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Renewable energy sources for peak load demand management in India

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Abstract

In developing country such as India, demand for power is increasing day by day; especially peak load demand management is becoming crucial. This paper highlights the gap between peak load power demand and availability of power at the regional level, furthermore proposes the suitability of power generation from renewable sources to fill the gap. The problem is formulated for the optimum allocation of the various renewable energy options to meet the peak load demand at the regional level of India, based upon the application of a linear programming algorithm, considering various constraints. Due to the geological profile, potential of various renewable energy sources such as, small hydel power, solar photovoltaic, wind power, co-generation and biomass energy is varying from region to region. A computational result indicates that the power generated by renewable resources is quite suitable to meet the peak load demand and in fact some of regions have the potential, which can be transferred to the other regions utilizing the existing transmission line network.

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1. Introduction

The development of industries, agriculture and infrastructure is dependent on the power sector, which enhances the economic development of a country. Electricity consumption is practically synonymous with modern life in the industrialized world. The growth rate of demand for power in India is higher than that of gross domestic product (GDP). It is envisaged that the electricity requirements in India would increase rapidly in the next couple of decades. With continued growth in the power sector the gap between demand and generation is growing every year.

The installed capacity of the electricity supply undertakings (utilization) in the country over 50 years has increased from 1700 MW in 1950 to 104917.5 MW at the end of March 2002. Installed capacity as on 31st March 2001 is, 71% thermal power generation, 25% hydel power generation, 3% nuclear power generation and about 1% wind power generation [1,2].

Despite of growth in power generation over years, India continues to face power shortage. Table 1 represents peak load

demand positions at regional and national level from April to December 2001.

The main difficulties for power system reliability and security are associated with the annual peak load period. The top 10% of the supply demand is only exceeded for a limited number of hours per year and the highest loadings are associated with only some 1% of the peak day's energy consumption. The top 10% of system load has the predominant influence for the acquisition of extra generation and augmenting lines, cables and sustains throughout the network. Sometimes system collapses if the existing system fails to takeover this excess load.

In developing countries the power sector is often unable to meet peak load demands, which causes load shedding, power cuts and voltage reductions and frequency variations. Today, almost all the regions in the country are short of power during peak load hours. During the course of a single day the frequency in a regional grid might vary from a level below normal to a level above normal, which is harmful for heavy rotating equipments and in particular considerable difficulties have been faced in the operation of generating stations as well as damage to the end user equipment. These problems will grow in near future [3].

Base load service is provided by high efficiency, fossil fuelled steam electric plants, hydro electric power plants and nuclear generation plants. These have high capital costs and low operating costs and operates for the entire year. Peak load

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Table 1 Peak load demand and generation at the various regions of India from April to December 2001

Region	Requirement	Availability	Shortage	Percentage
Northern	23,200	21,346	1854	8
Western	26,510	22,024	4486	16.9
Southern	21,804	17,591	4213	19.3
Eastern	7876	7648	228	2.9
North-eastern	1148	1008	140	12.2
All India	77,956	68,209	9747	12.5

Peak load demand and availability of power in megaWatt. *Source*. Annual reports 1998–1999 to 2001–2002, Ministry of Power, Govt of India. [12].

service, however, is usually provided by oil or gas turbines and diesel generators, which have relatively low capital costs and high operating (fuel) costs. These may be operated for less than 10-15% of the annual period. Sometimes these are also operated to meet some part of the base load.

Storage technologies, in particular batteries and superconducting magnetic energy storage (SMES) can be one of the solutions to meet peak load demands, but again its capability needs to prove in terms of capacity and cost [4].

Most of the renewable energy sources are environmentally benign and offering almost no costs for fuel and hence renewable energy sources will play significant role in meeting the peak load demand of the country.

2. Energy resources in India

Conventional power generation utilizes natural resources mainly water and fossil fuel. In the Indian power sector major share in electricity generation is thermal generation and the main fuel used is coal. India is endowed with 6% of coal reserves of the world and also has been gifted with huge hydel potential estimated about 84,000 MW at 60% plant load factor [5]. Like coal, oil and gas, hydro potential of the country is unevenly distributed, mostly concentrated in the north and north-eastern regions.

Fossil fuels are finite in nature. Exploitation of these resources has adverse effects on the ecology due to mining, deforestation, particulate matter emissions, handling of waste, transportation dependency, etc. Hydroelectric projects, especially those involving large dams, have significant environmental, social and economical impacts

- Deforestation due to increased catchments area has considerable effect on seasonal water flow, increase in silt flow in to the streams and rivers etc.
- Rehabilitation and resettlement of project affected families.
- Large gestation period to complete the project also escalates the project cost.

Even though coal and hydel generation will continue to be the main source for base load power generation [6]; the decentralized untapped renewable potential sources such as, bio-gas, solar photovoltaic, solar thermal, biomass gasifier, wind power, small hydropower, co-generation, etc. are slowly gaining importance [7].

The growing concern over environmental degradation caused by fossil fuel based systems, opposition to large hydel projects on grounds of displacement of land and population, and the ever-rising shortage of power have highlighted the need for tapping renewable sources as an alternate energy sources for power generation.

Significant efforts have been made to adopt various technologies for the development and induction of renewable energy sources throughout the world [8]. The use of some of these energy sources has been technically tested but it is not yet economically established though attempts are being made [9]. In India contribution of the power from renewable energy sources to the total installed capacity of electricity generation is rising. As of 31st December 2001, the cumulative installed capacity totalled 3387.08 MW [10,11] is representing more than 3% of the installed capacity. Table 2 shows the assessment of technical potential for renewable energy in India.

Considering the expected decline of energy generation from conventional energy sources in near future, various optimal hybrid models are proposed worldwide taking into account various renewable energy sources, while restructuring, expansion planning of the power sectors.

Some of the important features of the renewable energy technologies are listed below.

- (a) Strengths of renewable energy sources
 - Decentralized production
 - Zero or low fuel costs
 - Low gestation period, providing quicker benefits
 - Participant friendly
 - Provides energy security to developing economy.
- (b) Present constraints of renewable energy sources
 - Irregularity in supply

Table 2

Estimated potential of renewable energies for the various regions of India

Region	Small hydel power (MW)	Solar photo voltaic	Wind power (MW)	Co-generation (MW)	Biomass generation (MW)
Northern	3179.54	20 MW/km ² ,	885	1150	0.064
Western	660.785	5 kW h/m ² /day,	5940 (technical)	1200	14.5 (kW)
Southern	798.71	300 clear day Lanner	4880	950	143
Eastern	5289.98		1130	2007	_
North-eastern	1610.54		-	_	-

Source. Annual report 2001-2002, MNES, Govt of India (compiled together).

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