Available online at www.sciencedirect.com

ScienceDirect

Energy Procedia 110 (2017) 1 – 7

Energy Procedia

1st International Conference on Energy and Power, ICEP2016, 14-16 December 2016, RMIT University, Melbourne, Australia

Designing rural electrification solutions considering hybrid energy systems for Papua New Guinea

Tarlochan Kaur[a,*], Ravi Segal[b]

[a]*Electrical Engineering Department, PEC University of Technology, Chandigarh and 160012, India*
[b]*GE (Energy Consulting) Bengaluru, India*

Abstract

Papua New Guinea (PNG) is amongst the least developed countries in the world and has an unusual topography. About 90% of its population lives in rural areas and has little or no access to electricity. At a minimum, achieving PNG's target of 70% of the population having access to electricity means rural access rates will need to rise from 7.6% to close to 65%. The rural electricity market is very complex because the traditional model of utility based centralized grid extension cannot cover the entire population for demographic and economic reasons. Renewable Energy sources present unique opportunities for greater fuel diversity and security. In this work feasibility of hybrid electricity systems consisting of small scale Generating sets, Hydro, solar PV with and without energy storage solutions is studied. The potential of various renewable resources like Hydro, solar resource, etc. is estimated. Electric load for the basic needs of rural community including school, recreational and health centre is estimated. HOMER is used for optimization and sensitivity analysis of different hybrid systems. Considering the load profile and resource estimation, the most cost effective system is proposed.

Peer-review under responsibility of the organizing committee of the 1st International Conference on Energy and Power.

Keywords: Rural Electrification; Hybrid Energy systems; PNG.

1. Introduction

Electrification in remote areas is constrained by technical barriers like limited long distance transmission system, difficult terrains, highly dispersed with a low population density characterized by low level of education, low load

* Corresponding author. Tel.: 91-0172-275-3451; fax: +91-0172-274-5175.
E-mail address: tarlochankaur@pec.ac.in

Peer-review under responsibility of the organizing committee of the 1st International Conference on Energy and Power.
doi:10.1016/j.egypro.2017.03.092

density, and low revenues. In addition there is absence of market infrastructure to attract private investors. This paper focuses on designing rural electrification solutions considering hybrid energy systems for a country (PNG). Off-grid Hybrid systems often are the least-cost long-term energy solution, capable of delivering the best services of the three alternatives. Adverse environmental effect such as greenhouse gas emission, global warming, climate change, etc. has promoted focus on alternate energy generation like solar, wind, hydro, tidal and biogas etc. In recent years, application of renewable energy sources for electrification is becoming economically feasible due to rapid development of relevant technologies.

2. Literature Survey

Various researchers used different methods for optimization of hybrid renewable based power system, viz artificial intelligence, mathematical modeling, simulation and optimization software [1–5]. A genetic algorithm is used to optimize the hybrid power system of different combination of RE resources (Pico hydropower, diesel generator, solar photovoltaic and battery storage) [1]. Kenfack et al. [2], have studied feasibility analysis of solar photovoltaic and micro hydro hybrid power system, at Batocha (Cameroon), using HOMER software. Combination of solar PV, biomass, hydro and wind energy sources was optimized using HOMER and LINGO software [3]. Monte Carlo simulation program is used for the feasibility analysis of wind and hydro hybrid system to electrify an island in Greece [4]. HOMER is widely used for optimization of off- grid and grid connected power system. [5-6]. However, a detailed review of this literature.is beyond the scope of this paper. Givler and Lilienthal [7] conducted a case study of Sri Lanka where they considered an individual household base load of 5W with a peak of 40 W, leading to a daily load average of 305 watt-hours. Through a large number of simulations, the study found that the PV-diesel hybrid becomes cost effective as the demand increases. However, this study focuses on the basic needs as such and does not include productive use of energy. Similar case studies have been done for elsewhere. For example, Himri et al. [8] has presented a study of an Algerian village; Nandi and Ghosh [9] has discussed the case of a Bangladeshi village, while Nfah et al. [10] and Bekele and Palm [11] provided case studies of Cameroon and Ethiopia respectively. Most studies concentrate on supplying electricity only for domestic purposes and do not take into account the electricity demand for agricultural, community purposes and for small-scale business units for the socio-economic development of the whole region. These issues are considered in the present study, thereby bridging the knowledge gap.

3. Study Area

PNG lies in the eastern half of the island of New Guinea, north of Australia. PNG has one of the most rural areas in the world .Out of total 1.4 million houses, 90% household are in rural areas [13]. Most of the villagers depend upon agriculture for their income [14]. Port Moresby, capital city of PNG is at 9°25'S, 147°13'E, and elevation of from sea level 48 m. Port Moresby has a dry and humid climate with almost same temperatures (26-32°C). The average solar insolation is 4.5 kWh/m^2/day and on an average there are 2,489 hours of sunshine per year. This study cover techno-economic evaluation of various alternatives for village electrification in PNG.

4. Methodology

HOMER Pro (Hybrid Optimization Model for Electric Renewables), is used for designing the micro –power system. It is a preferred tool, because it can handle a large number of technologies and can perform hourly simulations. To compliment it, pre and post HOMER analysis is done as indicated in Fig 1. In the Pre-HOMER analysis phase, peak demand and energy consumption is estimated. Assessment of site and available resources is conducted. In the HOMER analysis the hybrid RET system is designed. Various combination of a combination of the following technologies, namely small hydropower (SHP), solar PV (SPV) systems, natural gas based generator and batteries for back-up. Fig. 2 shows schematic system configuration diagram. This is followed by techno-economic analysis which compares a wide range of equipment with different constraints and sensitivities to optimize the system design.. Based on the simulation results, the best suited configuration is selected having least LCOE. In post Homer phase case analysis is performed.