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Sources of Available Renewable Energy and Peak Load Demand in India: A Review

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Abstract: India has a vast supply of renewable energy resources, and it has one of the largest programs in the world for deploying renewable energy products and systems. This paper assesses different renewable energy sources, promotion policies adopted by government, and various sectors which influence the energy usage pattern in India. In developing country such as India, demand for power is increasing day by day; especially peak load demand management is becoming crucial. 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. 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. The renewable resources are 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. We look at the current status of renewable markets in India, the energy needs of the country, forecasts of consumption and production, and we assess whether India can power its growth and its society with renewable resources. This report gives an overview of the renewable energies market in India.

Keywords: Renewable Energy sources, demand, optimization and Energy Consumption.

INTRODUCTION

Energy is the basic and prime requirement for the human beings. It is one of the major factors on which the economic, social and industrial growth of any country and civilization depends. India is one of the biggest consumers of energy. India is the second largest population country after china. India has a vast supply of renewable energy resources, and it has one of the largest programs in the world for deploying renewable energy products and systems. India is the only country in the world to established ministry for renewable energy development, the Ministry of Non-Conventional Energy Sources (MNES). Recently, MNES was renamed the Ministry of New and Renewable Energy. The electricity sector in India had an installed capacity of 211.766 GW as of January 2013, and it is the world's fifth largest country.

Captive power plants generate an additional 31.5 GW. Non Renewable Power Plants constitute 88.55% of the installed capacity and 11.45% of Renewable Capacity. Over one third of India's rural population lacked electricity, as did 6% of the urban population. Of those who did have access to electricity in India, the supply was intermittent and unreliable. A well-known characteristic of the current electricity market is the low elasticity of its short run prices. This is mainly due to the fact that end consumers hardly react against peaks of demand, in spite of the fact that their consumption habits are largely causing imbalance. Renewable generation from wind and solar has increased substantially during past few years and forms a significance proportion of the total generation in the grid. This renewable generation is concentrated in a few states, to the extent that it cannot be called marginal generation and serious thought needs to be given to balance the variability of such generation. There is an ambitious programme for increase of such Renewable Generation and therefore, it is imperative to work out a way forward for facilitating large scale integration of such variable Renewable Energy Sources (RES), keeping in view the security of the grid.

Moreover, as we move towards a tighter frequency band, it becomes even more challenging to balance this variable RES. A critical challenge for the developing world is to establish an effective energy infrastructure which can facilitate growth and the transformation of people’s living prospects. Renewable energy sources are only part of the solution. Cost, security, corruption and timescale for development are all major risks and concerns to think about. India is blessed with an abundance of non-depleting and environment friendly renewable energy resources such as solar, wind, biomass, hydro, geothermal and cogeneration.

Total Renewable Energy Installed Capacity (31 Dec 2014)[4]

Source	Total Installed Capacity (MW)
Wind Power	22,465.03
Solar Power (SPV)	3,062.68
Small Hydro Power	3,990.83
Biomass Power	1,365.20
Bagasse Cogeneration	2,800.35
Waste to Power	107.58
Total	**33,791.74**

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The main objective of this Task is to study how to achieve a better integration of flexible demand (Demand Response, Demand Side Management) with Distributed Generation, energy storages and Smart Grids. This would lead to an increase of the value of Demand Response, Demand Side Management and Distributed Generation and a decrease of problems caused by intermittent distributed generation (mainly based on renewable energy sources) in the physical electricity systems and at the electricity market.
In the coming years, India will face challenges to its economy, environment and energy security. To overcome these challenges India needs to shift to non-polluting sources of energy. India has tremendous energy needs and it is becoming increasingly difficult to meet those needs through traditional means of power generation.

THE STATUS OF RENEWABLE ENERGY IN INDIA

The most important application for new alternative energy resources, such as wind, solar, micro-hydel, biomass and waste, is in the area of electric power generation. Wind energy, solar thermal as well as solar photovoltaic electric energy (that which comes from solar radiation) have substantial potential in India. Wind power can be generated from the energy potential of on-shore wind flow on a cost-competitive basis, but only at a low-load factor of about 20%. Solar thermal energy, on the other hand, is an economically feasible option mainly for water heating.

The solar photovoltaic power is still a high-cost option, with cost per unit being in the range of Rs. 15 to 20/kwh.

However, the development of solar thermal power involving the use of high temperature collectors with mirrors and lenses, and steam turbine is underway and could add substantial potential power generation in the future.

