorption of solar panels based on time. The goal of the optimized tracking system is to balance the energy absorbed and the power entered to the solar battery [5][6][7]. Another objective of this paper is to explain the system for monitoring and controlling energy than has been used on the panel and battery in the solar power plant.

2. METHODOLOGY

In this paper, the technology and method used is solar power generation. The aim is to determine the optimal absorption rate of solar energy based on time and light intensity. The following is a table of light intensity data based on trials:

Table 1. Data Light Intensity

Intensity (Lux) LDR	Condition
0 - 8	Sunny weather
8 - 11	covered in thin clouds
11 - 14	Cloudy
14 – 19	Rainy weather

From the intensity value based on table 1 above, the data is normalized using the average value, if rainy and cloudy weather is detected with a light intensity value of 11-19, the timer system will run, if the light intensity is 0 - 11 then the sensor will detect the lowest value as the optimal value. From these values are converted into binary values as input values using the following equation:

$$y = f(net) = \begin{cases} 1 & if\, net > 11 \\ 0 & if\, net \leq 11 \end{cases} \quad (1)$$

From the above equation, it becomes the input value of the Recurrent Neural Network using 1 hidden layer by having 3 sensors as input as can be seen in the following table:

Table 2. Data Sensor

Time	Sensor 1 (x1)	Sensor 2 (x2)	Sensor 3 (x3)
1	7,1	5,7	8,2
2	3,8	3,5	4,7
3	12,1	12,5	13,0
4	14,0	12,1	14,5

From table 2 then normalized using equation (1), then the input value of the Recurrent Neural Network is as follows:

Table 3. Normalization Results

x1	Weight 1	x2	Weight 2	x3	Weight 3
0	0,5	0	0,7	0	0,8
0	0,4	0	0,6	0	0,6
1	0,6	1	0,5	1	0,3
1	0,4	1	0,3	1	0,5

In the table above, there are input values and weight values from the Recurrent Neural Network, each layer in this method uses the activation function of the hyperbolic tangent with the equation:

$$f(x) = \tanh(x) \quad (2)$$

Each node performs an iterative process with the following competitive equation

$$h_t = fw(h_{t-1}, x_t) \quad (3)$$

The output of the equation will then become the input value for the next layer with different weight values ranging from negative 5 (-5) to positive 5 (5) with random weight taking. From the results of this value, the value will then be entered into the activation function as in equation (2) so that the output value is obtained. The purpose of applying this method is to determine the direction of the solar panels to the position of the sun, to obtain optimal light absorption. The movement of the panel is carried out by the Servo which is connected to the Arduino as a microcontroller.

3. RESULTS

In this paper, there were 4 weather conditions used for testing, i.e. bright sun, the sun is covered in thin clouds, cloudy and rainy weather. The testing was carried out 10 times and the average result is shown in the following table:

Table 4. Result with Tracker

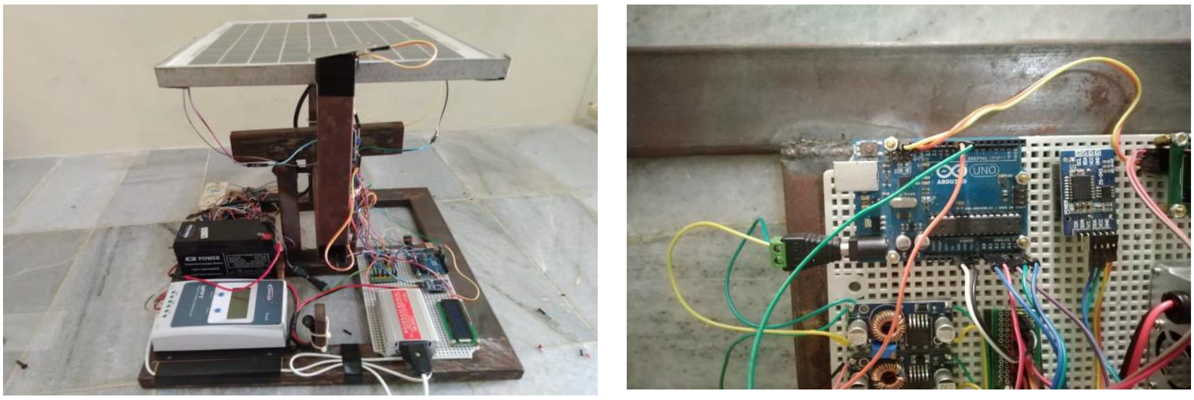
Time	Voltage (Volt)	Intensity (Amp)	Power (Watt)
08:00	13,62	0,38	5,1756
09:00	13,76	0,45	6,1921
10:00	13,82	0,45	6,2191
11:00	13,88	0,47	6,5236
12:00	14,09	0,49	7,0451
13:00	14,03	0,48	6,7344
14:00	14,02	0,46	6,4492
15:00	14,01	0,38	5,4321
16:00	13,97	0,28	3,9116

