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# Application of Solar Cells for Daytime Weather Study

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**Abstract**

The electric current is generated by the solar cell when the solar radiation is incident onto the solar cell. The intensity of the incident solar radiation can control the amount of generated electric current. In daytime, the variation of intensity of the incident solar radiation mainly comes from the cloud over the solar cell. It causes the variation of generated electric current. This phenomenon serves the new way to use the solar cell for meteorological purpose. In the period of experiment days, the results showed that the variation of generated electric current might be plausible to the daily weather condition. On the sunny day, the generated current was small fluctuation and had high level. Otherwise, a small fluctuation with low level one was appear on the cloudy day. On the rainning period, the generated current could drop down more than 3000 mA when compared with the sunny period.



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*Keywords:* Solar cell; Weather; Cloud; Rainy day

## 1. Introduction

In recent year, many instruments, methods and techniques were applied to the used of solar energy. Solar cell is one of them that can use to convert the solar energy into another energy form. Generally, the solar radiation, which is incident onto the solar cell, generates the electric current [1]. The total of electricity that solar cell can produce is mainly dependent on the intensity of the incident solar radiation [2 - 5]. It is well known that there are several features affecting the performance of the solar cell such as effect of cloud and rain [6]. The generated current from solar cell is small when cloudy and rainy days.

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For the solar cell engineering, it is set to be "the noise" of the solar cell used. In the other hand, the reducing current one is become "the meteorological signal" for meteorological study. In this paper, we demonstrated the simply way to use of the solar cell for meteorological study. The experiment was set to study the relationship between clouds over the solar cells and the generated electric current.

## 2. Observations and Results

The solar cell was installed on the top of the faculty of Science and Technology building, Rajamangala University of Technology Thanyaburi where is no any shadow effect to the solar cells, as shown in Figure 1. The solar panel consists of eight solar modules, which provide the power of around 1 kW. The specification of each solar module is shown in Table 1.

Sunny Data control is a computer program. It was installed to monitor the solar cell. All of informations from the solar cell were recorded and stored automatically on a monitoring server with sampling rate of 24 data per hour. In this experiment, we designed to use the data of direct current generated by solar cell (Ipv) in the unit of mA. The Ipv was generated when the sunlight is incident onto the solar cell. [7] and [8] suggest that the amount of direct current producing from the solar panels is directly dependent on the level of light they receive. In full and bright sunlight, solar panels receive maximum levels of light. During those peak sunlight hours, the solar panel will produce the maximum current, consecutively.

Fig. 1. The solar cell installed on the top of the faculty of Science and Technology building, Rajamangala University of Technology Thanyaburi, Thailand.

Table 1. The specification of solar module.

| Solar module | Detail |
|---|---|
| Name | Sharp Solar Module ND-130T1J |
| Maximum Power | 130.0 W |
| Open-circuit Voltage (Voc) | 22.0 V |
| Short-circuit Current (Isc) | 8.09A |
| Voltage at point of Maximum power (Vmpp) | 17.4V |
| Current at point of Maximum power (Impp) | 7.48A |
| Maximum system voltage | 600V |
| Over-current protection | 15A |

We used the Ipv data from 1st February, 2011 to 14th February, 2011. The data of each day was started around 7.00 Local time (LT) and ended of operating time around 17.00 LT. Total observational time per day is around 10 hours corresponding to the number of data per day of 240 data. Figure 2 is an example of Ipv data in the period of operating time. It showed the Ipv of 2nd February, 2011. The Ipv slightly increased in the morning section. The maximun Ipv was about 6000 mA at around 12.10 LT. Finally, Ipv slightly decreased in the afternoon section.

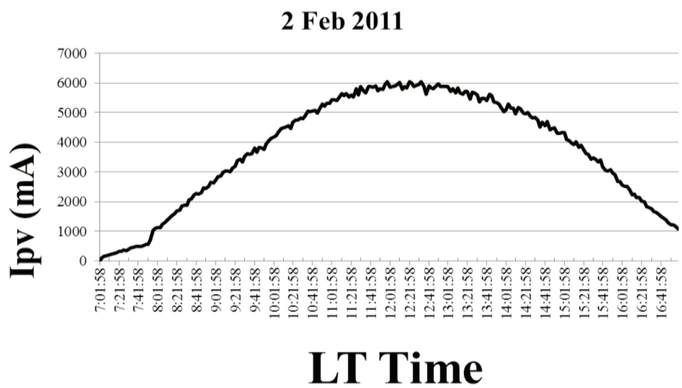


Fig. 2. Ipv on 2nd February 2011.

In the period of 14 days of this experiment, we also observed the weather of each day. we found four differrent weather conditions: 1) The clear sky day, 2) the cloudy day without rain, 3) the cloudy day with rain, and 4) the rainy day. Table 2 shows the daily weather conditions of all 14 experimental days.

