Journal of Cleaner Production 139 (2016) 61–73

Contents lists available at ScienceDirect

Journal of Cleaner Production

journal homepage: www.elsevier.com/locate/jclepro

Investigation of potential hybrid renewable energy at various rural areas in Malaysia

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ARTICLE INFO

Article history:
Received 29 February 2016
Received in revised form
21 June 2016
Accepted 25 July 2016
Available online 27 July 2016

Keywords:
Renewable energy
Feasibility study
HOMER software
Solar photovoltaic
Wind
Micro hydropower

ABSTRACT

Feasibility study of the renewable energy resources is usually employed as a primary step in the design of Hybrid Renewable Energy System (HRES), to highlight the most potential sources and the best combinations obtained by using HOMER software. Thus, the main objective of this study is to identify the potential areas in Malaysia utilize solar, the wind and Micro Hydropower (MHP) sources. For this purpose, the results of a study accomplished by Ibrahim Hussein in 2010 are considered to obtain sites with the greatest hydropower potential in Malaysia. Then, a renewable energy resource assessment for these sites was performed to identify the sites that have the greatest solar, wind and hydropower potentials based on total Net Present Cost (NPC) comparison. Based on the historical data, a daily pattern emerged in electricity consumption among rural residents in Malaysia. The results of this study indicate Langkawi is the most potential region for the solar/wind combination by the significant difference with other regions (total NPC of 696,083 USD). After Langkawi, Tioman Islands has the second rank (total NPC of 818,931 USD), while villages in Tioman are the most appropriate sites for installing hybrid renewable energy system with the current specifications. In terms of the premiered locations for solar and hydropower potential, four sites at Lawas in Sarawak and Ranau in Sabah were identified as the greatest potential (total NPC of 354,000 USD). These findings demonstrate that Tioman Islands and Malaysian Borneo Island (Sabah and Sarawak) can be considered as the most attractive regions for the solar/wind/MHP and solar/MHP, respectively.

1. Introduction

Electrification of remote rural areas do not have accessibility to the national electricity grid is an important issue for developing countries like Malaysia. According to the World Bank data, access to electricity in Malaysia has improved significantly over the past two decades, and about 100% of the population (urban and rural) would have access to electricity by 2012 (WB, 2013). Electrification of rural areas also experiences the same trend recently as shown in Fig. 1. This figure indicates the percentage of rural housing units having access to electricity in Malaysia between 2008 and 2012.

Based on the these data, the aim is electrification of rural areas, which consist of 26% of the total population (WB, 2014) is the main target for electrification. Clearly, access to electricity is dependent on various factors, which are social and geographical in nature, and the entire rural areas do not share similar have the same geography and social indexes (Čuček et al., 2012; Sánchez et al., 2015). In general, two factors including the number of people living in rural areas and the level of electrification are different between peninsular and East Malaysia. The current data indicates that 99.7% of people have electricity access in peninsular Malaysia, while the level of electrification in Borneo (Sabah and Sarawak) is less than peninsular Malaysia (KKLW, 2014). In fact, remote rural areas are the areas which do not have access to electricity. Typically, these remote areas are not connected to the national electricity grid due to geography and economics. In these cases, diesel generators are usually employed as the first solution for the electrification of these areas, but such solution has disadvantages such as high fuel and maintenance costs. Furthermore, diesel price fluctuated through the time based on oil price, so the operational cost of a diesel generator is not predictable. In terms of environmental effect, a lot

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http://dx.doi.org/10.1016/j.jclepro.2016.07.167
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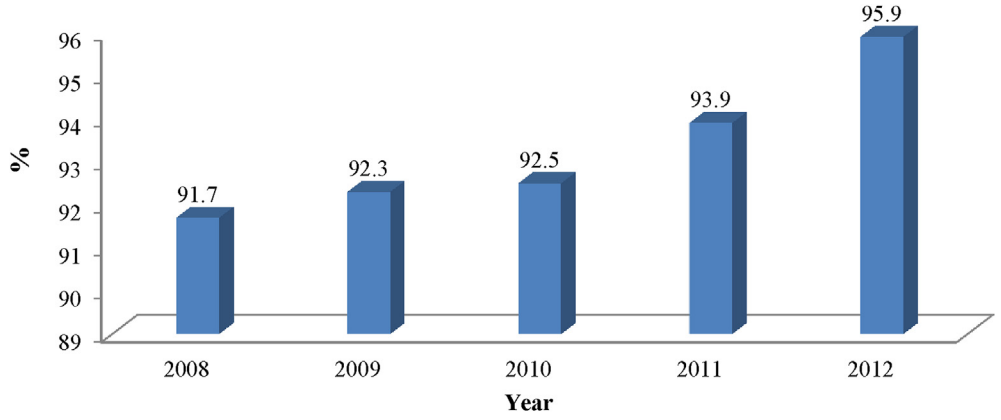

Fig. 1. Portion of rural housing units with electricity in Malaysia (EPU, 2013).

of harmful gasses are emitted by diesel generators, therefore it is important to consider alternative energy and environmental-friendly sources regarding cost and other constraints (Shin et al., 2015).

