PHOTOVOLTAIC BUS SHELTER

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ABSTRACT

This paper presents the design and installation of a 560 W_p stand-alone PV system to supply an electric power for a bus shelter. This system has been installed at the Faculty of Engineering in Rajamangala University of Technology Thanyaburi - RMUTT (former name was Rajamangala Institute of Technology - RIT), Klong 6 Thanyaburi district, Pathumthani province of Thailand. The purpose of this work is to study and to analyze the performance of the PV system that to be installed at the RMUTT. The university is located about 35 kilometers far from Bangkok which to be capital city of Thailand. The main reason for installing is to demonstrate the application of a PV stand-alone power system that is able to be used in the university or other places, not just in rural areas. The design of control circuit was experimentally done in this work. Protection of the battery from damage in terms of deep discharge and overcharge by a controller was also considered. In addition, microcontroller program for controlling the operation of LED (light emitting diode) lamps was developed to show the status of the battery's operation. During the night, an operation period of time for the fluorescent lamps, 14 x 36 watts to be installed, between 18.00 and 21.00 hours were also controlled. The system performance including the life cycle cost analysis of the system and measuring data at the design location are addressed. The results of testing are able to provide useful information for rural electrification planners to install in a particular rural school or university in Thailand. They should be applicable in other countries that are situated the same latitude angle with a similar climate.

Key words : PV stand alone, life cycle cost

1. INTRODUCTION

Photovoltaic (PV) systems are the most reliable technology for rural development. The PV has many contributions to make in developing countries, particularly in Thailand and their applications impinge on the work of many different ministries. The use of PV system as a power supply to load for small-scale represents a promising option for using solar energy productively and for generating income. Nevertheless, the use of PV system in Thailand is still held back lack of information and usefully practice experience [1,2]. This kind of information is very important for convincing people in

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the rural areas that it is worth considering the option in the first place.

Accordingly, this paper presents the design and installation of a stand-alone PV system to supply an electric power for a bus shelter. This system has been installed at the Faculty of Engineering in Rajamangala University of Technology Thanyaburi - RMUTT (former name was Rajamangala Institute of Technology-RIT), Klong 6 Thanyaburi district, Pathumthani province of Thailand. The project, which is partially supported by the government's budget. To provide the basic knowledge and concept of PV system to many students who have been studying at the university, especially engineering students, are important. This is because most of students come from many provinces of Thailand. Whenever they graduate from the university and back to their home town, they could bring the concept of PV system to inform some people who live in the rural areas to consider for installation. This PV stand-alone system has been the first system of demonstration in the university of Thailand.

2. SYSTEM COMPONENTS

In this research work, there are basically four main components of a PV system for supplying an electrical power to bus shelter that to be installed at the Faculty of Engineering in the RMUTT. They are as follows [3-7]:

2.1 Photovoltaic Module

Seven PV modules have been used and each module in terms of the characteristics can be shown as follows:

Rated power	80 watts@ 25^0C
Voltage @ max. power	17.1 volts
Current @ max. power	4.67 amps
Short circuit current	5.31 amps
Open circuit voltage	21.3 volts
Warranted minimum	76 watts
Maximum system voltage	600 volts
Temperature coefficient of I_{sc}	(0.065 ± 0.015) %/^{0}C
Temperature coefficient of V_{oc}	$-(80\pm10)$ mV/^{0}C
Temperature coefficient of power	$-(0.5\pm0.05)$ %/^{0}C
NOCT	47 ± 2^0C
Dimension	1200x530x35 mm
Weight	8.5 Kg

(1) These data present the performance of typical NE-80E1U module as measured at their output terminals. The data are based on measurements made in accordance with ASTM E1036-85 corrected to SRC (Standard Reporting Conditions, also known as STC or standard test conditions), which are: (a) illumination of 1 kW/m^2 at spectral distribution of AM 1.5 (ASTM E892-87 global spectral irradiance) and (b) cell temperature of 25^0C.

(2) The cells in an illuminated module operate hotter than ambient temperature. NOCT is an indicator of this temperature differential, and is the cell temperature under Standard Operating Conditions, ambient temperature of 20^0C, solar radiation of 0.8 kW/m^2, and wind speed of 1m/s.

The design of PV module sizing is mainly based on the climatic data on inclined surface at latitude angle of Pathumthani province of Thailand and daily load demand. The PV module sizing for installation can be determined from a computer program in which to be developed in this research work. Accordingly, the PV modules have been mounted on the top of the structure of PV bus shelter in which can be seen in Fig. 9, they having a slope of angle is about 14^0 [8-9]. This is the latitude angle of Pathumthani province, facing to the south of a compass. The DC output from the array is transmitted to the inverter through a main switch in the inverter that can be seen from the Fig. 1.