Table 2. The daily weather conditions of all 14 experimental days.

| Daily weather condition | Date (Feb 2011) |
|---|---|
| 1. The clear sky day | 4th and 8th |
| 2. The cloudy day without rain | 2nd , 3rd , and 5th |
| 3. The cloudy day with rain | 1st , 6th , 10th , and 11th |
| 4. The rainy day | 7th , 9th , 12th , 13th , and 14th |

At the first, Ipv of the clear sky days was used to make a reference index data (Ipv_i). The smooth runing average method with 15 points of window data was applied to compute the Ipv_i. Finally, the Ipv_i data was used to create the differrence Ipv (Ipv_d) by subtracting the Ipv_i data with daily Ipv data as show by Equation 1 below;

$$Ipv\_d = Ipv\_i - Ipv \tag{1}$$

Figure 3 shows the plotted of Ipv_d of the $1^{st}$, $2^{nd}$, $4^{th}$ , and $13^{th}$ of February 2011. Refer to Table 2, the $1^{st}$ February 2011 was under to the daily weather condition 3, the $2^{nd}$ February 2011 was under to daily weather condition 2, the $4^{th}$ February 2011 was under to the daily weather condition 1, and the $13^{th}$ February 2011 was under to the daily weather condition 4, respectively.

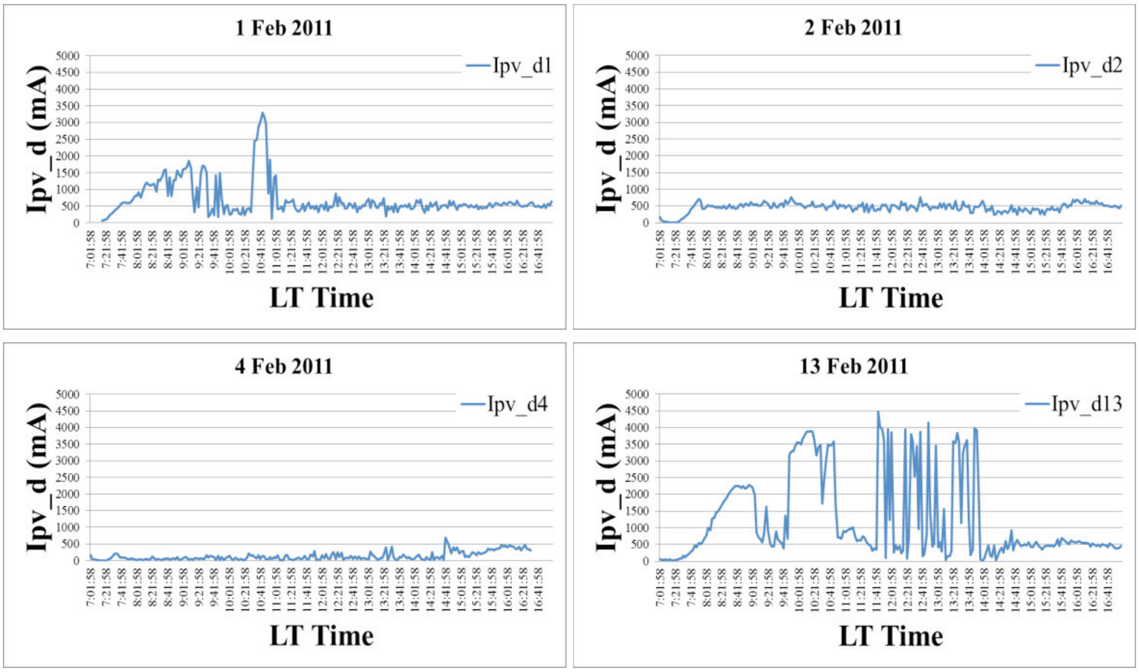


Fig. 3. Ipv_d of day $1^{st}$ , $2^{nd}$ , $4^{th}$ , and $13^{th}$ February 2011.

## 3. Discussion

Refer to the period of the experimental days, four weather conditions were observed as shown in Table 2. The investigations of four weather conditions were divided into two parts as shown below:

### *3.1. Clear sky day and Cloudy day without rain*

Refer to the observed-weather condition on Table 2, the clear sky day were on $4^{th}$ and $8^{th}$ of February 2011. It was plausible to the low level Ipv_d with small fluctuations as shown in Figure 3 for $4^{th}$ February 2011. Table 3 shows the average Ipv_d of each hour of both clear sky days and cloudy days without rain on a period of experimental days. It is seen in Table 3 that the averages of the Ipv_d on 4$^{th}$ and 8$^{th}$ February 2011 were around 100 mA. These were agreed quite well with the observed-clear sky on those days. The Ipv_d could have low level close to the Ipv_i on the clear sky day. The low level of Ipv_d illustrated the fact that the solar cell could receive maximum intensity of the sunlight all day long. Only in clear sky day condition, the solar cell will receive maximum one.

