10th Eco-Energy and Materials Science and Engineering Symposium


On December 5-8, 2012
Sunee grand hotel,
Ubon-ratchathani

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PREFACE:
Message from the President of
Rajamangala University of Technology Thanyaburi

Rajamangala University of Technology Thanyaburi (RMUTT), in conjunction with Kyoto University, is pleased to host the 10th Eco-Energy and Materials Science and Engineering Symposium (10th EMSES). This international conference is not only giving an opportunity for Thai and foreign researchers to present and discuss their research works and update their expertise but also to initially stimulate the development of research works on eco-energy and materials science and engineering. Our program consists of six research tasks: (1) Energy Technology, (2) Environmental and Social Impact, (3) Nanotechnology and Materials Science, (4) Energy Economics and Management, (5) New Energy Technology and (6) Nuclear Technology.

I would like to take this opportunity to express our sincere gratitude to our two distinguished Plenary Speakers for kindly accepting our invitation. I deeply appreciative of the very strong support given by Kyoto University. Thanks to the tireless works of the Organizing Committee, the Technical Program Committee, the invited speakers and paper and poster contributors, and excellent program been assembled to cover a broad spectrum of interesting topics.

We warmly welcome you to the 10th EMSES on December 5-8, 2012, Ubon Ratchathani, Thailand.

Numyoot SONGTHANAPITAK, Ph.D.
President of Rajamangala University of Technology Thanyaburi
and Conference Chairman of 10th EMSES 2012
PREFACE:
Message from the Director of
Institute of Advanced Energy, Kyoto University

It is my great pleasure to have the 10th Eco-Energy and Materials Science and Engineering Symposium (EMSES) with Rajamangala University of Technology Thanyaburi (RMUTT) under the long-term collaboration between RMUTT and Kyoto University. The 1st EMSES was held in 2001 in Thailand and the symposium has been expanded in its scientific contents as well as the academic network. I believe that the 10th EMSES gives a good opportunity to all participants to exchange their knowledge and idea to realize eco-friendly energy system in society. I would like to express my welcome to all participants and sincere thanks to the 10th EMSES organizing committee and all supporting organizations to make us having this symposium. I hope that the symposium will be successful and lead to further progress in energy science and technology and also in friendships of participants.

Professor Yukio Ogata, Ph.D.
Director of Institute of Advanced Energy, Kyoto University
PREFACE:
Message from the Former Dean of Graduate School of Energy Science, Kyoto University Program Leader, Global COE “Energy Science in the Age of Global Warming”

I want to express my hearty welcome to all participants of Eco-Energy and Materials Science and Engineering Symposium (10th EMSES). This symposium is aiming the realization of importance of energy and materials technology through the academic, science and technology network among the world communities. The symposium gives an opportunity for researchers to discuss their research works and also to initially stimulate the development of research works on eco-energy and materials science and engineering. Once the cooperation among researchers has been created, the further cooperation work will be developed.
I would like also extend my sincere thanks to all who made the meeting possible, including the 10th EMSES organizers, the SEE forum committee members, and the Japanese Government, JSPS, for their kind support. I am looking forward to seeing you in Ubon Ratchathani, Thailand.

Yours sincerely,

Professor Takeshi YAO, Ph.D.
Former Dean of Graduate School of Energy Science, Kyoto University
and Program Leader, Global COE “Energy Science in the Age of Global Warming”
Rajamangala University of Technology Thanyaburi (RMUTT), in conjunction with Kyoto University, is pleased to host the 10th Eco-Energy and Materials Science and Engineering Symposium (10th EMSES).

RMUTT has a major mission on encouraging and supporting all areas of research. One of the key reasons is to assist in developing capability in science and technology in order to cope with recent rapid change in this field. We have jointly set up an academic symposium on the 10th EMSES with the perception on the significance of exchanging knowledge and research experiences between researcher in the field of energy, materials technology and environmental science. This symposium is not only giving an opportunity for Thai and foreign researcher to present and discussion their research works and update their expertise but also to initially stimulate the development of research works on eco-energy and materials science and engineering. Once the cooperation among researchers has been created, the closer future cooperation incorporate with joint-research works will be developed. Thus, to support the aforesaid role, the symposium working committee would like to invite you to participate in this academic symposium.

I would like to express our sincere thanks to the organizing committee, participants and contributors for your kind corporation to this symposium. I wish this symposium proceeding will be a useful reference for future scientific research development.

