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Techno-economic evaluation of various hybrid power systems for rural telecom

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ABSTRACT

Nowadays, utility has started to consider the green power technology for having a healthier environment. The green power technologies reduce combustion of fossil fuels and the consequent CO_2 emission which is the principle cause of global warming. By maximising the use of the renewable energy, the usage of diesel generator for powering the base transceiver stations could be reduced or removed. This paper aims to investigate the economic, technical and environmental performance of various hybrid power systems for powering remote telecom. Simulations using Hybrid Optimisation Model for Electric Renewable (HOMER) software are performed to determine the Initial Capital, the Total Net Present Cost (TNPC), the Cost of Energy (COE) as well as the system Capacity Shortage of the different supply options. The simulation results suggest a suitable hybrid system which would be the feasible solution for generation of electric power for remote telecom. A detailed analysis, description and modelling of the system are also presented in this paper.

Contents

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1. Introduction

In the recent years, India's energy consumption has been increasing at a fast rate in the world due to population growth and economic development [1]. In India, Industrial consumers are the largest group of electricity consumers, followed by the domestic, agricultural and commercial consumers, in that order. The Indian telecommunications industry is one of the fastest growing industries in the world. India is currently adding 8–10 million mobile subscribers every month [2–5]. The power woes of India's telecom sector especially in the rural areas are quite apparent. It is a big challenge for the industry to meet its regular power requirements through traditional fuel, which is expensive [6]. Power deficits coupled with the rising cost of diesel pose a significant challenge to the mid-term growth and profitability of the telecommunication sector. Continued reliance on diesel will also substantially increase the environmental costs in the form of carbon emissions. The telecommunication sector is well placed to transit to a business model which relies on energy efficiency measures in combination with harnessing clean energy sources for its operations. This has compelled the industry to look for alternative green energy solutions.

India has one of the highest potentials for harnessing the renewable energy. Renewable energies are also inexhaustible and clean. Renewable Energy Systems, particularly hybrid systems, have the additional advantage of being complimentary [7–9]. A hybrid system consists of two or more renewable energy sources used together to provide green energy, increased system efficiency as well as greater balance in energy supply.

Thus, India's growing telecommunication tower industry can achieve substantial cost savings, while reducing their fossil-fuel dependence and carbon footprint, by switching to hybrid renewable power generated electricity supply. The various Renewable Energy Sources (RES) such as solar energy, wind energy, fuel cells and so on are used for telecommunications applications in the developing countries. Many literature references have discussed the economic cost analysis of combinations of hybrid power system [10–13]. Also, there is a lot of literature about design and analysis in the context of renewable energy power generations [14–19].

The main objective of this paper is to compare various hybrid renewable energy systems in all aspects like optimal cost allocation of each individual components present in the system, sensitivity variable solar radiation, wind speed, emissions, electricity production and to examine the best effective renewable based hybrid system configuration. For all the combinations of hybrid power system combinations, the meteorological data of solar radiation and wind speed is taken for Chennai [20–26], India with the Latitude 13° North and Longitude 80.18° East and the pattern of load consumption of typical telecom load profiles are suitably modelled. Here, Hybrid Optimisation Model for Electric Renewable (HOMER) software is used to analyse hybrid power system.

2. Various hybrid systems

The intermittent nature of the solar and wind energy under varying climatic conditions requires a feasibility assessment and optimal sizing of hybrid solar and wind energy system. Without proper technical and financial feasibility study, the hybrid alternative energy systems may end up in a poor efficient system. The intent behind this paper is to design, optimise and analyse an effective hybrid power system for a remote telecom station and to compare then with the existing Diesel power scheme. HOMER determines the operational strategy for a hybrid renewable energy system based on three tasks which are simulation, optimisation analysis and sensitivity analysis. It simulates the operation of the system based on the components chosen by the user. So, here the hybrid combinations chosen are (i) Diesel generator (ii) Grid-Diesel generator (iii) Solar PV-Diesel Generator (iv) Solar PV-Wind system-Diesel generator-Battery (v) Solar PV-Wind system-Diesel generator-Battery-Fuel cell (vi) Solar PV-Wind system-Battery-Fuel cell (vii) Solar PV-Wind system-Battery. The architecture of various hybrid system is shown in Fig. 1(i)–(vi). HOMER simulates the system based on the estimation of installing cost, replacement cost, operation cost, fuel and interest. The list of various configurations of hybrid renewable energy will be tabulated from the lowest to the highest total net present cost (TNPC). It then determines the best feasible system configuration which can adequately serve the electric demand. The optimal solution is referring to the lowest total net present cost (TNPC).

HOMER compares a wide range of equipment with different constraints and sensitivities to optimise the system design. The analysis is based on the technical properties of the system and the life-cycle cost (LCC) of the system. The LCC comprises the initial capital cost, cost of installation and operation costs over the system's life span. HOMER performs simulations to satisfy the given demand using alternative technology options and resource availability.

3. Modelling of the hybrid system

Hybrid Optimisation Model for Electric Renewable (HOMER) software helps us to determine how different renewable, and hybrid systems interact with end-use demand. Based on the availability and potential of renewable energies in the particular area a hybrid energy system is modelled.

3.1. Telecom load

The Telecom load (Base Transceiver Station-BTS) is considered as primary load. The BTS is a telecom infrastructure used to facilitate wireless communication between subscriber device and telecoms operator network. The global development of BTS is increasingly taking place in regions in which the power distribution grid often breaks down for long periods of time or where there is no access to the power distribution grid.

So the BTS in such regions, diesel generators with batteries are used to back-up the grid for electricity supply and ensure network availability. But these require a high level of maintenance work and consume relatively high amounts of diesel fuel for low level outputs. As a result diesel generators incur high operating expenses. The growing cost of energy (COE) due to increasing diesel prices and concerns over rising greenhouse emissions have caused the telecom companies to focus on better power management methods. The price of diesel since 2004 is shown in Fig. 2.