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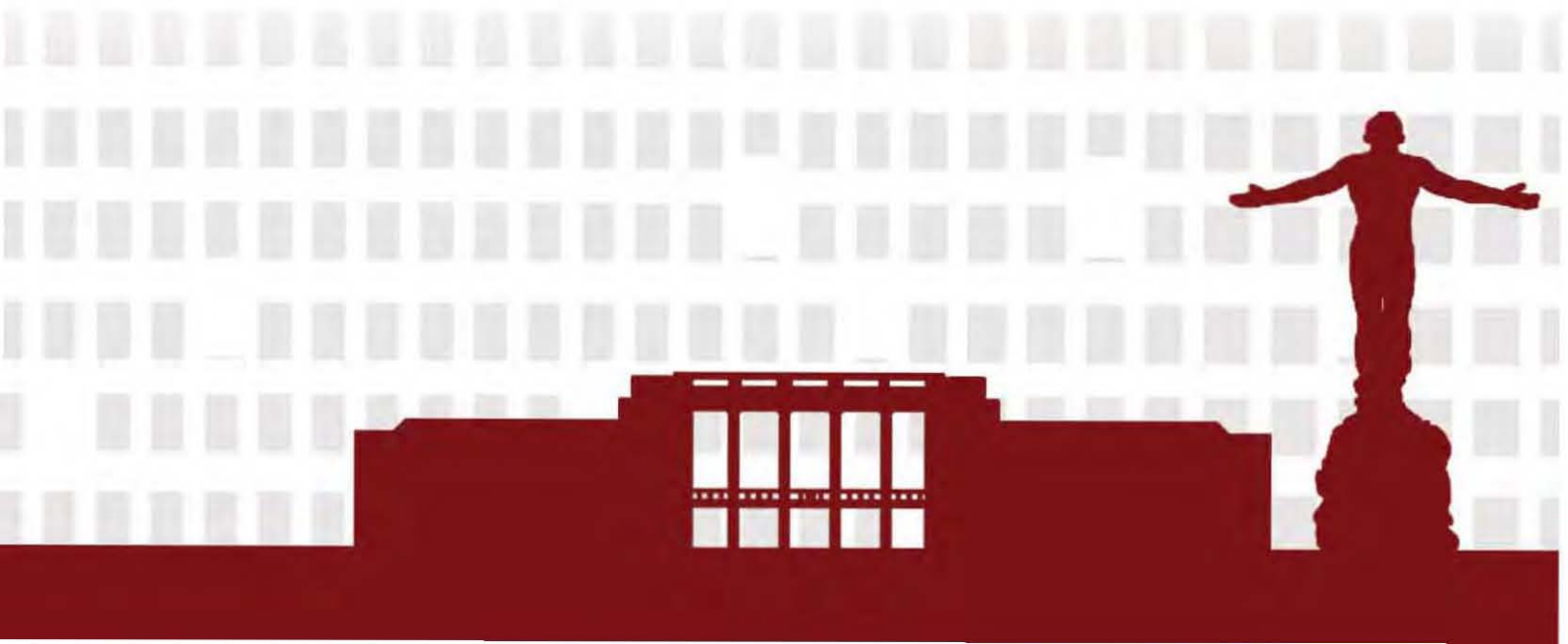

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PERFORMANCE OF A HYBRID SYSTEM AT PHU KRADUENG NATIONAL PARK

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ABSTRACT

The paper presents the analysis of a hybrid system installed at the Phu Kradueng National Park, Thailand. A hybrid PV-wind-battery-diesel generator was installed and monitored since December 2013. Data from the system were sent by mobile network to a server in Bangkok to be analyzed. Eleventh months-data were analyzed using the standard ICE 61724. The preliminary results from data collected during December 2013 until November 2014 revealed that the array yield (Y_A), final yield (Y_f), average reference yield (Y_r) were 3.0 kWh/kWd, 2.85 kWh/kWd, and 4.08 kWh/kWd, respectively. The performance ratio (R_p) was 72.33%. The mean array efficiency (η_{Amean}) was 10.4%. The overall efficiency of the hybrid system was 9.87%.

Keywords: Hybrid systems, PV systems, National Parks,

Introduction

In Thailand, there are over 120 national parks, where they are open for visitors. Some of them are arranged as overnights camping site and are able to facilitate many activities for visitors. However, many of the camping grounds inside the national parks are remote and the national electric power line cannot be reached. To provide a basic comfort for park rangers, the locals, and visitors, park rangers and the locals rely on small power diesel generators as a source of electricity. Even though diesel generators can generate sufficient electricity, some drawback of diesel generators are noise and air pollutions, gasoline leakage, and increasing gasoline prices. Therefore, to alleviate these problems, stand-alone hybrid systems are being introduced as a source of electricity to national parks.