Table 3. The Ipv_d with averaged every hour of 2$^{nd}$ , 3$^{rd}$ , 4$^{th}$ ,5$^{th}$ , and 8$^{th}$ February 2011.

| Date | 7-8 LT | 8-9 LT | 9-10 LT | 10-11 LT | 11-12 LT | 12-13 LT | 13-14 LT | 14-15 LT | 15-16 LT | 16-17 LT | Average |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Clear sky day | | | | | | | | | | | |
| Feb 4$^{th}$ | 61.22 | 40.76 | 73.05 | 77.74 | 72.64 | 106.43 | 117.11 | 183.29 | 272.45 | - | 111.63 |
| Feb 8$^{th}$ | 143.42 | 280.48 | 104.26 | 91.08 | 103.14 | 105.95 | 107.54 | 96.42 | 99.60 | 65.81 | 119.77 |
| Cloudy day without rain | | | | | | | | | | | |
| Feb 2$^{nd}$ | 224.99 | 490.81 | 561.73 | 511.65 | 446.06 | 493.45 | 482.86 | 361.82 | 431.58 | 562.33 | 456.73 |
| Feb 3$^{rd}$ | 374.52 | 1302.40 | 774.44 | 662.81 | 471.60 | 462.58 | 269.48 | 425.12 | 567.16 | 615.67 | 529.58 |
| Feb 5$^{th}$ | - | 438.44 | 540.69 | 536.23 | 509.68 | 455.50 | 311.56 | 227.37 | 266.62 | 369.83 | 406.21 |

According to Table 3, the Ipv_d on 2$^{nd}$, 3$^{rd}$, and 5$^{th}$ of February 2011with average around 450 mA showed good agreement to the cloudy day without rain. It reflects to the fact that the current generated by the solar cell would be depended on the intensity of the sunlight. On the cloudy day without rain, the cloud covers all the sky and the intensity of the sunlight is small. Consequently the solar cell generates low Ipv. Thus, the computed Ipv_d showed high level around 450 mA. The result from Table 3 showed that the average Ipv_d on 3$^{rd}$ February 2011 of around 500 mA was larger than the averaged Ipv_d on both 2$^{nd}$ and 5$^{th}$ February 2011. From this evidence, it might be expected that the cloud on 3$^{rd}$ February 2011 could thick and dark more than the cloud on 2$^{nd}$ and 5$^{th}$ February 2011. It should be noted that the Ipv_d in the period of 8.00 LT to 9.00 LT on 3$^{rd}$ February 2011 was about 1302 mA. It is corresponding to the thick and wide cloud covering the sky of Bangkok area which can see from MTSAT-2 IR1 JMA satellite image on that day (http://weather.is.kochi-u.ac.jp). Figure 4 illustrated the comparison between the Ipv_d of the clear sky day on 4$^{th}$ February 2011 and the cloudy day without rain on 2$^{nd}$ February 2011. The average of difference between them is 342 mA. This difference confirmed that on the clear sky day, solar cell will generate high level of Ipv corresponding to the low level of Ipv_d. In the other hand, the Ipv_d of the cloudy day without rain will have higher level of Ipv_d than the Ipv_d of the clear sky day.

### *3.2. Cloudy day with rain and Rainy day*

According to Figure 3, Ipv_d on the 1$^{st}$ February 2011 increased in a period of around 7.00 LT to 9.00 LT. It fluctuated from 9.00 LT to 10.00 LT and increased from 10.20 LT to 11.00 LT. The average Ipv_d on a period of 7.00 LT to 10.00 LT was around 900 mA. During the time 10.20 LT to 11.00 LT, the average Ipv_d was around 1600 mA. After 11.00 LT, the average Ipv_d was around 520 mA. These results could be plausible to our observation of weather condition on the 1$^{st}$ February 2011. It was the thick cloud and then rain in the morning section and it was cloudy again in the afternoon section. In addition, the MTSAT-2 IR1 JMA satellite image of the period from 7.00 LT to 11.00 LT also showed that the cloud covers the Bangkok and the central part of Thailand.

