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Economic evaluation of hybrid energy systems for rural electrification in six geo-political zones of Nigeria

Lanre Olatomiwa [a, b, *], Saad Mekhilef [a, *], A.S.N. Huda [a], Olayinka S. Ohunakin [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] Mechanical Engineering Department, Covenant University, P.M.B 1023, Ota, Ogun State, Nigeria

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ABSTRACT

Rural electrification improves the quality of life of rural dwellers having limited or non-access to electricity through decentralized electricity coverage. Since the price of oil is unstable and fluctuating day by day and grid expansion is not also a cost effective solution, integrating renewable energy sources thus become an important alternative for rural electrification. The present study investigated the feasibility of different power generation configurations comprising solar array, wind turbine and diesel generator in different locations within the geo-political zones of Nigeria. Six rural communities were randomly chosen from each of the six geo-political zones in Nigeria with the intention that the results of the study could be replicated in other remote locations of the selected zones with similar terrains. HOMER (Hybrid Optimization Model for Electric Renewable) simulation software was used to determine the economic feasibility of the systems. The simulations concentrated on the net present costs, cost of energy and renewable fraction of the given hybrid configurations for all the climatic zones. The analysis indicates that the PV/diesel/battery hybrid renewable system configuration is found as optimum architecture for both sensitivity cases of 1.1 and $1.3/l of diesel. It also displayed better performance in fuel consumption and CO_2 reduction.

1. Introduction

Sufficient energy supply is indispensable for sustainable economic development of any nation. A country will not grow beyond the subsistence level without an appreciable access to energy [1]. An estimated two billion people around the world mostly in small villages in developing countries currently lack grid-based electricity services according to the United Nations Environment Program (UNEP) [2,3]. The escalating population resulting to increased socio-economic activities, however, calls for continuous energy supply to meet the teeming energy demand. Electricity is thus concluded as a key measure to sustainable socio-economic growth needed for human development. In Nigeria, approximately 40% of the population are connected to the national grid, leaving the rest (mostly living in rural areas) to biomass/fuelwood consumption [1] and at times self-powered generation (diesel generator). According to Suresh Kumar and Manoharan [2], installation and supply of electricity through grid poses serious logistics in developing economics, particularly if specific areas are remote and sparsely populated. Even in places that are connected to the grid, incessant power supply (that characterizes supply insufficiency) has always being the situation in most cities in Nigeria due to the poor power situation, thus making electric energy consumers to supplement grid connections with self-powered generation (through diesel/petrol electric generators).

Other than grid unavailability, energy supply mix in Nigeria is dominated by fossil sources [1]; apart from the environmental consequence of fossil energy utilization, the rate of depletion of fossil reserves in the country, put in doubt the ability to cope with the teeming population growth and rising socio-economic activities in terms of the energy demand at the present and future scenario. These reasons led to several researches into renewable energy technologies (RETs)/low carbon generators including photovoltaic, micro turbines, diesel generators, wind turbines, fuel cells, etc. and hybrid power systems (HPSs) that combine two or

* Corresponding authors. Power Electronics and Renewable Energy Research Laboratory (PEARL), Department of Electrical Engineering, Faculty of Engineering, University of Malaya, 50603 Kuala Lumpur, Malaysia. Tel.: +60 129138237.
E-mail addresses: olatomiwa.l@futminna.edu.ng (L. Olatomiwa), saad@um.edu.my (S. Mekhilef).

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