Phu Kradueng National Park, located in Loei province, covers an area of 348.12 km^2 with 60 km^2 plateau. The highest peak is 1,316 m. above sea level, which is too costly to have a national power grid line links into the park. However, Phu Kradueng attracted as many as 56,160 visitors in 2014 [1]. The park's visitors center at Wung Gwang provided 13 bungalows, two sleeping halls, 10 toilet stalls, 28 food stalls, 3 souvenir shops, and camping ground. Water is available 24 hrs./day. The electricity is available to shops and visitors between 18.00 – 22.00 hr. However, the unique of the national park is that the load profile is different throughout the year. At Phu Kradueng national park, the load profile can be categorized into three periods: high season (October – January), low season (February- May), and (park) shutdown season (June – September).

The hybrid system designed for the park was a combination of photovoltaic (PV) and wind system with a diesel generator as a backup energy to support the reliability of the hybrid system [2]. Several research on off-grid and on-grid PV system analysis have been done to determine system performance in different part of the world to observe the degradation and long-term effect of the system [3-5]. The analysis of the systems would lead to further improvement of the system performance.

In this work, a hybrid system was installed at the Phu Kradueng national park in Thailand and data from the hybrid system is being monitored and analyzed to study the long-term operation of the hybrid system. The standard IEC 61724: Photovoltaic System Performance Monitoring-Guidelines for Measurement, Data Exchange and Analysis was used as an analysis guideline.

The Hybrid System at Phu Kradueng National Park

The stand-alone hybrid system, shown in Figure 1, installed at the Wung Gwang visitors center in the Phu Kradueng national park consisted of 24.5 kW- solar cells, 2.5 kW - wind turbine, a 60 kV.48 kW- diesel generator, 240 kWh - battery storage, 25.5 kW-inverter, 30 kW - Bi-directional inverter, and a multi cluster controller.

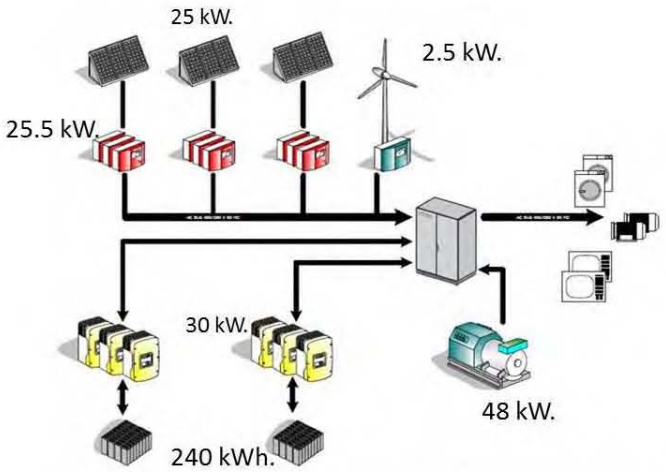

Figure 1. Schematic diagram of the stand-alone hybrid system at Phu Kradueng National Park.

Measured and calculated Parameters

The measured parameters to be monitored are from the meteorology, photovoltaic array, wind turbine, energy storage, and load. The calculated parameters are grouped into meteorological, electrical energy quantities, balance of system (BOS) component performance, and system performance indices. In this work, the calculated parameters were the reference yield (Y_r), array yield (Y_A), final PV system yield (Y_f), the performance ratio (R_p), and the system efficiency. The data to be analyzed were collected from December 2013 to November 2014.