Sommai PIVSA-ART, Ph.D.
Dean of Faculty of Engineering, RMUTT
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Reproduced Solar Radiation Derived from Electric Current of Solar Cell for Daytime Meteorological Study

Nithiwatthn Choosakul*, Chanoknan Banglieng* and Naris Barmthip*

1Division of Physics, Faculty of Science and Technology,
Rajamangala University of Technology Thanyaburi, Klong 6, Thanyaburi, Pathumthani 12110
E-mail: cnwatthn@rmutt.ac.th

Abstract—During the day, the electric current were generated by the incidental sunlight onto the solar cell. The current variation was linearly depended on the variation of solar radiation of each day. The linear relationship between the solar cell-generated electric current and the incidental solar radiation can successfully be used as an index to convert back the current to the solar radiation in term of the used of solar radiation for meteorological purpose in the area that had no any solar instrument except the solar cell. In the 6 months experiment period from January 1st to June 30th, 2012, it was demonstrated that the relationship between the variation of the electric current and solar radiation was the linear relationship with mean of $R^2 = 0.913$. The linear relationship index was different on each month based on the monthly solar radiation. The mean overall index was 0.107. By using the index, we were successfully reproduced the solar radiation from the electric current generated by solar cell. The results showed good agreement with $R^2 = 0.95$ of the relationship between the reproduce solar radiation and the original one. The case study of June 7th, 2012 shows good results of the use of the reproduced solar radiation in the study of the cloud covering the sky. In the morning from around 7.00 LT to 12.30 LT, the reproduced solar radiation showed the slightly increase with small variation indicated that it was in the normal sunny condition. After 12.30 LT, the reproduced solar radiation was dropped down to the low level of solar radiation until the end of the day at around 17.30 LT. It was indicated this area was cover by cloud from around 13.00 LT to around 17.30 LT. This result agrees quite well with the satellite image that illustrated the cloud was cover this area at the same time of the dropdown reproduced solar radiation.

Keywords—Reproduced Solar radiation, Solar cell, Cloud cover, Meteorology.

1. INTRODUCTION

Solar cell is the one of the suitable instruments for the clean energy that used in the present day. The electricity will generates when the solar radiation is incident onto the solar cell during the daytime [1-4]. Amount of the electricity that solar cell can generated was directly depended on the intensity of the incidentally solar radiation onto the solar cell. Also the weather condition of the day could control the intensity of solar radiation [5]. Cloud and rain are the main influence factors to the variation of solar radiation. In the cloudy or rainy condition, the electric current that solar cell can produced was in the low level when compare with the electric current generated in the sunny condition. These phenomena of the variation of electric current was depended on the variation of weather condition served the very useful technique to use solar cell as the meteorological tool for the daytime weather study especially for the variation of solar radiation in the area that has no any solar radiation devices but solar cell. In this paper, we illustrated the relationship between the electric current obtained from the solar cell and the solar radiation as well as the reproduced solar radiation computed from its relationship. Moreover, we also showed the used of reproduced solar radiation for the study of cloud cover duration in meteorological purpose.

2. EXPERIMENTAL SETUP

In the experiment, we used the data from two instruments, solar radiation sensor and solar cell, respectively. The solar radiation data was from the Silicon pyranometer solar radiation sensor which was installed on the top of the Faculty of Science and Technology building, Rajamangala University of Technology Thanyaburi as shown in Figure 1.

Figure 1 Silicon Pyranometer solar radiation Sensor (in the circle)
The solar radiation data was recorded by the HOBO U30 weather station in every 15 minutes. We setup the experimental time period of ten-hour daytime from around 7.00 LT to around 17.00 LT. 40 solar radiation data per day were collected. The example plotted of solar radiation on March 20th, 2012 was illustrated in Figure 2.

Figure 2 The solar radiation of March 20th, 2012

The solar cell was also installed nearby the solar radiation sensor where was no any shadow from anything affected to it as shown in Figure 3. The photovoltaic current (Ipv) was directly generated by the solar cell every day in the period of the experiment. Its sampling interval was 24 data per hour. Then 240 Ipv data per day were collected.

Figure 3 Solar cell used in the experiment

Choosakul et al. [5] suggests that Ipv was generated when solar radiation was incident onto the solar cell. Generally, the generated Ipv slightly increased in the morning. The maximum Ipv is at noon and slightly decreased in the afternoon.

Because the sampling data of solar radiation are smaller than the sampling data of solar cell, we designed to select the Ipv data from the solar cell with corresponding to solar radiation time interval. Thus 40 Ipv data were selected. Figure 4 Ipv with corresponding to solar radiation time interval on March 20th, 2012 illustrated well-correlation tendency. Both of the data slightly increased in the morning. The maximum values of both data reached at the same time of about 11.15 LT. The other data shown in Figure 5b to Figure 5d were also illustrated well-correlation tendency respectively. To investigate how well of the correlation tendency, we compared both solar radiation and the Ipv of over all 6 months data in the period of the experiment. Figure 6 illustrated the correlation between both data on the overall 6 months data. It was shown in the overall data plot that both data had good agreement of its correlation with $R^2 = 0.913$. We also made an investigation on the correlation between both data of each month. We found that they had good agreement among their correlations.

Based on the well-correlation tendency of both data, we could analyze the linear relationship index from the correlation between them from each month. 

