Assessment of a 20 kWp GCPVS in Ratchaburi, Thailand

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Abstract: The aim of this paper is to present the results from the first assessment of a 20 kWp GCPVS in Ratchaburi, Thailand. The main objective of an assessment is to evaluate the grid connected photovoltaic technology, which operated under the hot and humid climate of Thailand. A 20 kWp GCPVS consists of 3 sub-arrays, monocrystalline, CdTe thin film and a-Si thin film sub-arrays, designed each to generate equally of 7.2 kWp, D.C. control cabinet and 3 grid connected type inverters. Technical aspect of each sub-array has been evaluated in terms of module efficiency, DC voltage and current and power, energy yield and performance ratio. Results from a typical day revealed that the DC electrical power of monocrystalline, CdTe thin film and a-Si thin film sub-arrays were about 5.724 kWh/d, 5.689 kWh/d and 4.890 kWh/d when the solar radiation intensity was about 7 kWh/m^2/d. Results showed that the module efficiency of monocrystalline, CdTe thin film and a-Si thin film solar cells were about 9.78%, 5.33% and 4.62% respectively. The energy yields and the performance ratio for each sub-array were in the range of 2.97-2.98 h/d and 0.56-0.57 respectively.
Key Words: Energy Yield, Monocrystalline, Grid Connected Photovoltaic, Performance Ratio, Thin Film.

1 Introduction

Since the grid connected photovoltaic system (GCPVS) has been introduced and installed worldwide under different climatic conditions. Most of the systems aimed at to develop self-sustainable PV market and to promote this kind of technology. Nowadays, the results from monitoring of some sites were published in order to evaluate the grid connected photovoltaic technology [1-2]. In Thailand, the first GCPVS has been installed in Sakeaw province. This project, undertaken by the Electricity Generating Authority of Thailand (EGAT), has a 20 kWp electrical power. Later, the 14 kWp GCPVS has been installed in Chiang Mai province in order to increase the reliability of the power grid utility in northern Thailand. Recently, the 500 kWp GCPVS is set up and implemented in Mae Hong Son province [3]. Both projects were supported by the Energy Policy and Planning Office (EPPO), Ministry of Energy. At present, the 20 kWp GCPVS are installed at the Regional Office of Alternative Energy Development and Efficiency about 4 sites almost throughout the kingdom of Thailand, namely, Phittsanulok province (Northern), Mahasarkham province (Northeastern), Pathumthani province (Central) and Ratchaburi province (Western). The project was also supported by the EPPO. Since the solar radiation and ambient condition vary from site to site, therefore, the objective of this paper is to assess the grid connected photovoltaic system in Ratchaburi province in order to investigate the best type of solar panel which able to response to the hot and humid climate of central Thailand by producing the maximum energy yields.

2 Description of a 20 kWp GCPVS

The 20 kWp GCPVS is comprised of 3 sub-arrays, i.e. monocrystalline sub-array, CdTe thin film sub-array and a-Si thin film sub-array, D.C. control cabinet, 2.5 kW battery back-up for any emergency case, charging controller and 3 grid connected type single phase inverters respectively. Each sub-array was designed to produce the electrical power by about 7.2 kW. The monocrystalline sub-array is comprised of 48 solar panels having 150 Wp each. The maximum power is about 7.200 kW. The CdTe thin film sub-array is comprised of 104 solar panels having 70 Wp each. The maximum power is about 7.280 kW. The a-Si thin film sub-array is comprised of 168 panels having 43 Wp each. The maximum power is about 7.224 kW. In fact, four inverters (2 types) are used in this GCPVS. The first three inverters are 7 kW grid-connected type inverter. Another type is 2.5 kW stand alone type inverter, which is used to convert DC power from the battery back-up into AC power for the distribution of electrical power to the office in case of any emergency. Single line diagram of the 20 kWp GCPVS in Ratchaburi province is shown in Fig.1.