[1]

Like in other developing countries, there is a wide gap between demand and supply in India.
There is also considerable environmental and resource degradation because of a higher dependence on fossil fuels. This dependence on fossil fuels, which are imported, exacerbates its foreign exchange debt burden.

These factors, along with the country's large endowment of renewable resources, suggest that the development of RE (renewable energy) will go a long way in meeting the challenge of providing clean power in India.

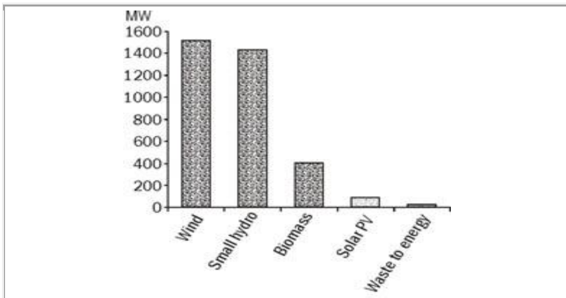

Figure 1a Installed capacity in India

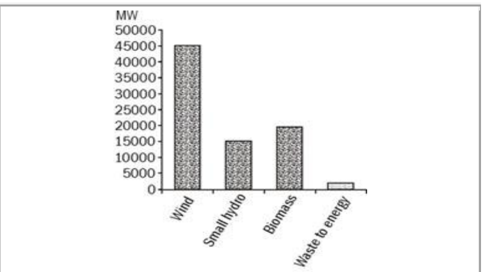

Figure 1b Potential in India

The MNES (Ministry of Non-Conventional Energy Sources), Government of India, has undertaken measures to facilitate the growth of both grid and off-grid RE power through specific programmes. Major programmes in India for power generation include wind, biomass (cogeneration and gasifiers), small hydro, solar, and energy from wastes. The contribution of renewables to the total installed capacity of electricity generation has been rising. The contribution of RE sources is shown in Figure 1a. The total potential of renewables for power generation is estimated to be 82000 MW with the major contribution coming from wind energy (Figure 1b). Thus the contribution of renewables to the overall power scenario is expected to increase substantially. The status of different renewable technologies and related issues are discussed below.

a) HYDRO ENERGY

The hydroelectric power refers to the energy produced from water (rainfall flowing into rivers, etc). Consequently, rainfall can be a good indicator to investors looking for a location to implement or build a new hydroelectric power plant in India. The dominant annual rainfall is located on the north/eastern part of India: Arunachal Pradesh, Assam, Nagaland, Manipur and Mizoram, and also on the west coast between Mumbai (Bombay) and Mahe.Primary hydroelectric power plants situated at Bihar, Punjab, Uttaranchal, Karnataka, Uttar Pradesh, Sikkim, Jammu & Kashmir, Gujarat, and Andhra Pradesh. If we consider the annual rainfall of Bangalore (central south), we see that most of the rainfall occurs from May to November. Consequently, we can predict that hydro energy could be harnessed during the rainy season. Good water management and storage allows for continuous electrical generation throughout the year. In India, small hydro is the most utilized renewable energy source for energy production.

Some key figures concerning small hydro in India:

1. Less than 25 MW is in the “small hydro” designation
2. There is a potential of 15,000 MW
3. Installed is 1,520 MW to date
4. 096 potential sites have been identified
5. Technology is mature and reliable
6. Two types of technology are used:
7. High-head systems
8. Low-head systems

b) SOLAR ENERGY

Because of its location between the Tropic of Cancer and the Equator, India has an average annual temperature that ranges from 25°C – 27.5 °C. This means that India has huge solar potential. The sunniest parts are situated in the south/east coast, from Calcutta to Madras. Solar energy has several applications: photovoltaic (PV) cells are placed on the roof top of houses or commercial buildings, and collectors such as mirrors or parabolic dishes that can move and track the sun throughout the day are also used. This mechanism is being used for concentrated lighting in buildings. Photovoltaic (PV) cells have a low efficiency factor, yet power generation systems using photovoltaic materials have the advantage of having no moving parts. PV cells find applications in individual home rooftop systems, community street lights, community water pumping, and areas where the terrain makes it difficult to access the power grid. The efficiency of solar photovoltaic cells with single crystal silicon is about 13 % - 17%. High efficiency cells with concentrators are being manufactured which can operate with low sunlight. India has one of the largest SPV (solar photovoltaic) markets, driven by government programmes of subsidies, tax, and financial incentives that began in the 1980s. Loans and financing schemes have supported private sector sales, while subsidies have been provided for the installation of solar home systems. There are many applications have been established which includes solar lanterns, home lighting systems, street lighting systems, water pumping systems etc.