<table>
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<tr>
<th>Month</th>
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<th>$R^2$</th>
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<tr>
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<td>0.104</td>
<td>0.976</td>
</tr>
<tr>
<td>2</td>
<td>0.105</td>
<td>0.942</td>
</tr>
<tr>
<td>3</td>
<td>0.102</td>
<td>0.882</td>
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<td>4</td>
<td>0.102</td>
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<tr>
<td>5</td>
<td>0.097</td>
<td>0.662</td>
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<tr>
<td>6</td>
<td>0.089</td>
<td>0.609</td>
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<tr>
<td>Overall</td>
<td>0.107</td>
<td>0.913</td>
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Table 1: The relation Index of 6 months experiment

Table 1 demonstrated that the Index slightly decreased from January to June. It should be noted that the number of rainy and cloudy day have increase from January to June and the net solar radiation of each month is dependent on the orbit of the earth.
Figure 5. The comparison between the solar radiation data and Ipv data on January 12 to 15, 2012

Figure 6. The comparison between Ipv and solar radiation on overall 6 months of the experiment.

The index from the experiment period illustrated that the Ipv data which were generated by the solar cell and solar radiation data observed by the solar radiation sensor could have linear relationship. By using the overall index, we computed the solar radiation from Ipv data, and compared the solar radiation with the reproduced solar radiation as shown in Figure 7. The reproduced solar radiation obtained from Ipv was agreed quite well to the solar radiation obtained from solar radiation sensor. It could be confirmed that the solar radiation was successfully reproduced from Ipv obtained from solar cell.

Figure 7. An example of the comparison between the reproduced solar radiation and the original solar radiation on June 6th, 2012

Based on the variation of net solar radiation of each month, the used of the index of each month could suitable compute the solar radiation than the used of the overall index. To investigate them we make 2 set of the plot, first plotted of the correlation between the reproduced solar radiations with using the monthly index and the original one, second plotted of the correlation between the reproduced solar radiations with using the overall index and the original one as showed in Figure 8.

Figure 8a showed that correlation with $R^2 = 0.956$ of the reproduced solar radiation using overall index and Figure 8b showed that the correlation with $R^2 = 0.925$ of the reproduced solar radiation using monthly index.

\[ y = 0.1075x + 19.486 \\
R^2 = 0.9132 \]
For the other months in the experiment (not showed in this article) we found that the R^2 of the both quit similar to each other. By this result we might suggested that we can used the overall index as well as the used of the monthly index.

![Reproduced Solar radiation with overall index](image)

\[
y = 1.0502x - 22.749 \\
R^2 = 0.9555
\]

![Reproduced solar radiation with index 0.089](image)

\[
y = 0.8806x - 13.199 \\
R^2 = 0.9252
\]

Figure 8 An example of the correlation between the reproduced solar radiation and solar radiation on June 6th, 2012. a) using overall index. b) using monthly index

4. METEOROLOGICAL CASE STUDY

Cloud cover detected by solar cell: Experiment day 07/06/2012

We used the Reproduced solar radiation to study the cloud cover the study area on June 7th, 2012. Based on the Ipv data with 240 data per day, we used the overall index to compute the Reproduced solar radiation as showed in Figure 9. The Reproduced solar radiation slightly increased in the morning section from around 7.00 LT to around 12.50 LT with some dropdown interval around 9.00 LT when the cloud move over the solar cell. The dropdown interval caused by cloud move over the solar cell area can be seen in the satellite image of MTSAT-2 IR1, JAM at 12060702GMT as showed in Figure 10 (http://weather.is.kochi-u.ac.jp)

In the afternoon section from around 13.00 LT to around 17.00 LT, the Reproduced solar radiation dropped to around 100 W/m^2 caused by the cloud move over the solar cell area.

![Reproduced solar radiation 07 June 2012](image)

Figure 9 Reproduced solar radiation of June 7th, 2012.

![Reproduced solar radiation with index 0.089](image)

Figure 10 satellite images at 12060702GMT

The cloud move over the solar cell area in these time interval could confirmed by the satellite image of MTSAT-2 IR1, JAM at 12060706GMT with corresponded to around 13.00 LT in Figure 11. The image of cloud covers Bangkok area. The cloud still covers Bangkok area and central of Thailand until the end of observation time at around 17.00 LT as showed in Figure 12 and 13 respectively. These were corresponded to the value of Reproduced solar radiation of around 100 W/m^2 from 13.00 LT to 17.00 LT in Figure 9.

![Reproduced solar radiation with index 0.089](image)

Figure 11 satellite images at 12060706GMT
5. CONCLUSION

The amount of generated electric current from the solar cell depended on the incident solar radiation. From the experiment, the linear relationship between the generated electric current and solar radiation was found. Because of the linear relationship, it is capable to use its linearization index to reproduce the solar radiation from the electric current. The results from the experiment were showed that we were successful to reproduce the solar radiation from the Ipv. This might be the useful application of the solar cell in the area where is no any solar radiation instrument but solar cell for daytime meteorological study.

ACKNOWLEDGMENT

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REFERENCES