2.2 Controller

A controller or regulator of BP solar # GCR 3000 has been mounted to control the state of charge and discharge of the battery as shown in Fig. 2. Maximum rating of current for this type is about 30 A. This charge control is specifically developed for charging battery powered by photovoltaic modules. It includes an LCD display that provides continuous battery storage and state of charge of the battery. Nevertheless, the controller is certainly the heart of the energy management of PV power system. This is because it controls the energy of the battery and the way it is spent on the different parts of the system. Accordingly, the design of an additional control circuit was experimentally done in the project work. Basically, the operating voltage of this system is 12 volts approximately. A solar charging controller with 30 A rated has been used. Its internal circuit can be shown in [10].

2.3 Inverter

An inverter of model # 1600 watts power surge inverter has been installed to change the voltage level from DC to AC. The AC output voltage and frequency vary continuously as a function of the irradiation that can be seen from the Fig. 2. Its characteristic can be shown as follows:

Continuous Power	800 watts
Peak power	1600 watts
AC output	220 volts
Regulation	$\pm$5%
Output waveform	modified sine wave
Phase	single phase
DC input voltage	11-15 volts
Low battery alarm	10.5 volts
Low battery shut down	10 volts
Frequency	50 Hz
Efficiency	90%

2.4 Battery

This PV project, the two batteries with maintenance free sealed lead acid type #DJM12120 have been mounted. The rating of voltage and ampere-hour are 12 volts and 120 ampere-hours respectively that can be seen in Fig. 3.

2.5 Lamp

To provide the lighting during the night time for advertising or users is wanted. A circuit of 36 watts fluorescent lamp, number of the fluorescent lamps for using is 14, has been mounted under the roof of the structure of the bus shelter or under the PV modules. In addition, an operating time of these fluorescent lamps is between 18.00 and 21.00 hours and they have been controlled by computer programming from the controller or regulator.

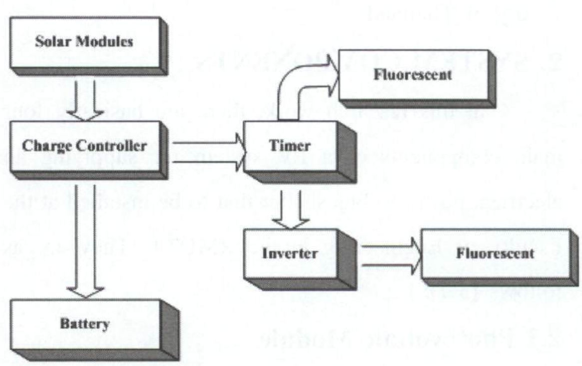

Figure 1 : Block diagram of the PV stand alone system powered bus shelter.

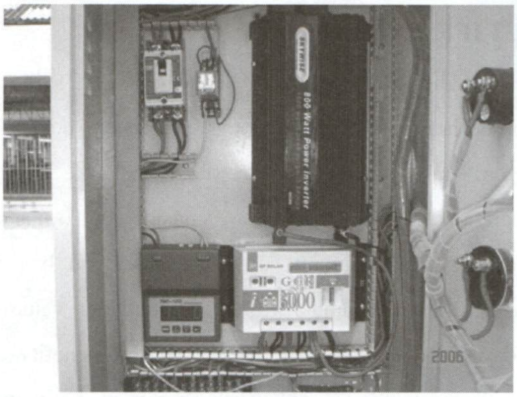

Figure 2 : The control box consists mainly of a controller, an inverter, measurement devices.

Figure 3 : Two batteries before conceal them within the compartment.

3. MEASUREMENT AND DATA RECORDING

In this project, the fluorescent lamps that to be used for lighting can be divided into two parts in terms of power supply. In fact, AC and DC sources have been used for comparing the system performance each other. One of the results has been shown that the average illuminance in lux of the fluorescent lamps which supplied by AC sources is more efficient than DC sources. It is about two times.

Table I : Comparison of the value of an average illuminance in lux of the fluorescent lamps from each source.

AC source		DC source	
lamp	lux (lm/m^2)	lamp	lux (lm/m^2)
1	1940	1	700
2	2300	2	760
3	2300	3	910
4	2210	4	850
5	1138	5	510
6	2410	6	970
7	3360	7	970
8	2340	8	980
9	766	9	940
10	2240	10	970
11	2300	11	970
12	2300	12	970
13	1450	13	630

Figure 4: The PV bus shelter during night time.

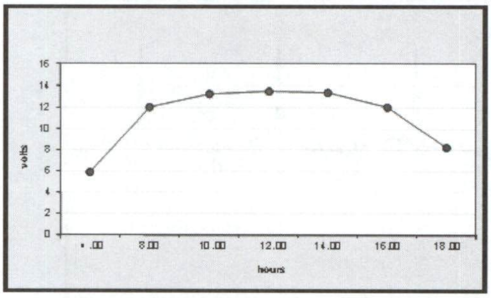

Figure 5: An average level of output voltage in volts that can be generated by PV modules against period of time in March 2006.

