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Energy Policy 34 (2006) 101–111

ENERGY POLICY

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Comparison of options for distributed generation in India

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Available online 31 July 2004

Abstract

There is renewed interest in distributed generation (DG). This paper reviews the different technological options available for DG, their current status and evaluates them based on the cost of generation and future potential in India. The non-renewable options considered are internal combustion engines fuelled by diesel, natural gas and microturbines and fuel cells fired by natural gas. The renewable technologies considered are wind, solar photovoltaic, biomass gasification and bagasse cogeneration. The cost of generation is dependent on the load factor and the discount rate. Gas engines and Bagasse based cogeneration are found to be the most cost effective DG options while wind and biomass gasifier fired engines are viable under certain conditions. PEM Fuel cells and micro turbines based on natural gas need a few demonstrations projects and cost reductions before becoming viable. A strategy involving pilot projects, tracking of costs and dissemination of information is likely to result in DG meeting 10% of India's power needs by 2012.

Keywords: Distributed generation; Annualized life cycle cost; Load factor

1. Introduction

The earliest electric power systems were distributed generation (DG) systems intended to cater to the requirements of local areas. Subsequent technology developments driven by economies of scale resulted in the development of large centralized grids connecting up entire regions and countries. The design and operating philosophies of power systems have emerged with a focus on centralized generation. During the last decade, there has been renewed interest in DG. This paper reviews the different technological options available for DG, their current status and evaluates them based on the cost of generation and future potential. The relevance of these options for a developing country context is examined using data for India.

Different definitions of DG have been proposed. Some have linked this to the size of the plant, suggesting that DG should be from a few kW to sizes less than 10 or 50 MW. Ackerman et al. (2001) provides a review of alternative definitions of DG and suggests that *DG be defined as the installation and operation of electric power generation units connected directly to the distribution network or connected to the network on the customer site of the meter*. DG is also referred to as dispersed generation or embedded generation. DG options can be classified based on the prime movers used—engines, turbines, fuel cells or based on the fuel source as renewable or non-renewable. There are a large number of possible system configurations.

In this review the comparison is limited to the following options:

(*A*) *Non-Renewable*

1. Internal combustion engine fuelled by diesel
2. Internal combustion engine fuelled by natural gas
3. Micro-turbine fuelled by natural gas
4. Proton exchange membrane (PEM) fuel cell with reformer fuelled by natural gas

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doi:10.1016/j.enpol.2004.06.006

(*B*) *Renewable*

5. Wind turbine
6. Solar photovoltaic (PV)
7. Biomass gasifier connected to a spark ignition engine (dedicated gas engine)
8. Bagasse cogeneration in sugar factories

Other options that have not been considered here are small hydropower, geothermal, ocean thermal, tidal and solar thermal power generation options. In order to place DG in the context of the Indian power sector, a brief background of the Indian power scenario is provided before comparing the DG options.

2. Indian power sector

India had an installed capacity of 105,000 MW (Ministry of Power, 2003a, b) in the centralized power utilities on 31st March 2003. Of this 74,400 MW is accounted for by thermal power plants, 26,300 MW of large hydro plants and 2700 MW of nuclear. The focus of power planning has been to extend the centralized grid throughout the country. However the capacity addition has not been able to keep pace with the increasing demand for electricity. This is reflected by the persistent energy and peak shortages in the country. The transmission and distribution losses are extremely high (estimated to be more than 25%, this includes theft).

India has a plan to add 100 000 MW of additional power generation capacity by 2012 (MOP, 2001). This requires an average capacity addition of more than 10,000 MW per year. Centralized generation alone is unlikely to meet this target. In this context DG is likely to be important. DG also has the advantage of improving tail-end voltages, reducing distribution losses and improving system reliability.

The present installed capacity of DG is about 13,000 MW (10,000 MW diesel, 3000 MW renewables). The majority of this is accounted for by diesel engines that are used for back-up power (in the event of grid failure) and operate at very low load factors. The share of the energy generation from DG is marginal (about 2–3% of the total generation). Apart from the diesel engines, the DG options that have been promoted in India are modern renewables.

India is probably the only country with a separate Ministry of Non-conventional Energy Sources (MNES). The renewable energy installed capacity was 205.5 MW in 1993 (104.6 MW small hydro, 39.9 MW Wind). This increased to 2978 MW in 2001 (as on 31st March 2001) and accounted for almost 3% of India's installed power capacity (MNES, 2001; Annual Reports MNES, 2000, 2001, 2002). The growth rate of installed renewable power capacity during the period 1993–2001 was 39% per year. During the period January 2000–April 2001 the installed capacity increased from 1600 MW to 2978 MW (an annual growth rate of 49%).

Fig. 1 shows the installed capacity of different renewable energy technologies (Annual Report MNES, 2002). The major contributors are small hydro (<25 MW) which accounts for 1341 MW (45%) and wind which accounts for 1267 MW (42%). The installed capacity in Biomass based power generation is 308 MW (10.3%), with most of it coming from bagasse based cogeneration. Most of the installed capacity available from renewables is accounted for by grid connected systems (wind, small hydro and biomass cogeneration). This accounts for about 3% of India's installed capacity contribute to about 1–2% of the total generation (due to low capacity factors on renewables). The growth rate has been significant (above 30% per year). This has been facilitated by an enabling policy environment and a supportive government.

Despite the emphasis on extending the centralized grid to the rural areas, 78 million rural households (Ministry of Power, 2003b) or 56.5% of rural households are still unelectrified. The recently passed Electricity Act (2003) has made it a statutory obligation to supply electricity to all areas including villages and hamlets. The act suggests a two pronged approach encompassing grid extension and through standalone systems. The act provides for enabling mechanisms for service providers in rural areas and exempts them from licensing obligations. MNES has been given the responsibility of electrification of 18,000 remote villages through renewables. The ministry has set up an ambitious target of meeting 10% of the power requirements of India from renewables by 2012 . In most cases, the areas to be electrified do not have sufficient paying capacity. Most systems are subsidized by the Government or the utility. The power sector has significant losses and needs to ensure that the DG systems selected are likely to be cost-effective. This paper examines the cost effectiveness of the different DG options selected.

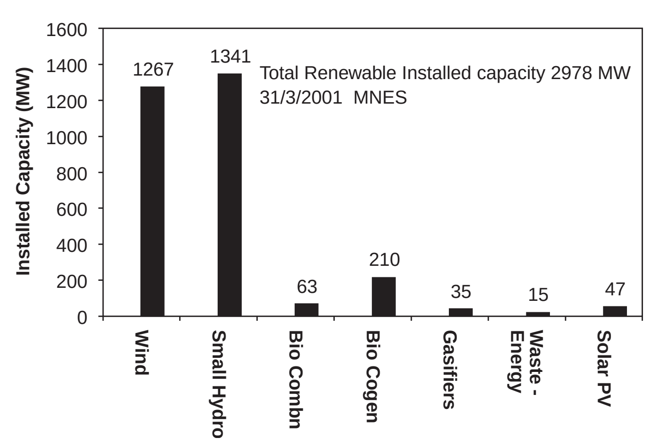

Fig. 1. Installed capacity of renewables in India.