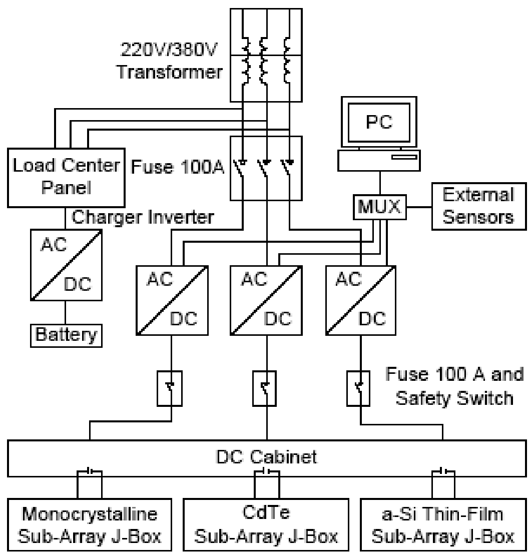

Fig.1 Single line diagram of the 20 kWp GCPVS

3 Assessment of a 20 kWp GCPVS

The assessment of photovoltaic system requires the data of the solar radiation intensity. Although it is the most important, however, the energy yield generated by such type of solar panel depends not only on the solar radiation intensity but also upon the other parameters such as solar panel temperature. The magnitude of solar panel temperature varies depending on the climatic condition of such site. Since the solar radiation and ambient condition vary from location to location. Therefore, their effects are investigated in this assessment. Solar radiation intensity on both horizontal plane and tilted plane were measured by CM11 pyranometers and the signal was amplified by CT24 amplifiers. Temperature sensors were installed at the rear of the solar panel in each sub-array. The built-in data logger in the inverter, which was later interfaced with a PC, recorded all parameters. Real time data were sampled in every 15 seconds and were calculated to be an average value in every 15 minutes. The data access was executed by the transferring the data within the built-in data logger in the inverters via the PC. In this paper we considered the following parameters for the first assessment of the 20 kWp GCPVS in Ratchaburi province; module efficiency, DC voltage, DC current and DC power, module efficiency, sub-array efficiency, inverter efficiency, energy yield and performance ratio. The effect of solar radiation and solar panel temperature are also investigated and presented in this paper.

4 Results and Discussion

Results from the first assessment revealed that the efficiency of monocrystalline solar cells was the highest by about 9.78% whereas the efficiency of CdTe thin film and a-Si thin film solar cells were about 5.33% and 4.62% respectively. Normally, the efficiency of inverter is quite high about over 80% but in this assessment, we found that its efficiency is rather low when compared to other systems and its value is in the range of 61-64% as shown in Fig.2. Furthermore, results showed that the produced DC current linearly depends upon the intensity of solar radiation as shown in Fig.3. One important thing that we can observe is that the CdTe thin film sub-array could produce the DC current higher than that produced by the monocrystalline and a-Si thin film sub-arrays when the intensity of solar radiation is in the range of 450-550 W/m^2. Not only that, the solar panel temperature does not affect the voltage output obviously.

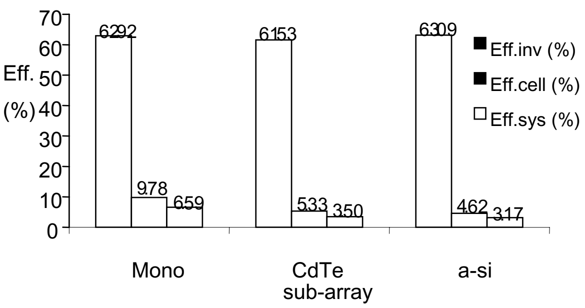

Fig.2 Inverter, module and system efficiency of each sub-array

Moreover, results from a typical day revealed that the DC electrical power of monocrystalline, CdTe thin film and a-Si thin film sub-arrays were about 5.724 kWh/d, 5.689 kWh/d and 4.890 kWh/d when the solar radiation intensity was about 7 kWh/m^2/d. The energy yields and the performance ratio for each sub-array were in the range of 2.97-2.98 h/d and 0.56-0.57 respectively. Finally, the long-term monitoring of the system is needed to clarify the effect of seasonal variation.

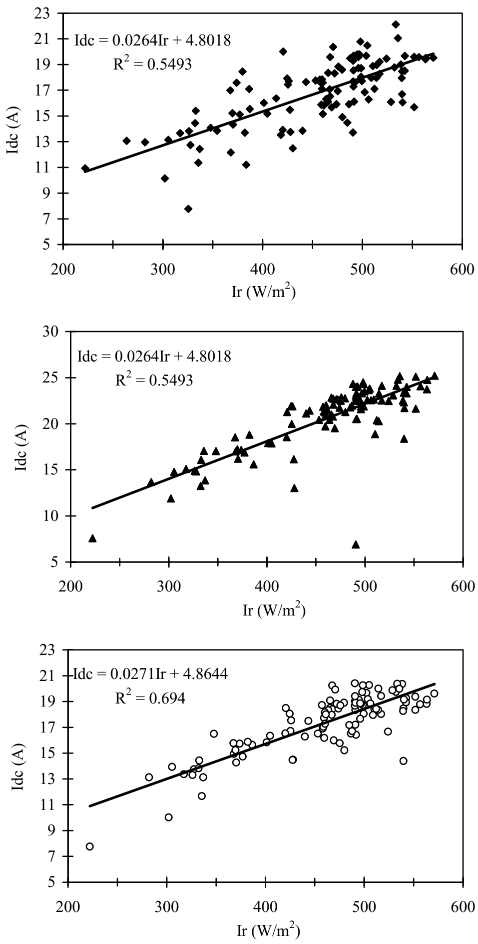

Fig.3 Effect of solar radiation intensity on DC current of monocrystalline sub-array (upper), CdTe thin film sub-array (Middle) and a-Si thin film sub-array (lower)

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