

FORECAST ANALYSIS OF THE POTENTIAL AND AVAILABILITY OF RENEWABLE ENERGY IN INDIA: A REVIEW

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Abstract- India is blessed with enormous renewable energy resources and is known to have one of the largest programs in the world for the development of renewable energies, thereby witnessing over 20 percent growth in the last five years. The renewable energy sources like wind energy, solar power, biomass energy, small hydro power may be used efficiently for the development of India by overcoming the shortage. Renewable energy sources have potential to provide solutions to the problems faced by different countries for their development. India is the only country in the world to have an exclusive ministry for the growth and enhancement of renewable energy resources. India is working hard to increase the productivity of renewable energies by moving on from megawatts to gigawatts. In this study, the availability, current status, major achievements and future potential of renewable energy in India is discussed. Moreover, this paper also discusses about the steps taken by the government to increase the growth of renewable energy in the upcoming years in order to meet the nation's energy need.

Keywords- Renewable energy, Solar power, Wind energy, Biomass energy, Small hydro power.

I. INTRODUCTION

Renewable energy is generated from natural resources like wind, rain, tides and sun which have the capability of being generated again and again as per requirement. Indeed, it is the only country in the world to have an exclusive ministry which is dedicated for the development of renewable energy, and is known as the Ministry of Non-Conventional Energy Sources (MNES) [3]. Based on various promotional efforts made by MNES, considerable progress is being made in power generation from renewable energy sources. In October, MNES got its new name as the Ministry of New and Renewable Energy. Specifically, 3,700 MW is being currently powered by renewable energy resources which corresponds to 3.5 percent of total installed capacity). This is projected to be 10,000 MW from renewable energy by 2012. India has a vast supply of renewable energy resources for the deployment of energy products and systems. Commencement of world's largest and most ambitious programs on renewable energy was initiated soon after the formation of this ministry. India has developed extensive data basis for renewable energy resources in the country. India has the fifth largest generation portfolio all over the world with a power generation capacity of 27.722 GW as on March, 2015. Many renewable energy projects developed on large scale are suited to rural and remote areas. Based on REN21's 2016 report around 19.2 percent renewables were contributed to human's global energy consumptions and 23.7 percent for the generation of electricity in 2014. [3] and 2015 respectively.

The core drivers for the deployment and development of new renewable energy are: -

(i) Energy security: At present India's power generation capacity is 60 percent based on coal. The net coal import has risen from negligible in 1990 to 23 percent in 2014 [3].

(ii) Electricity shortages: Despite of increased installed capacity by more than 110 times in 62 years, India has still not met its peak demand for electricity as well as energy. The peak power deflected in the financial year 2001-2002 by 12.2 percent which is approximately 9,252 MW, but at the end of 2013-2014, the peak power deflects decreased to the order of 4.5 percent which is approximately 6,103 MW.[13] Similarly, for peak energy requirement there was shortage in terms of the energy available which was 7.5 percent at the end of the year 2001-2002 which was approximately 39,187 million units, whereas at the end of year 2011-2012 it reduced to 4.2 percent, which has approximately increased to 45,428 million units [12].

(iii) Energy access: India has a great challenge to ensure the availability of renewable, reliable and modern forms of energy to all the citizens. Around 85 percent of rural households depend on solid fuel for their cooking needs and only 55 percent of rural households have access to electricity. However, most rural households face issues with quality of energy supplied. The lack of supply of light leads to eager scale use of kerosene. [3]

(iv) Climate change: India has taken a deliberate commitment of reducing the emission intensity of its GDP by 20-25 percent from 2005-2020. Parties were invited to communicate Intended Nationally Determined Contributions (INDCs) towards the climate change mitigation [7].

