Thesis Title	PV-Wind-Diesel Generator Hybrid System for Power Generation at the Tarutao National Park.
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Abstract

This thesis was a part of the research project on hybrid power generation systems from clean energy for national parks and wild life sanctuaries. The research was implemented by King Mongkut's University of Technology Thonburi and funded by the Energy Conservation Fund, the National Energy Policy Office. The overall project consisted of the design, installation, testing and evaluation of the 3 hybrid systems at the Tarutao National Park, the Pukadung National Park and the Huaykakang Wildlife Sanctuary. The project started at end of 1997.

This thesis focused on the system at the Tarutao National Park. The work consisted of 4 main parts. First, the performance of the initial system between April1998 until 2001 was analysed, the sizing of which are based on solar radiation data at Satun Province for the photovoltaic system and the wind data at Phuket Airport for the wind generator. The second part is on an analysis of potential renewable energy (solar and wind) of the site, based on on-site monitoring during April 1998 – December 2000. The equipment were put in place at the time of the original system installation. Thirdly, a new system was designed using the newly obtained data and, subsequently, installed in December 2000. Finally, economic analyses were made on the original and new systems.

The first system of the Tarutao National Park consisted of a 7.5 kWp PV array, one 10 kW wind turbine generator, a 234 kWh batterry system and a 48 kVA diesel generator. Operation of the first hybrid system was that of a switched hybrid system.

Meteorological data between April 1998 – December 2000 showed that the daily average of solar radiation was 4.76 kWh/m^2 day and close to the designed value used in the original system. The solar energy level can be divided into 2 groups, i.e. high monthly value during November – April and low monthly value during May – October. The average wind speed was 2.48 m/s, lower than the desired value. December has the highest average wind speed of 4.76 m/s while May has the lowest average wind speed of 0.65 m/s. Weibull parameter analysis of wind data showed that the yearly average value was 1.77, indicating that at the site low velocity wind speed predominated. Its value is comparable to that of the Mediterranean wind condition. The parameter level is 2.64 and is a measure of an average wind speed value.

System performance and efficiency analyses showed that

1. The PV array efficiency was 8.77 %, less than typical values of commercial PV panels. One of the reasons was losses in connecting PV modules. However, the array efficiency is close to those of water pumping systems and hybrid systems previously reported in Thailand.

The average energy production capacity (PV system yield) was 4.12 at the daily solar energy of 7.02 kWh/m^2. Electrical outputs varied linearly with solar radiation over the range of observation.

2. The power coefficient of wind turbine and the wind speed are linearly related over the wind speed of 2.5 to 8.0 m/s. Its value was 0.3, higher than the designed value.

Upon considering the actual electricity output from the wind generator, it was lower than that of the designed or predicted value based on simulation using the windKMUTT program, because of the lower wind velocity.

3. The 60% depth of discharge of the battery system was observed and was close to the designed value.

4. The efficiency of the energy conversion system, i.e. inverters and battery chargers, was 80% if operated over 15% of rated values.

The initial system at first performed close to the designed condition. In the hot season when solar radiaiton was high, electricity was adequately produced by renewable subsytems. In the rainy season when radiation was low, the diesel generator was run to augment the required energy. Later on, the electrical load was increased by 30%, the renewable subsystems became less reliable. The generator had to operate longer.

In the last part of the project, a new system was designed and installed in April 2001. Solar array wattage was increased by 30%. Based on available data, the array could deliver an increase in energy of 44%. The system then performed according to the design. Renewable subsystems become more reliable.

Economic analysis based on the Net Present Value, at the discount rate of 10%, showed that it is greater than one, the benefit to cost ratio (B/C) is more than 1 and the IRR is higher than the interest rate.