The Evaluation of Electricity Generation and Consumption from Solar Generator: A Case Study at Rajabhat Suan Sunandha's Learning Center in Samutsongkram

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Abstract**—**This paper presents the performance of electricity generation and consumption from solar generator installed at Rajabhat Suan Sunandha's learning center in Samutsongkram.

The result from the experiment showed that solar cell began to work and distribute the current into the system when the solar energy intensity was 340 w/m^2, starting from 8:00 am to 4:00 pm (duration of 8 hours). The highest intensity read during the experiment was 1,051.64w/m^2. The solar power was 38.74kWh/day. The electromotive force from solar cell averagely was 93.6V. However, when connecting solar cell with the battery charge controller system, the voltage was dropped to 69.07V. After evaluating the power distribution ability and electricity load of tested solar cell, the result showed that it could generate power to 11 units of 36-watt fluorescent lamp bulbs, which was altogether 396W. In the meantime, the AC to DC power converter generated 3.55A to the load, and gave 781VA.

Keywords**—**Solar Cell, Solar-cell power generating system.

I. Introduction

SAMUTSONGKRAM is a province in Thailand, located in the middle part of the country close to Thai Gulf Sea. Samutsongkram is famous for its history, culture, natural tourist attractions and the traditional way of life of the local people, who mostly still live with nature and commute in the canals. The majority of the local people are farmers and fishermen. Most areas of the province are fruit farms, especially coconuts and lychee farms.

Samutsongkram's provincial development strategy is to make the province become "the center of relaxation and eco-tourism". The governor aims to promote tourism along with the domestic agricultural products' quality improvement. The plan is also the attempt to improve the quality of life and promote the sufficiency philosophy in order to create strong community.

The Faculty of Industrial Technology of Suan Sunandha Rajabhat University has the potential staff and information which can be delivered to serve the community. Therefore, a learning center was set up to be the center of knowledge supporting the strategic plan in Bangkontee.

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At the learning center and surrounded area, electricity is generated by the adaptation of solar cell, since Samutsongkram is in the area where the solar energy intensity is enough to distribute power. My purpose of the research was to study the power generating process of the solar system here as the role model of solar system in Thailand in the future.

2 sets of the 24V & 258W solar cells are installed at the house of priest in Chonburi. [1] Their study has proved that the solar system there could distribute 354.49W on the sunny days and 125.67W on the cloudy days. They used the electricity generated from the solar cell with the 400W power amplifier, 50W fan and other electronic devices. Generally, their solar system will generate 3kW of electric per day.

Installed and tested 2 systems of electric generation from solar cell [2], [3]. The first system, tested the technical competency of lighting system in Naresuan University. The test subject was the solar cell generator which contained 2.56 kW solar cells, 1,000 W solar charge controller, 80 A battery with 24 V and 30 kWh battery to distribute power to 123 fluorescence 5 W light bulbs.

The solar cells in this system could generate power averagely 6.76 kWh/day. The electricity current could be charged into the battery for only 6.28 kWh/day. However, the electricity current needed for all the tested light bulbs were 6.35 kWh/day, which obviously was more than what the system could generate. Therefore, more power from the metropolis was still needed for this test.

The second system, the researchers tested the technical competency of the solar cell on the rooftop to distribute power with the grid inverter. The 2.81 kW solar cell was connected to the 3.5 kW grid inverter. The device was installed on the roof of school of alternative energy, Naresuan University. The voltage from solar cells was averagely 198 V and the distributed electricity was 14.83 kWh/day. The solar cell initiated the power distribution into the grid inverter when the light intensity was at 270 W/m^2. The electricity from this system was 12.66 kWh/day, with the power generating potential of 0.81.

II. Objectives

1. To evaluate the electricity distribution of solar cell
2. To look for the outcome of power usage ability of solar cell

III. Methodology

The solar generator panels used in this study were manufactured by Kaneka Company. They are the 60 W, G-EA060 Amorphous Silicon cells. I used 5 panels of this solar cell connected in parallel circuit. The device could generate power for 300 W at the highest voltage of 67 V and 4.5 A. The panels were installed on the roof of the learning center. The solar cell was turned to the southeastern direction at 145 degrees and 15 degrees elevation angle.

TABLE I
THE ELECTRICAL CHARACTERISTICS OF G-EA060 KANEKA SOLAR CELLS [4]

Electrical characteristics	Value	Unit
Maximum power (Pmax)	60	W
Open circuit voltage (Voc)	91.8	V
Shot circuit current (Isc)	1.19	A
Voltage at Pmax (Vmpp)	67.0	V
Current at Pmax (Impp)	0.90	A
Module efficiency (η)	6.3	%

TABLE II
THE ELECTRICAL CHARACTERISTICS OF SPT-2412 LEONICS SOLAR CHARGE CONTROLLER WITH MPPT AND DC LOAD TIMER 10A. [5]

Electrical characteristics	Value	Unit
PV Input		
Maximum power (W)	320	W
Maximum open circuit (Voc)	96	V
DC output to battery (Lead Acid battery)		
Nominal battery voltage	24	V
Boost charging voltage	30	V
Float charging voltage	27.6	V
Low battery disconnect voltage	21.6	V
Battery reconnection voltage	25	V
Maximum charging current	12	A
DC output control load		
Nominal voltage	24	V
Maximum current	10	A

TABLE III
THE ELECTRICAL CHARACTERISTICS OF APOLLO S-212B LEONICS DC/AC POWER CONVERTER [6]

Electrical characteristics	Value	Unit
Nominal input voltage	24	V_{DC}
Input voltage range	21 - 29	V_{DC}
Output power continuous	800	VA
Output voltage	220	V_{AC}
Output frequency	50/60	Hz
Maximum system efficiency	>82	%

As the angle of the roof at the center and the building structure were the main condition of the panels' performance, the SPT-2412 battery charger controller with 320 W input power could only distribute 12 A of 24 V power to batteries. The DC/AC Power Inverter which had 800 VA in 50/60 Hz called APOLLO S-212B and had Deep Cycle battery was considered the appropriate tool to use with the testing device. Because it could charge the battery very well and distribute the power to electricity load constantly in a long period of time. We used 4 pieces of 12 V battery that had 120 Ah in this study. They were connected in series in pairs. 2 pairs of battery connected and distributed 24 V and 240 Ah of electricity.

