



Sensitivity analysis of optimal renewable energy mathematical model on demand variations

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Abstract

Energy demand is increasing rapidly because of developments in the industrial, agricultural, commercial and transportation sectors. The population rise and improved life style are other reasons for the increase in energy demand. Since commercial energy sources are non-renewable and depleting in nature, it is essential to seek renewable energy sources. After a few decades, renewables have to play a major role to meet the growing energy demand. A Delphi study has been conducted to find the level of social acceptance in the utilisation of renewable energy sources for the year 2020–2021. The experts' opinion revealed that 25% of total energy demand could be met by renewable energy sources. An Optimal Renewable Energy Mathematical (OREM) model is developed to allocate the predicted renewable energy demand for different end uses. The model is analysed to meet 20, 25 and 30% of the total energy demand in the year 2020–2021. In the case of the 25% energy demand, the renewable energy contribution would be 8.127×10^{15} kJ. A sensitivity analysis has been done to validate the OREM model. The analysis reveals that the energy distribution pattern changes, even with an increase of 1% energy demand, for which the coefficient of sensitivity is 1.84%. This study will help in the formation of strategies for effective utilisation of renewable energy sources in India. © 1999 Elsevier Science Ltd. All rights reserved.

1. Introduction

Energy is a vital input for the economic and social development of any country. India has made rapid strides in the development of electricity generation, with capacity increasing from

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nearly 1700 MW in 1950 to nearly 85,000 MW in 1998. Yet, the demand is continuously increasing. The utilisation of commercial energy resources is increasing enormously which will inevitably lead to a tremendous amount of atmospheric pollution and global warming due to the green house effect. It is, therefore, essential to search for non-polluting renewable sources of energy. Solar, wind and biomass are accepted as dependable and widely available sources of renewable energy. Generation and utilisation of energy from these renewables are non-polluting in nature and are acceptable as environmentally clean sources.

Renewable energy sources are being used in the industrial, transportation, domestic, agricultural and commercial sectors. Considering the health impairment effects and depleting nature of commercial energy sources, it can be said that renewable energy can be obtained at a reasonable social cost. Though the present cost of renewable sources is on the high side, there is a possibility for further reduction by achieving higher efficiencies of energy conversion devices by using advanced technology, large scale demands, by adopting more efficient manufacturing methods and by discovering suitable sites where renewables could be applied effectively [1].

2. Review of energy demand models

The previous models related to energy demand were reviewed. An econometric energy-economy simulation model was developed by Rahman [2] for energy policy studies for a wide range of developing countries. It has also been used for forecasting India's long term energy demand. The variables used in the model were gross domestic product (GDP) and investment. Huntington [3] stated that shifts among economic sectors will continue to be an important source of uncertainty in forecasting industrial energy demand. He used gross national product (GNP) as a variable for energy demand forecasting. Gilland [4] stated that a rising standard of living for the world's growing population meant increasing world energy consumption. Harel and Baguant [5] estimated the GDP growth rate for Mauritius by analogy with the observed growth in more developed countries, such as Singapore and Hong Kong. Lakshminarayana [6] described the pattern of electrical energy consumption on a medium/long term basis based on its interaction with other related techno-econometric and demographic indicators (variables), such as population, GNP, capital invested in the industrial sector and gross oil and coal production.

Sterman [7] tested the ability of adaptive expectations and univariate trend extrapolation to explain the history of energy demand forecasts. Sudhakara Reddy [8] observed that the demand for energy in the rural sector in 2000 A.D. will be three and half times the present energy demand. The author stressed the need for improving the energy efficiency of existing devices and development of appropriate technologies to harness solar, biogas and energy plantation options. The variables used for the projection were population, energy requirement per village, number of villages in India and number of persons per village. Rijal et al. [9] developed an energy demand model which could project energy requirements in rural Nepal. In order to decide on an optimum energy resource and technology mix, a linear multiple regression model was developed for specific end use energy requirements of the rural household

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