and here is a table without tracker

Table 5. Result without Tracker

Time	Voltage (Volt)	Intensity (Amp)	Power (Watt)
08:00	13,98	0,27	3,7746
09:00	14,32	0,37	5,2984
10:00	14,47	0,38	5,4986
11:00	14,6	0,4	5,84
12:00	14,72	0,42	6,1824
13:00	14,78	0,41	6,0598
14:00	14,76	0,39	5,7564
15:00	14,5	0,25	3,625
16:00	13,9	0,19	2,641

From the table above, the testing was carried out from 08.00 AM until 16.00 PM and with the sun tracking's optimal value obtained at 12 PM. The optimal value of the voltage is 14.9 Volt, the electric current is 0.49 ampere, and the resulting power is 7,0451 Watt. This is considered reasonable because the optimal point solar panels were obtained when the sun was right overhead. While doing testing without the sun tracking system, the resulting optimal point time is the same as the optimal time when using tracking system. However, there are differences in voltage, current, and power values. For the testing result without sun tracker, the obtained voltage is 14,72 volts, the electric current is 0,42 Ampere and the power is 6,1824 watts. This difference occurs due to solar panels which using tracking system can adjust to direction of the sun. Below is the solar panel prototype when it was tested in the laboratory.



(a) (b)

Figure 1 (a) Solar Panels Circuit and (b) Control Circuit

From the results of the tests that have been carried out, the following is a comparison of the value of the current, voltage and power produced when compared to solar panels that use tracking and those that don't use tracking as shown in the graph below:

