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CO_2 emission reduction potential assessment using renewable energy in India

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ABSTRACT

The Indian power sector is experiencing a lot of pressure to supply sustainable electricity at affordable cost due to heavy demand especially in the summer peak season. Most of India's electricity is produced by fossil fueled power plants, which are the source of CO_2 emissions. In this case, renewable energy sources play a vital role in securing sustainable energy without environmental emissions. This paper examines the effects of renewable energy use in electricity supply systems and estimates the CO_2 emissions by developing various scenarios under the least cost approach. The LEAP energy model is used to develop these scenarios. The results show that in a ARET (accelerated renewable energy technology) scenario, 23% of electricity is generated by renewables only, and 74% of CO_2 reduction is possible by 2050. If the maximum energy savings potential is combined with the ARET scenario, the renewables share in electricity supply rises to 36% as compared to the reference scenario, while the CO_2 emission reduction in this case remains at 74%.

1. Introduction

India's substantial and sustained economic growth is putting enormous pressure on the country's energy resources. The threat of severe energy demand and supply imbalances is pervasive, requiring serious efforts by the Government of India to augment energy supplies. India imports about 80% of its oil [1]. There is a risk that this capacity cannot be increased much further, which will create serious problems for India's future energy supply security. There is also a significant risk of lesser thermal capacity being installed on account of a lack of indigenous coal in the coming years because of both production and logistic constraints, and an increased dependence on imported coal. Significant accretion of gas reserves and production in recent years is likely to mitigate power needs only to a limited extent. The difficulties of large hydro are increasing because of the displacement of people living in reservoir areas, and nuclear power is also beset with problems due to international agreements for nuclear fuel. The country thus faces potentially severe energy supply constraints. Economic growth, increasing prosperity and urbanization, the rise in per capita consumption, and the spread of energy access are the factors most likely to substantially increase the total demand for electricity, threatening the security of energy supply. Already today, official peak deficits in the electricity sector are in the order of 12.7%, a value which could increase even more over the long term.

Renewable energy can make a substantial contribution in each of the above mentioned areas. It is in this context that the role of renewable energy needs to be seen. It is no longer “alternate energy”, but is increasingly becoming a key part of the solution to the nation's energy needs.

In 2002, the installed capacity for renewable energy-based power generation was 3475 MW, which amounted to 2% of the total installed power generation capacity in India [2]. By the end of 2010, it had reached 18,655 MW, which is about 11% of the total installed capacity of 168,945 MW, and which corresponds to a percentage contribution of about 4.13% to the electricity mix [1]. Fig. 1 provides the fuel-wise break-up of the installed power capacity in the country.

During the first three years of the 11th plan period and the current (base) year up to 2010, renewable power capacity addition was 8395 MW, while the conventional power capacity addition amounted to 25,598 MW, which corresponds to over 24% of the total capacity addition [1]. It should also be noted that 23% of the total capacity installed today is large hydro, which is renewable but

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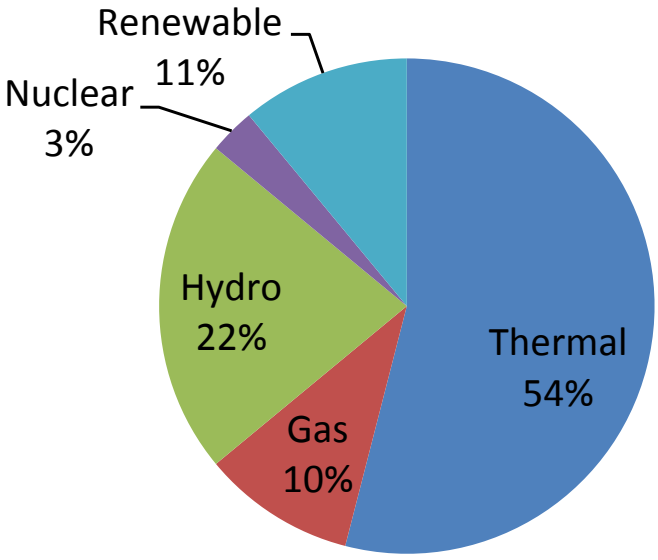

Fig. 1. Installed capacity, by fuel type [1].

counted differently from other renewable resources because of well-developed technology and production at large scale in India since long time. The major contribution to the existing capacity has come from wind power, which amounts to about 70% of the total renewable capacity.