Grid-interactive PV systems for tail-end applications (voltage boosting) in remote sections of the grid, and peak load shaving are also focus areas. An integrated solar combined cycle power project is planned at Mathania in the state of Rajasthan. This plant of total capacity 140 MW has a solar thermal component of 35 MW, based on the parabolic trough collector technology.

c) WIND ENERGY

India is the fifth largest producer of wind power in the world after Germany, North America, Denmark, and Britain, with a wind power generation achievement of 1507 MW, of which 1444 MW has come through commercial projects (MNES 2002). The wind speeds in India are in the low wind regime with average wind speeds between 17 and 24 km/h. However, with a wind power potential of about 45000 MW, there is significant room for advancement. Wind has the highest potential in the country and is expected to contribute 60% of the above-mentioned target of power generation from renewables. The ten machines near Okha in the province of Gujarat were some of the first wind turbines installed in India. These 15-meter Vestas wind turbines overlook the Arabian Sea. The C-WET (Centre of Wind Energy Technology) in Chennai is a specialized institution in this field. Research and development, standardization, testing and certification, along with resource assessment, are undertaken by C-WET. India has established a good manufacturing base with about 12 manufacturers of wind turbines and allied equipment. A new concept of mega wind farms owned by the private sector is being tested in India to increase the penetration of wind power, and invite greater participation from the private sector. The advantage of such an approach will be reduced capital cost. Mega wind farms can also negotiate a better power purchase agreement with the utilities.

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Advantages of Wind Power

1. It is one of the most environment friendly, clean and safe energy resources.
2. It has the lowest gestation period as compared to conventional energy.
3. Equipment erection and commissioning involve only a few months.
4. There is no fuel consumption, hence low operating costs.
5. Maintenance costs are low.
6. The capital cost is comparable with conventional power plants. For a wind farm, the capital cost ranges between 4.5 crores to 5.5 crores, depending on the site and the wind electric generator (WEG) selected for installation.

Limitation of a Wind farm

1. Wind machines must be located where strong, dependable winds are available most of the time.
2. Because winds do not blow strongly enough to produce power all the time. Energy from wind machines is considered "intermittent," that is, it comes and goes. Therefore, electricity from wind farms must have a back-up supply from another source.
3. As wind power is "intermittent," utility companies can use it for only part of their total energy needs.
4. Wind towers and turbine blades are subject to damage from high winds and lighting. Rotating parts, which are located high off the ground can be difficult and expensive to repair.
5. Electricity produced by wind power sometimes fluctuates in voltage and power factor, which can cause difficulties in linking its power to a utility system.
6. The noise made by rotating wind machine blades can be annoying to nearby neighbors.
7. Some environmental groups have complained about aesthetics and avian mortality from wind machines.

d) BIOMASS ENERGY

India has a huge biomass potential owing to the large quantities of agricultural, forestry, and agro-industrial residue produced. The present capacity of biomass-based power generation totals 358 MW (including cogeneration and biomass gasifiers) (MNES 2002). India has instituted a National Programme on Biomass Power/Cogeneration to establish the techno-commercial potential of power generation from biomass materials. Biomass includes solid biomass (organic, non-fossil material of biological origins), biogas (principally methane and carbon dioxide produced by anaerobic digestion of biomass and combusted to produce heat and/or power), liquid biofuels (bio-based liquid fuel from biomass transformation, mainly used in transportation applications), and municipal waste (wastes produced by the residential, commercial and public services sectors and incinerated in specific installations to produce heat and/or power). The most successful forms of biomass are sugar cane bagasse in agriculture, pulp and paper residues in forestry and manure in livestock residues.

Biomass may be used in a number of ways to produce energy. The most common methods are Combustion, Gasification, Fermentation and Anaerobic digestion.

India is very rich in biomass. It has a potential of 19,500 MW (3,500 MW from bagasse based cogeneration and 16,000 MW from surplus biomass). Currently, India has 537 MW commissioned and 536 MW under construction. The facts reinforce the idea of a commitment by India to develop these resources of power production.
Following is a list of some States with most potential for biomass production:
Andhra Pradesh (200 MW),Bihar (200 MW), Gujarat (200 MW), Karnataka (300 MW), Maharashtra (1,000 MW), Punjab (150 MW), Tamil Nadu (350 MW), Uttar Pradesh (1,000 MW) etc.

