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Performance analysis of hybrid PV/diesel/battery system using HOMER: A case study Sabah, Malaysia

Laith M. Halabi [a,*], Saad Mekhilef [a,*], Lanre Olatomiwa [b], James Hazelton [c]

[a] Power Electronics and Renewable Energy Research Laboratory (PEARL), Department of Electrical Engineering, Faculty of Engineering, University of Malaya, 50603 Kuala Lumpur, Malaysia
[b] Department of Electrical & Electronic Engineering, Federal University of Technology, PMB 65, Minna, Nigeria
[c] School of Photovoltaics and Renewable Energy Engineering, University of New South Wales, Sydney, NSW 2052, Australia

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ABSTRACT

This study considered two decentralized power stations in Sabah, Malaysia; each contains different combination of photovoltaic (PV), diesel generators, system converters, and storage batteries. The work was built upon previous related site surveys and data collections from each site. Verification of the site data sets, simulation of different operational scenarios, and a comparison with the optimum design were all considered in the work. This includes all possible standalone diesel generators, hybrid PV/diesel/battery, and 100% PV/battery scenarios for the proposed stations. HOMER software has been used in the modeling entire systems. The operational behaviors of different PV penetration levels were analyzed to accurately quantify the impact of PV integration. The performance of these stations was analyzed based on technical, economic and environmental constraints, besides, placing emphasis on comparative cost analysis between different operational scenarios. The results satisfied the load demand with the minimum total net present cost (NPC) and levelized cost of energy (LCOE). Moreover, sensitivity analysis was carried out to represents the effects of changing main parameters, such as; fuel, PV, battery prices, and load demand (load growth) on the system performance. Comparison of all operational behaviors scenarios was carried out to elucidate the advantages/disadvantages of utilizing each scenario. The impact of different PV penetration levels on the system performance and the generation of harmful emissions is also investigated. The results show more trends towards using renewable energy (RE) sources in energy generation and less dependence on standalone diesel generators. Hybrid PV/Diesel/Battery system is seen to be the best technical performance compared to all other scenarios, while also reporting good economic and environmental performance, which result in increased system sustainability. The 100% RE system showed the best environmental characteristics with the highest costs. This study has demonstrated that the presence of RE sources improves the performance of standalone systems and reduces energy storage requirements.

1. Introduction

Out of all renewable energy (RE) technologies that can be used in decentralized applications, solar energy has the widest applications in electricity generation. It provides reliable and low cost of energy when employed in remote areas [1]. It also enhances local development by creating new jobs and training opportunities. Furthermore, its environmental friendliness enhanced it is applicability [2]. This technology offers greater potential for developing countries, where a significant percentage of the population lives in various regions that have limited or no electricity access. In such places, RE sources are considered a suitable solution for rural electrification. This type of energy generation could play an important role in energy provision. Where the presence of electrical energy access positively influences the human development index (HDI) [3], a strong relation links the national energy consumptions and the gross national product (GDP) because electricity is a key requirement for societies' development over economic, education, and health sectors [4]. For example, in Malaysia, a certain portion of the population lives below the poverty line, this is mostly found in remote places of Sabah and Sarawak, with poverty levels 67.05% and 66.91%, respectively [5]. Malaysia has a good potential of solar energy, due to the abundance of solar radiation averaging 4.8–6.1 kW h/m^2/day. Based on this, solar energy has always been

* Corresponding authors.
E-mail addresses: l.halabi@outlook.com (L.M. Halabi), saad@um.edu.my (S. Mekhilef).

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