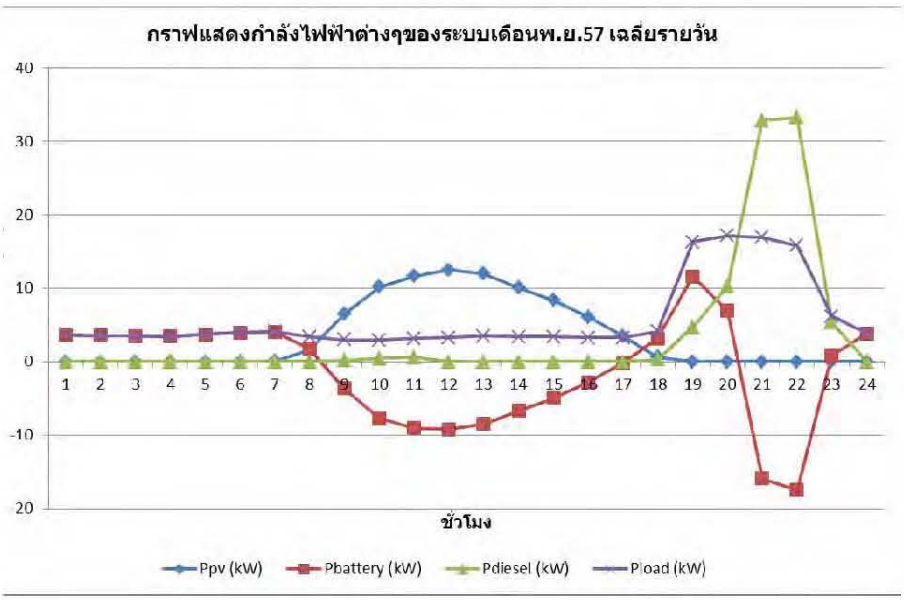

Figure 2. Average Daily power for a high season month (November 2014)

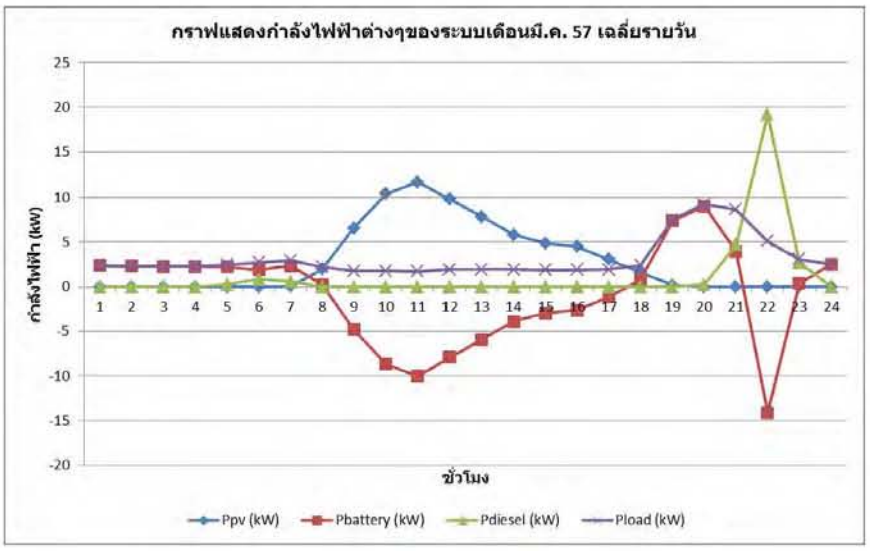

Figure 3. Average daily power for a low season month (March 2014)

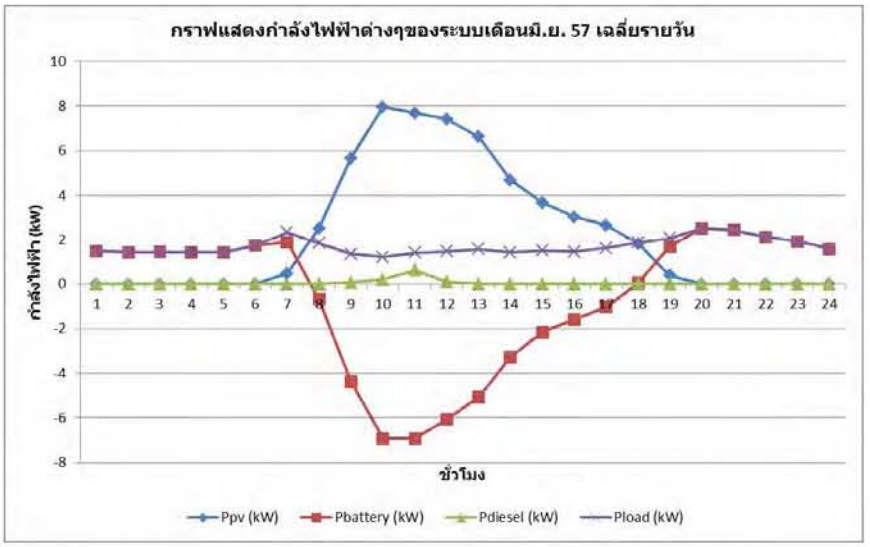

Figure 4. Average daily power for a shutdown month (June 2014)

Conclusion

According to the measured and calculated values from December 2013 – November 2014, based on the IEC 61724, the preliminary result for the Phu Kradueng national park hybrid system indicated that the average daily irradiation is 4 kWh/m^{2}day. The system's reference yield, array yield, and final yield were 4.08, 3.0, and 2.85 kWh/kWd, respectively. The performance ratio was 72.33 %. The mean array efficiency was 10.4 % and the overall system efficiency is 9.87 %.

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