Currently, gas and coal are major electricity sources in Malaysia and more than 87% of electricity has been generated using these sources (NEB, 2013) that cause lots of harmful gasses. As a reference, results of a research by Safaai et al. (2011) enclosed that CO_2 emission from electricity generation has been increased significantly in the 21st century in Malaysia. The authors have forecasted that the CO_2 emission from electricity production may reach to about 125 million tons by 2020. Thus, the renewable energy resources growth rather than fossil fuels to produce electricity is an important affair in Malaysia that can help to reduce the harmful effect of greenhouse gasses emission. Fig. 2 shows the percentage of available energy sources applied to generate electricity in Malaysia.

As can be seen in Fig. 2, electricity produced by renewable energy sources was less than 1%, while Malaysia is a tropical country with the enormous renewable energy potential (such as solar and hydropower resources). Among the renewable energy sources, hydropower is considered a vital resource since it ranked third in electricity generation (IEA, 2013). The largest portion of this hydropower energy has been harvested from huge dams that have a

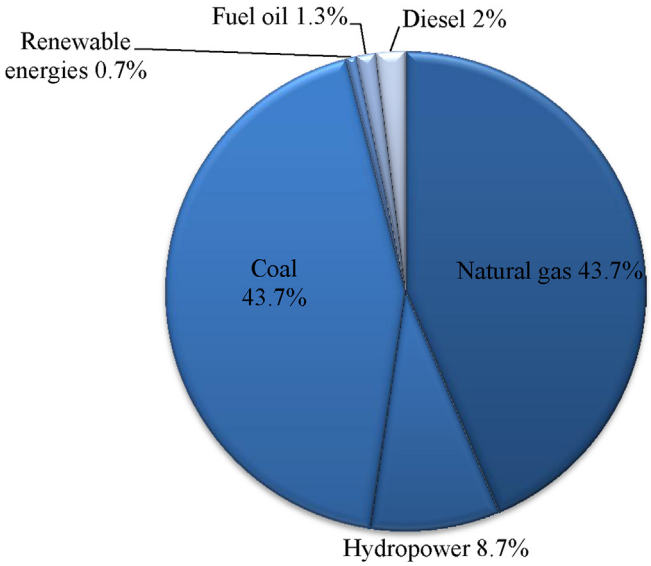

Fig. 2. Share of different resources for electricity generation in Malaysia (NEB, 2013).

substantial impact on the environment and lead to social obstacles. Indeed, giant hydrological dams have direct influences on the biological, chemical and physical properties of rivers environments. In terms of social effects, tribal and indigenous communities are the first victim of the huge dam construction. Furthermore, the ecosystem is affected by giant dams and makes lots of problem for the ecosystem. For instances, dam wall blocks fish migrations and traps sediments which are vital for the preservation of life cycle in the streams. Thus, the large-scale hydropower has usually faced lots of oppositions such as environmental activists, especially in a country like Malaysia with different indigenous and tribal communities living in exotic, unique nature. As an example in Malaysia, 10000 tribal people have been dislocated for constructing the Bakun dam in Sarawak state. Therefore, it is better to introduce and propose the less challenging renewable energy sources such as solar resources.

Typically, tropical countries have great solar energy potential, however, the percentage of photovoltaic (PV) in Malaysia was only 0.15% of the total electricity production (141 of 94631GWh) in 2013 (IEA, 2013). In terms of PV technology. The PV efficiency has been improved significantly in last decade and reached more than 40% in some multi-junction cells (NREL, 2015). Therefore, production of electricity by using solar resource or combination of different resources deserves serious consideration in the generation of cleaner electricity. The possibility of employing alternative energy as an off-grid system in the remote areas is also more cost effective compared with other conventional energy sources that are not available and that these remote rural areas have limited access to the national electrical grid. Consequently, finding the potential of renewable energy sources (such as solar, wind, hydropower and etc.) should be given due priority and be the first step in electrification projects (Sigarchian et al., 2015).

For comparing the Malaysian energy generation status with the world average, Fig. 3 illustrates the portion of electricity generation by renewable energy resource in the world.

As can be seen from Fig. 3, the portion of renewable energy sources for generating electricity in the world is about eight times more than renewable energy quota in Malaysia. This comparison proves that the electricity generation by these clean sources should grow in the future.

The main objective of this study is to figure out the best locations with high potential for solar, wind and hydropower resources in different states of Malaysia. In fact, this article covers techno-economic study, performing a comparison between the various rural areas in terms of solar, wind and micro hydropower (MHP) potentials and Hybrid Renewable Energy Systems (HRES) cost, by