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Assessment of hybrid renewable power sources for rural electrification in Malaysia

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ABSTRACT

Research works on hybrid renewable energy systems for rural electrifications have been quite intensive in recent years. Traditional power systems for remote or rural areas are based on fossil fuels. After addition of renewable energy resources, solar energy applications have become popular in remote energy systems. The recent study and research works show that adding other possible renewable energy resources such as wind, hydro and biomass could make a hybrid system more cost-effective and environmentally friendly. Hence, in the present study, an overview of applied hybrid renewable energy system (HRES) for worldwide villages with special attention on Malaysia has been proposed to help present and future works for better achievement in this field. Furthermore, a proper design and analysis for one village in Malaysia based on proposed combination is provided. The results show that combination of photovoltaic-wind -battery is defined as a cost-effective HRES for villages in Malaysia.

Contents

1. Introduction

Approximately twenty percent of global population or 1.3 billion people are living without electricity in the world. In developing countries in Asia, the percentage is around 36% of the total population. Furthermore, the number of people without access to the electricity will remain high at around 16% of total by 2030 [1]. Thus, rural electrification with the proper energy system in this part of Asia is an urgent issue in the energy sector [2].

Although the first solution for rural electrification is the extending of national grid by power transmission line, but in some cases it is not a possible solution [3]. According to the World Bank, grid extension prices vary from $6340/km in a densely populated country to $19,070/km in other countries [4]. Hence, the

Abbreviations: RE, renewable energy; PV, photovoltaic; RES, renewable energy system; HRES, hybrid renewable energy system; RETs, renewable energy technologies; HOMER, hybrid optimization model for electric renewable; HOGA, hybrid optimization by genetic algorithms

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off-grid power system offers an effective solution. The conventional method of local generation uses diesel generator that is not environmentally-friendly. Therefore, as an improved model of local energy generation, stand-alone renewable energy system with cleaner energy has been proposed [5]. In previous decade, the application of stand-alone renewable energy (RE) systems has increased steadily as a suitable solution for rural areas.

In recent years, researchers have focused on a more reliable RE system to combine with many sources of renewable energies to form a single system, which is called a hybrid renewable energy system (HRES).The reliability and cost of energy have improved in this combined units due to availability of many sources of energy to support each other in a cost-effective way [6]. For example, when solar energy is not available at night, wind source is a suitable support and while many sources of energy are available, choosing the source with lower cost of energy is preferable. Furthermore, the life time of battery bank in HRES can be increased as compared to single renewable energy system (Fig. 1). The PV panels and wind turbines produce the DC power and the diesel generator is connected to the DC line by using a rectifier.

Malaysia is chosen as a study case of this work and summary of Malaysia's plan for HRES in both application and research parts for rural areas is included in this article. Referring to the Tenth Malaysia Plan, the percentage of villages without electricity coverage was 0.5% to 33% in various territories of country in 2009. It is expected that 100% coverage of electricity in Peninsular Malaysia and 99% in Sabah and Sarawak can be achieved by 2015 as shown in Fig. 2. On the other side, the current focus of this country is to increase the share of renewable energy (RE) and reduce emission intensity [7].

In this paper, first a comprehensive overview of applied HRESs for stand-alone applications in the world with special attention to the Malaysia is presented. Second, according to the suggested combination for HRES by previous researchers in Malaysia, a hybrid renewable power system is designed and provided for a village in Malaysia.

2. Literature review

2.1. Rural electrification by HRESs

Whereas the stand-alone HRES design and performance depending on location and climate [8], the optimization of various

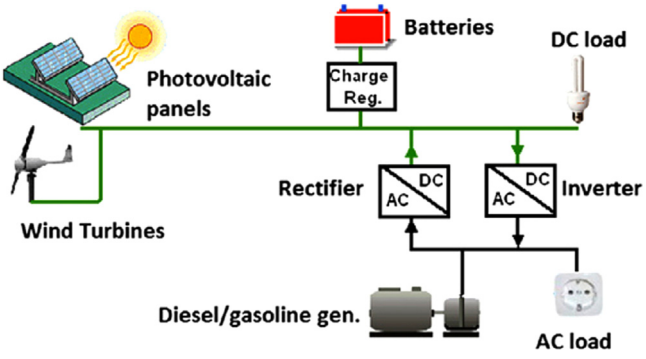

Fig. 1. PV–wind–diesel–battery HRES.

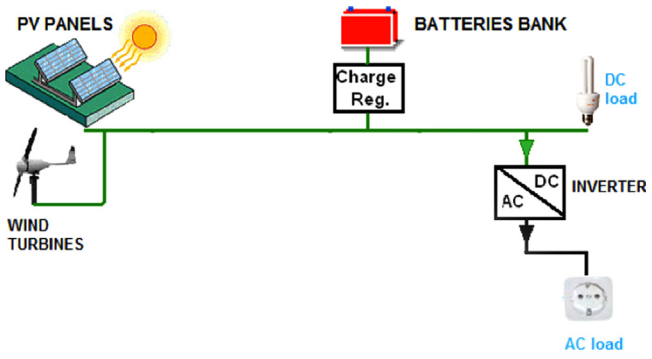

Fig. 3. Simulated model of PV–wind–battery system using iHOGA.

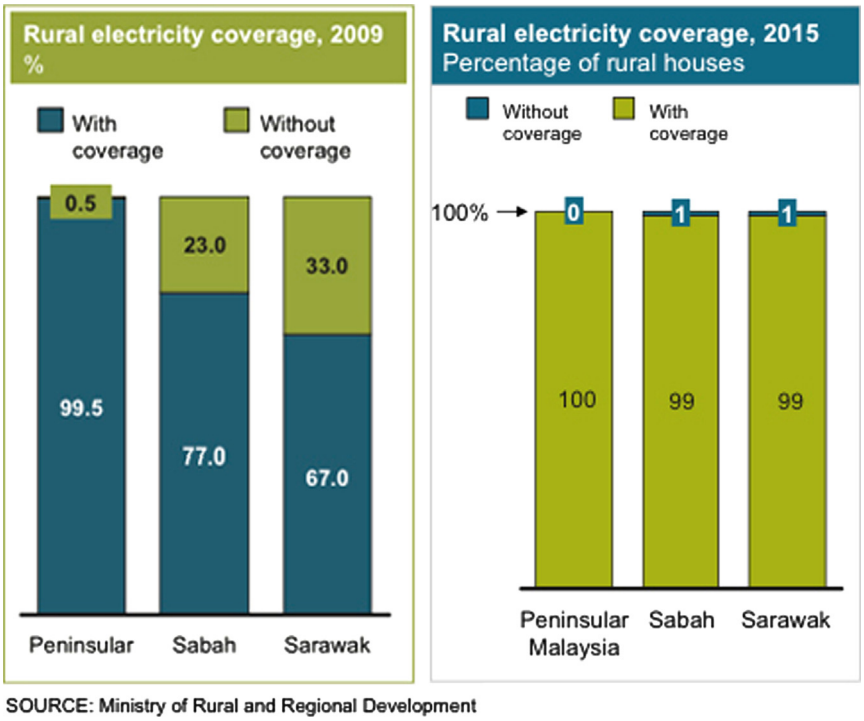

Fig. 2. Rural electrification coverage for Malaysia in 2009 and 2015.