Figure 5 illustrated the comparison of Ipv_d between the clear sky day and the rainy day. It is clearly seen from Figure 5 that rain affects the generated current from solar cell. On 13$^{th}$ February 2011 we observed that the first rain of the day started at around 8.00 LT and ended at around 9.00 LT, corresponding to the high level of Ipv_d in the period of 8.00 LT to 9.00 LT with its average of 1800 mA. The second rain started at around 9.40 LT and ended at around 10.40 LT, corresponding to the high level of Ipv_d in the period of 9.40 LT to 10.40 LT with its average of 3000 mA. The swing of drizzling rain and heavy rain appeared in the period of around 11.20 LT to 14.00 LT, corresponding to the fluctuation at the high level of Ipv_d in the period of 11.40 LT to 14.00 LT with its average of 1800 mA. The Ipv_d of the raining period on 13$^{th}$ February 2011 had high level and large fluctuation of Ipv_d in comparing to the Ipv_d of the clear sky day on 4$^{th}$ February 2011. It could be agreed with the fact that the sunlight can reflect and scatter by the raindrop. Then, the small intensity of the sunlight caused by the rain drop to the solar cell could reduce the current that generated by the solar cell. The Ipv_d on the clear sky day on 4$^{th}$ February 2011 had small fluctuation because it had no effect of the rain drop to the solar cell.

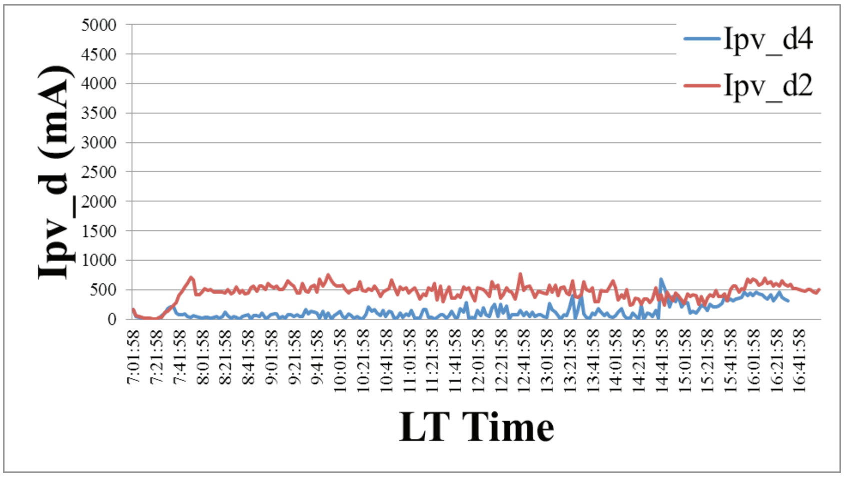


Fig. 4. Comparison of Ipv_d between 2$^{nd}$ and 4$^{th}$ of February 2011.

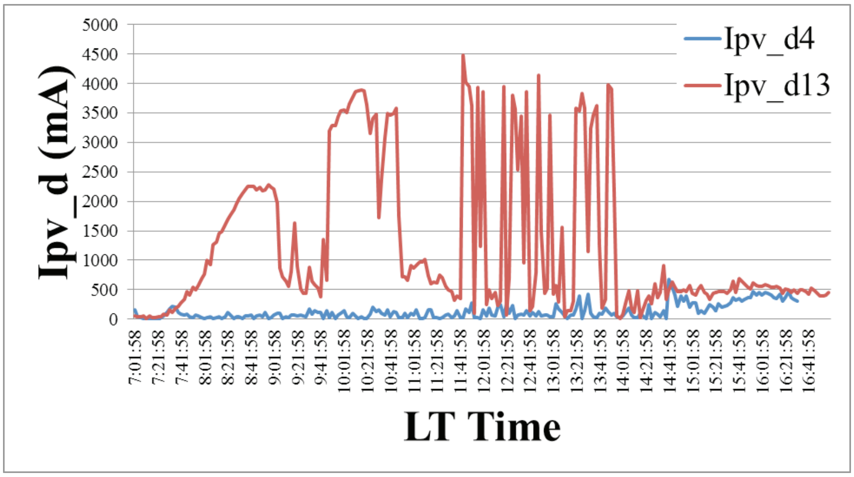


Fig. 5. Comparison of Ipv_d between 4$^{th}$ and 13$^{th}$ February 2011.

## 4. Conclusion

Electricity can be generated by the solar cell when the solar radiation is incident onto it. The amount of electric current depends on the intensity of the incident solar radiation. In daytime, the generated electric current is varied. It is caused by the varying of the intensity of the solar radiation. The variation of intensity of the incident solar radiation mainly comes from the cloud on the sky over the solar cells. This experiment illustrated that the using of the solar cell for daytime weather study could be conducted. The variation of Ipv_d might be plausible to the weather conditions. In the period of experiment days, the variation of Ipv_d showed good agreement with the daily weather conditions. For the clear sky day, the Ipv_d illustrated low level at around 100 mA. Otherwise, the Ipv_d at around 400 mA could be considered as the cloudy day without rain. The period of Ipv_d with high level more than 1600 mA might be considered as the raining period of the day. However, there are some developments still existed. For example, the range of the using of Ipv data was limited. The Ipv in early morning and late afternoon are very low. That means they cannot be used to study the daily weather via the method in this experiment. We need to investigate and find the solutions in the future studies.

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