This paper investigates the future sustainable electricity supply by using the renewable energy resources in India. Various scenarios have been developed to estimate the most favorable energy future for the Indian economy by considering the demand of these sectors. The newly added LEAP optimization m has been used to find the least-cost solution of the energy mix and the corresponding CO_2 emissions. Mainly renewable energy and energy-saving potentials in various sectors of the economy have been considered in order to access the requirement of new power plants to be built and the potential of carbon emission abatement.

2. Renewable energy overview

India is endowed with an enormous potential of renewable energy resources to meet its energy needs. However, in spite of this large potential, the high cost and the need for storage are some of the major barriers for the large-scale diffusion of renewable energy technologies [3]. It is recognized that there is a downward trend in the cost of renewables, and that the reliability of renewable energy technologies is gradually improving. In the Indian context, power generation from wind and solar have become commercial both in the large-scale (grid-connected) applications and small-scale (decentralized) applications, respectively. However, decentralized energy applications require significant further cost reductions in order to be adopted on a large scale, or alternatively, will require subsidies from the Government. The long-term benefit of renewable energy technologies and the associated social and environmental gains in many cases justify the granting of subsidies for renewables. In this context, the potential of different renewable energy technologies that can be effectively harnessed would largely depend on future technological developments and breakthroughs, leading to further cost reduction. Table 1 shows the total installed capacity vs. renewable installed capacity in India. The trend shows an increasing percentage of renewables over the years.

Fig. 2 shows that the major contribution of the renewables comes from wind power, while small hydro only accounts for 12% of the total installed capacity from renewables. This is because the estimated small-scale hydro potential in India is only 15 GW. Solar and biomass have an enormous potential that still needs to be harnessed.

Table 1
Growth of installed capacity and percentage shares of renewables in the total installed generating capacity [4,5].

Year	Total installed capacity (GW)	Total installed renewables (GW)	% of total capacity
1990	63.6	0.02	0.03
1992	69.0	0.03	0.05
1997	85.7	0.90	1.05
2002	105.0	1.65	1.58
2007	132.3	7.76	5.86
2008	143.0	11.13	7.78
2009	147.9	13.24	8.95
2010	159.4	15.52	9.74
2011	173.6	18.46	10.63
2012	199.9	24.50	12.26
2013	223.2	27.54	12.34
2014	245.3	31.69	12.93
2015	271.2	35.77	13.20

The different renewable energy resources and their available to the Indian energy market are explained next.

2.1. Large hydro power plants

Hydro power is the second most widely accepted technology for power generation in India, after coal power plants. The much quoted estimated potential of slightly more than 84 GW in capacity is for sites offering a minimum of 60% PLF (plant load factor) due to the availability of water resources. This potential is considered as the economic potential for hydro power in India. This value increases to 150 GW if some additional sites, offering more than 40% PLF, are also considered [7]. As the reference value, however, the established figure of economic potential (rounded-off to 150 GW) is used in the LEAP analysis only as a lower bound for this technology.

Besides the availability of water, environmental impacts of hydro power plants also need to be examined thoroughly while considering construction of large hydropower plants. Some of these considerations are the mass resettlement of families, the threat of

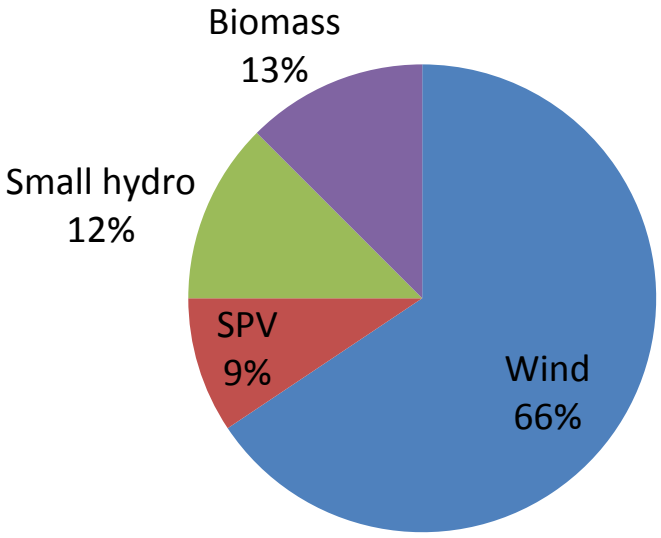

Fig. 2. Percentage shares of individual renewables with regard to the total installed capacity from renewables in 2012 [6].