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A hybrid renewable energy system for a longhouse

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Abstract: Renewable energy sources (RES) have already become important alternative electric power generation technologies, due to the adverse impacts of global warming brought about by the use of fossil-fuelled generation. To combat such impacts, a hybrid energy system which consists of more than one source of renewable energy would replace conventional electricity generation for Malaysia's longhouses existing in rural areas. Due to the limitation of electricity access in such areas, a hybrid system that consists of solar PV and wind energy as well as energy storage is proposed in this paper as a standalone RE system for electricity supply. Modelling of the hybrid system is then carried out based on selecting the most suitable system components, such as PV arrays, wind turbines, batteries and the inverter that satisfy both the technical and financial feasibility criteria. The model is then simulated using HOMER software to calculate the net present cost and the levelised cost of energy (LCOE). Results of the hybrid system simulation are compared with a diesel power generation, representing conventional energy supply, as the existing energy source. The comparison highlights the economic viability of the proposed hybrid system as a sustainable energy alternative to supply electricity to the longhouse.

Keywords: Hybrid power system, renewable energy resources, optimization.

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1. INTRODUCTION

The world mainly consists of three major energy sources: fossil fuels, nuclear and renewable energy sources [1]. Fossil fuel will continually remain as the major source of power generation in the world, as well as in Malaysia [2]. However, there are a number of negatives environmental impacts associated with using fossil-fuelled generation, such as acid rain, ozone layer depletion and global climate change [2, 3]. A renewable energy resource is defined as a sustainable resource available at a reasonable cost that can be regenerated or replenished for fulfilling the load demand without causing negative impacts to the environment. A renewable resource is also expressed as a clean energy source. The optimal use of these resources in power system could minimise the environmental impacts with the reduction in greenhouse gases emission, which is a major factor of global warming [4]. An integrated hybrid power system is a power generation system which consists of multiple electricity generating components. In this paper, two types of renewable energy resources, namely solar PV and wind generation, are chosen to supply the hybrid power system.

A longhouse, or 'Rumah Panjang' in the local language, is a timber house raised three to five feet off the ground on stilts. Between 20 – 40 families of the 'Rungus', an ethnic group in the Borneo, residing primarily in northern Sabah, in the area around Kudat, dwell these longhouses. Each family usually have its own apartment while sharing a common living area [5, 6]. Most of these longhouses are located far from the town and reside in the inner part of the jungle. Rural electrification is the process of bringing electrical power to rural and remote areas. The difficulty to extend grid connection through the thick jungle as well as the associated power transmission losses, make the grid power supply in rural areas infeasible and uneconomical. Renewable energy could supply the rural power demand without the consideration of the transmission cost from the grid. Malaysia is an equatorial country which has abundant potential of the RESs [7], whereas Kudat, in particular, located in the northern part of Sabah, possess high wind and solar potentials [8].

A few optimization techniques have been utilized for hybrid system sizing and modelling in the literature, such as graphical construction [9], artificial intelligence [10], dynamic programming [11], linear programming [12], multi-objective design [13], and iterative approach [12, 14]. In this paper, HOMER, a micro-grid analysis tool, is chosen to perform the hybrid system modelling and optimization, in order to model the technical and economic considerations for a hybrid system. Three load profiles, representing various weather conditions; including hot, rainy and normal weather days were developed to represent the annual load curve. Meteorological data of solar irradiation and wind speed were collected at the Kudat area. Simulation results were carried out and compared with the existing diesel power generation option.

The paper is organised as follows. Section 2 outlines the model of the hybrid power system. Section 3 describes system technical modelling in HOMER, whereas Section