This report is meant only as an overview in hopes that it will encourage even more rapid and extensive development of the renewable energy resources on the Indian subcontinent.

e)WASTE-TO-ENERGY

The National Programme on Energy Recovery from Urban and Industrial Wastes in India aims at promoting efficient and proven technologies for the treatment, processing, and disposal of wastes, not only as a means of improving the waste management practices in the country, but also for augmenting power generation. A wide range of waste material can be used to recoverEvery year, about 55 million tonnes of municipal solid waste (MSW) and 38 billion litres of sewage are generated in the urban areas of India. In addition, large quantities of solid and liquid wastes are generated by industries. Waste generation in India is expected to increase rapidly in the future. As more people migrate to urban areas and as incomes increase, consumption levels are likely to rise, as are rates of waste generation. It is estimated that the amount of waste generated in India will increase at a per capita rate of approximately 1-1.33% annually. This has significant impacts on the amount of land that is and will be needed for disposal, economic costs of collecting and transporting waste, and the environmental consequences of increased MSW generation levels.
Types of Waste can be broadly classified into (a)Urban Waste (b)Industrial waste (c)Biomass Waste and (d)Biomedical waste.

POLICY AND FINANCING ISSUES

Fiscal incentives are being offered to increase the viability of RE projects, the main incentive is 100% accelerated depreciation. Other incentives include a tax holiday, lower customs duty, sales tax, and excise tax exemption for RE projects.

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The Indian Renewable Energy Development Agency is the main financing institution for renewable energy projects. It offers financing the renewable projects with lower interest rates, which vary with the technology, depending on it the commercial viability. Though interest rates are falling in India, they are not in the renewables sector for various reasons but mainly due to perceived high risk. The interest rates vary from 11% (for biomass cogeneration) to 14.5% (for wind).

PEAK LOAD DEMAND MANAGEMENT

Peak load management is defined as an "economic reduction of electric energy demand during a utility's peak generation period. A peak load management strategy is required to maintain the power supply and consumption. A company's electric bill consist of two major components: demand charge and energy consumption charge. Peak load management strategies that lower a facility's demand during times when the peak demand is measured can result in significant facility cost savings, especially for commercial, industrial and institutional clients.In a model of distributed generation you place small scale diesel generators, or solar panels, or wind mills, or water wheels (all renewable and sustainable energy sources, except diesel) on a very localized basis and generate the power exactly in the place where it is needed. Reduce peak load consumption. I know this is easier said than done, especially when there is already comparitively very little consumption in developing countries. But distributing the loads, simply by altering work timings in different regions or for different businesses in the same region will distribute peak load more evenly. Develop home grown renewable energy solutions. It is scary even in India that we are largely dependent on someone else’s technology. One of the ways in which some of the money spent on purchasing technology from overseas can be ploughed back, is to ask for a 35% buyback from India (or developing country) i.e. the seller of the technology has to buy at least 35% of their earnings from sales in India as goods or services.

CONCLUSION

The very high potential of renewable, the MNES target of realizing 10% of new capacity additions through renewable, some renewable technologies becoming financially viable (e.g. biomass cogeneration), an established institutional framework with industrial base, increased awareness of environmental issues and energy security issues are the factors that will help the penetration of renewable power. However, this depends on how the challenge of adapting to the changing face of the power sector in India is handled. However, among the policies, 8% growth along with real energy price rise through fiscal taxation at the rate of 3% per year gives us the least estimate of primary energy intensity of GDP (that is of 3.74 gm/ rupee) while the low growth (6% per year) strategy with no price rise will give us the highest primary energy intensity of GDP (that is 5.92 gm/ rupee) by 2031-2032. The comparative projections further show that decelerating the growth rate of an economy is an inefficient strategy for conserving the bio-capacity or reducing the carbon footprint as compared with price (tax) induced energy conservation or to the enforcement of power generation by new renewable.

Demand-side management is challenging, since it often requires active, and often burdensome, consumer involvement. Forcing people to think about how they use power is simply not effective in encouraging broader adoption of demand-side management. Thus, we focus on quantifying the benefits of scheduling the multi-source environment according to the peak demand requirement. The approach will flatten the house-hold demand over each day and reduces the on generating station during peak demand hours. The proposed method Control Methodology for Peak Demand through Multi-Source Environment at Demand Side shows an alternate approach for load shedding. With the increase in incentives from the government for renewable based homer power automation, the solution shows great promise in current market.

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