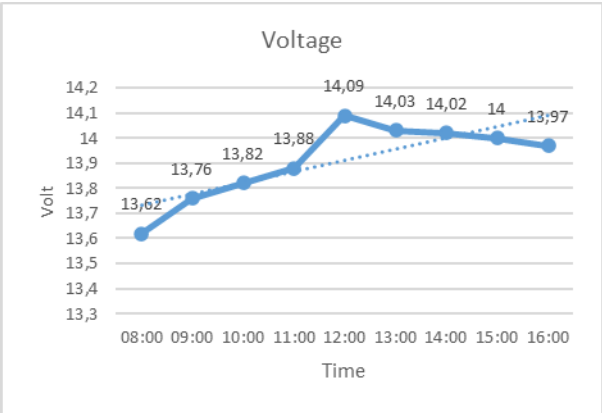


Figure 2 Voltage using tracking

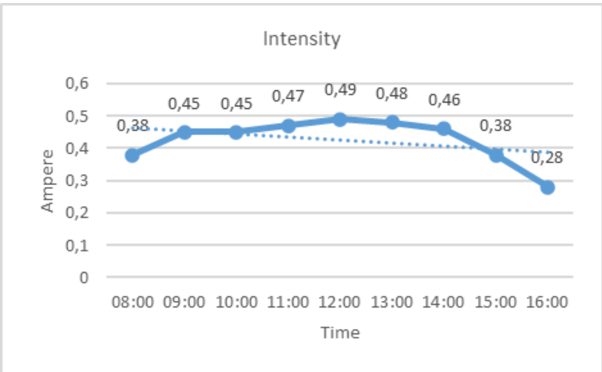


Figure 3 Electric current using tracing

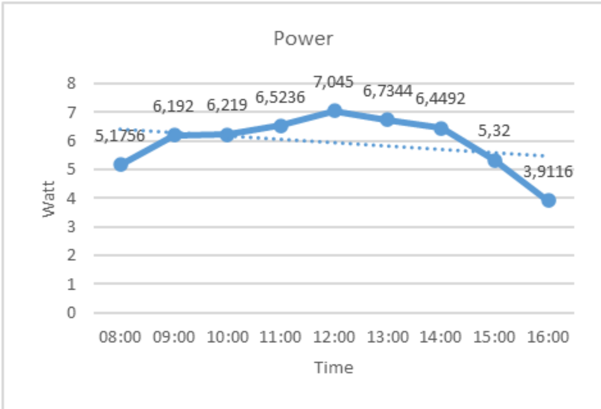


Figure 4 Electric power using tracking

And here are the results of an experiment that does not use sun tracking. This experiment was carried out at the PLN Institute of Technology campus environment which was tested using sun tracking, namely the voltage, current and power generated as shown in the graphic below:

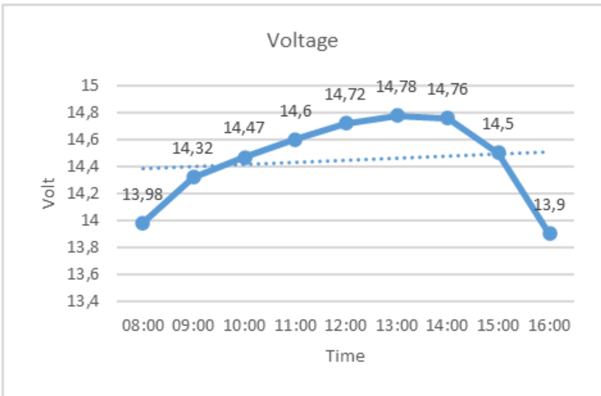


Figure 5 Voltages that do not use sun tracking

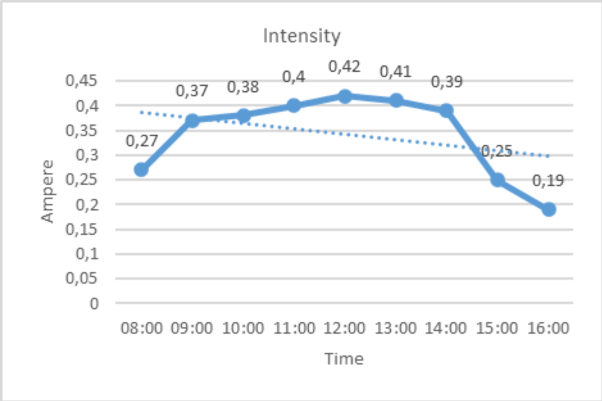


Figure 6 Currents that do not use sun tracking

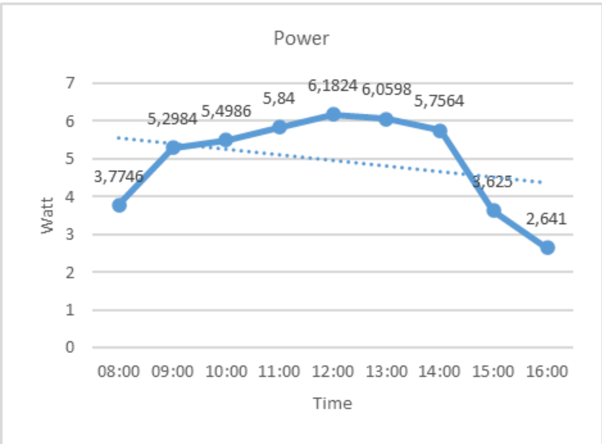


Figure 7 Power does not use sun tracking

4. CONCLUSION

Result that has been achieved in this paper can be concluded that the voltage generated if without using control tracking higher compared to using tracking system can achieve value 14,8 volt at time 13.00 pm, however if seen on the graph it is not stable this is caused by several factor as like when do testing at the areas which less get optimal sunlight. Whereas if seen value electric current comparison which the result tends to be better using tracking system with higher value at 12 pm with get value 0,5 Ampere whereas in the comparison value power generated by using tracking system still better with high power produces at 12 pm with higher value is 7 watts. The results of this test are much influenced by the testing location and the condition of the solar panels used. The average value of the test results per day is 14.78 volt for voltage, while the average electric current is 0,34 Ampere and the average value of the test result is 5,95 watt, this very good due to low voltage can be result optimal power.

5. ACKNOWLEDGMENT

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