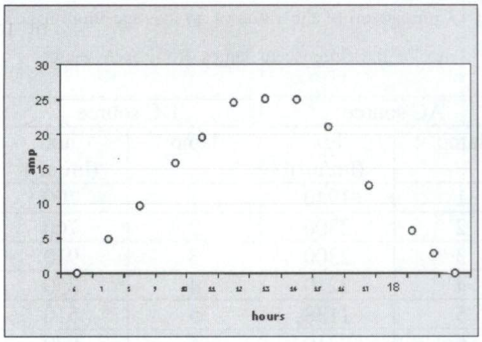

Figure 6: An average level of output current in ampere that can be generated by PV modules against period of time in March 2006.

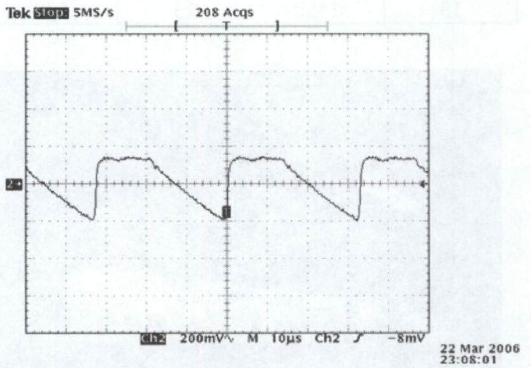

Figure 7 : Input current of ballast of the fluorescent lamps system.

Figure 8 : Output current of ballast of the fluorescent lamps system.

4. LIFE CYCLE COST ANALYSIS

The life cycle cost analysis (LCC) is the appropriate method to find out the system cost. The initial costs and all future costs for the entries operational life of a system are considered. To make a meaningful comparison, all future costs and benefits have to be discounted to their equivalent value in today's economy. All future costs and benefits are discounted to the present worth or present day values. A LCC analysis is based on the key assumptions (year 2005). The costs of installation and operation and maintenance are estimated by multiplying the capital cost of PV arrays with 0.2 (20%) and 0.02 (2%) respectively. The results of an analysis was found that the value of level energy cost was 20.93 baht/kW (1 US$ ≈ 45 baht) approximately. This is based on 20 years of the period of life time for analysis and the value of the inflation rate is 5%.

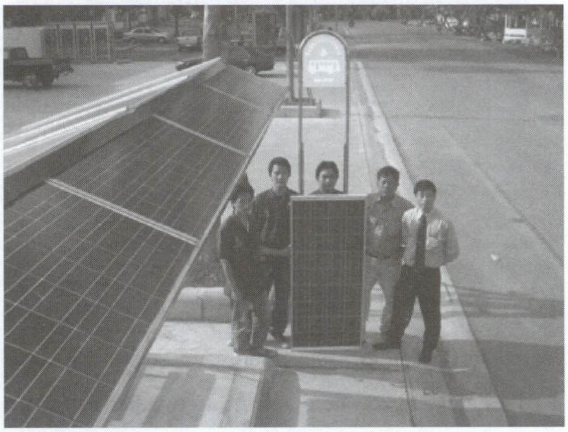

Figure 9 : PV bus shelter in the university.

5. CONCLUSION

This PV bus shelter system consists of 7 modules that connected in series and each module has generated power of 80 W_p (watt peak). It has also nominal voltage of 12 volts. The data from experimental testing has been shown that the system is able to produce an energy of 1,600 watt-hours/day to supply the load for fluorescent lamps and each lamp has power consumption of 36 watts. The total number of fluorescent lamps is 14 that to be used during night time is approximately 3 hours between 18.00 and 21.00 hours daily. Nevertheless, this research has been found that the average illuminance in lux of the fluorescent lamps supplied by AC source (220 V 50 Hz) for the PV bus shelter system that located at Rajamangala University of Technology Thanyaburi (RMUTT) in Pathumthani province of Thailand has been more higher than the fluorescent lamps supplied by DC source (12 VDC). In addition, the life time of the fluorescent lamps supplied by DC source has been also shorter than the fluorescent lamps supplied by AC source. An average total efficiency of PV bus shelter system is approximately 18.36 percent .

However, the main reason for installing is to demonstrate the application of a PV stand-alone power system that is able to be used in the university or other places, not just in rural areas. To give the basic knowledge and concept of PV system to many students who have been studying at the university, especially engineering students, are important. This is because most of students come from many provinces of Thailand. Whenever they graduate from the university and back to their home town, they could bring the concept of PV system to inform some people who live in the rural areas to consider for installation. Since the process of information dissemination for the successful implementation for photovoltaic program in developing countries is very necessary. It is essential to consider the modeling for implementation of a PV project to ensure that it will be successful. The results of the survey for users showed that in most cases the social university are already convinced of the value of PV project. Many people (university staff and students) who work or study in the university have been satisfied for using the PV bus shelter, especially during night time. It can be addressed that there are normally no problems with the design and installation process and the visual appearance could often be improved. However, this project has been one of the successful PV stand-alone system installed in the RMUTT so far.

5. ACKNOWLEDGEMENT

I would like to many thank to my colleagues at the electrical engineering department which support me a useful information and data. Some students who help me to install and record data are gratefully acknowledged.

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