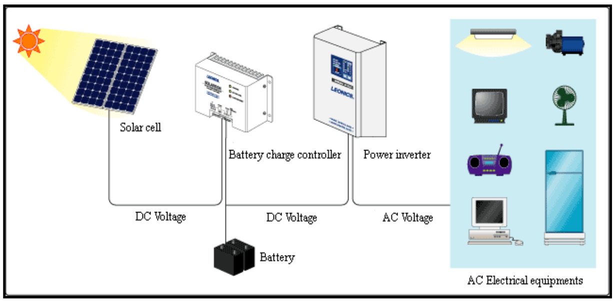

Fig. 1 The diagram of solar generator installed on the roof of the learning center

Fig. 2 Solar Panel on the roof

Fig. 3 Battery charge controller and AC distribution

A. The Experiment

1. During the evaluation period, the solar panels were observed constantly. The solar light intensity of the panels, voltage and current distributed were recorded every 10 minutes from 6 am to 6 pm of the day. The panels were tested in different seasons throughout the year. They were used in summer (April 1-15), rainy season (10-24 August), and winter (7-21 December) for totally 45 days. The data collected were used as the evaluation support.
2. The test was run by charging the 24 V and 240 Ah batteries using the solar panels on the roof so the battery is ready to distribute the power to the electricity load.

Then the 36-watt fluorescent light bulbs were attached to the system. We increased the number of the bulbs each time we recorded the voltage and electricity volume. The recorded data were part of the evaluation.

IV. Results

Although we set up the solar panel from 6:30 am to 6:00 pm (11.5 hours), the effective duration was from 8:00 am to 4:00 pm (8 hours) when the solar energy density was at its peak at 1,051.64 w/m^2. The solar cell initiated the power distribution when the solar energy density was at 340 w/m^2 and 38.74 kWh/day.

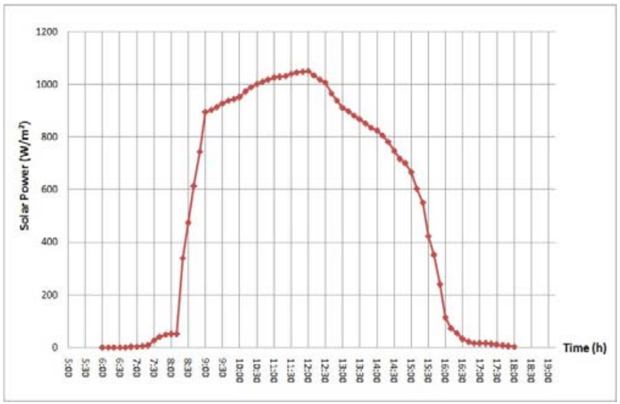

Fig. 4 Graph of solar energy density reflecting on the cell

From the experiment, the average voltage from the device was 93.6V, but it was reduced to 69.07 V when generating power to the charge controller. The voltage used during battery charging was around 27.5 - 29 V. the power distributed from the DC/AC power inverter to the electricity load was 221.17 V.

TABLE IV
THE EXPERIMENT OF ELECTRICITY GENERATED FROM THE TESTING DEVICE

No. of Light bulbs	Light bulbs power (Watt)	Current distributed to the bulbs (Amp)	Electricity Load Power (VA)
1	36	0.25	55
2	72	0.60	132
3	108	0.95	209
4	144	1.40	308
5	150	1.65	363
6	216	1.90	418
7	252	2.35	517
8	288	2.80	616
9	324	3.00	660
10	360	3.30	726
11	396	3.55	781
12	432	3.80	**836 (Over load)**

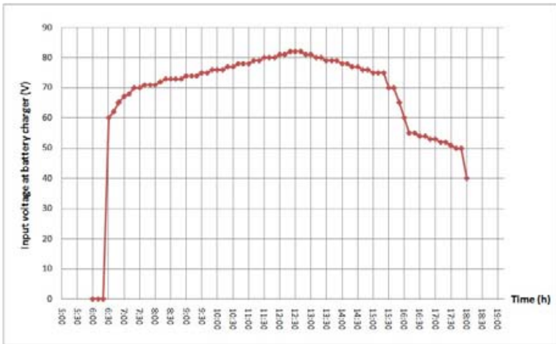

Fig. 5 Graph of Voltage from solar cell distributing to the battery charge controller

When more electrical load was added by using more fluorescence bulbs in the device, the system generated more power. Altogether, the power used received from the system was 396 W. The DC/AC inverter would generate 3.55 A, which was 781 VA. When the battery was fully charged, it could generate power for 2.6 days without recharging.

The experiment of Solar-Cell power generator took place at Rajabhat Suan Sunandha's learning center in Samutsongkram. The testing device consisted of 300 W solar cell which could distribute power to 11 units of 36-watt fluorescence light bulbs together at the same time through DC/AC inverter which was charged with 240 Ah. The solar cell device lasted for 2.6 days.

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