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Technical and Economic Analysis of Renewable Energy Powered Stand-alone Pole Street Lights for Remote Area

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Several different stand-alone pole street lighting (SPSL) models, using a light emitting diode (LED) lamp, were tested over a 1-year period on Penang Island in northern Malaysia. The models were powered by lead–lead dioxide batteries, autonomously recharged by a renewable energy power source (RES): either a photovoltaic (PV) generator or an integrated PV/Wind-turbine generator system. The technical requirements and economic impact (capital and operating costs) of these two configurations are analyzed and compared. Additionally, some of these configurations were programmed with an energy load savings scheme. The impact of operating with this scheme was compared to operations performed at full load. Results of this comparative analysis revealed that the most efficient system for the test environment was the PV generator operating with the energy savings scheme. © 2013 American Institute of Chemical Engineers Environ Prog, 33: 283–289, 2014

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INTRODUCTION

Street lighting has been considered essential for road safety and crime prevention since the Middle Ages. The technology has progressed a long way from the simple oil lamps used by these ancient civilizations. In modern societies, street lighting can be considered a measure of the quality of life [1]. Modern street lights generally have an automated switch that only provides power to the lamp when the level of daylight reduces beyond a prescribed intensity (e.g., night or during adverse weather conditions). Automation conserves energy and costs, because no power is expended when the street light is not needed. Despite this, the cost of maintaining street lighting is a challenging energy and financial burden for governments around the world. As an example, Peninsular Malaysia used 876.3 GWh of power for public lighting in 2006 (Figure 1). This represented 1.07% of the total electricity demand in Peninsular Malaysia for that year, with an equivalent cost of RM 67.3 million per hour (1RM Equivalent 3US $) [2]. These costs continually increase in locations experiencing urbanization or population growth. Diminishing energy sources and environmental pollution hinder the expansion of street lighting capacity. Lighting in rural or remote areas is often difficult to handle due to grid extension costs and inaccessibility. These problems highlight the need for stand-alone lighting powered by sustainable, renewable, and clean sources of energy.

Several stand-alone pole street light (SPSL) models have been developed to meet this requirement. Models with renewable energy sources (RES) are generally based on: photovoltaic (PV) generators (commonly known as solar power), wind turbine generators, or an integrated combination of these two systems (PV-Wind). Different configurations of these models have been developed with varying pole heights (normally between 8 and 15 m), illumination intensities (optimized for urban or country regions), and optimizations for operation in windy or sunny regions [3].

Creating an optimal design of a renewable SPSL involves scrutiny of the many photovoltaic panels, wind turbines and batteries offered by industry. Several software programs have been developed to analyze these systems [4]. The analysis presented in this article was performed using HOMER, developed by the national renewable energy laboratory (NREL) based in the United States. HOMER performs the three principle tasks (shown in Figure 2). The program starts with a simulation of renewable energy components with different configurations. This is followed by an optimization of system components to determine the best possible system configurations. Ultimately, analysis is done to reveal the output's sensitivity to the variation of input parameters [5].

There are many published research papers that also used HOMER to aid in analysis. G. J. Dalton, performed a feasibility analysis on the ability of a renewable energy system (RES) to supply power to a large stand-alone hotel (with over 100 beds), located in a subtropical coastal area in Queensland, Australia. The study showed that the RES configuration could fully supply the power demand of the hotel [6]. Askari and Ameri conducted a feasibility analysis which examined several RES options for supplying power to