II. RENEWABLE POWER INSTALLED CAPACITY

The Renewable power installed capacity of various sources is depicted in Fig.1. As of March 2016, solar, wind, biomass and hydropower has touched the figure of 26,769.05 MW of wind power, 6,762.85 MW of solar power, 4,831.33 MW of biomass power, 4,273.90 MW of small hydro power, which is totally 42,752.21 MW for the installed capacity of renewable energy in India. This is great increased as compared to the data of December 2014 whereby the total capacity was 33,791 MW with 22,465 MW of wind power, 3,062 MW of solar power, 4,272 MW of biomass power and 3,990 MW of small hydro power. [9]

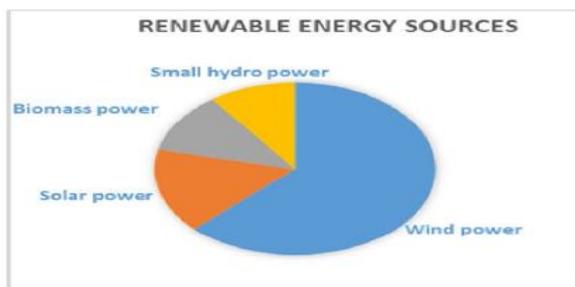


Fig.1. Availability of renewable energy sources in India

III. SOURCES OF AVAILABLE RENEWABLE ENERGY IN INDIA

3.1 Wind Energy

India has the fifth largest installed wind energy in the world and it is the largest renewable energy source available in India. Fig.2 depicts the status of wind energy being installed in various countries [3].

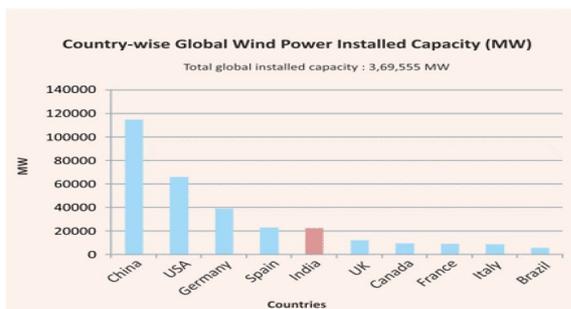


Fig.2. Country-wise Global Wind Power installed capacity

From the graph it can be seen that as of 31st March 2016, the total installed capacity in wind power in India was 26,769.05 MW which was mainly spread across the south, west and north region.

Wind is a free resource in India, but it is much intermittent than solar energy. Wind energy is used for many purposes such as sailing boats, pumping water, grinding mills and generation of electricity. However the initial cost for wind turbine is greater than that of the conventional fossil fuels generators. India is surpassed only by Germany as one of the

world's fastest growing markets for wind energy [4]. By the mid 1990s, the subcontinent was installing more wind generating capacity than North America, Denmark, Britain, and the Netherlands. [3]

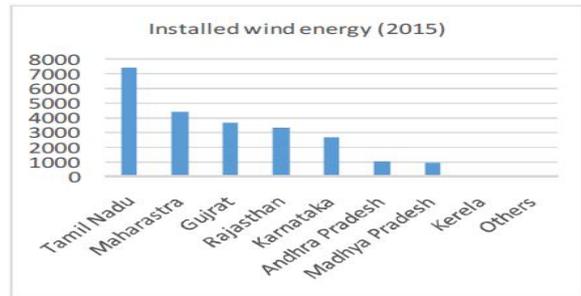


Fig.3. Country-wise Global Wind Power installed capacity

The potential and installed capacity of energy in different states is shown in Fig.3. Accordingly, Tamil Nadu wind power capacity is almost 35% of India's total installed wind power capacity. In 2015 also Tamil Nadu had the largest availability of wind energy in India, with Maharashtra being the second highest. The largest Wind farm is Muppandal Windfarm which is in Kanyakumari, Tamil Nadu. [18]

Wind power is a clean fuel which doesn't pollute the air as compared to power plants that rely on the combustion of fossil fuels, such as coal and natural gas. Yearly the wind energy production has increased thrice since 2011, growing rapidly and has reached around 4% worldwide electricity usage [4&5].

3.2 Solar Energy

The earth receives an incredible supply of solar energy providing sufficient energy in a single minute which corresponds to the world's energy needs for one whole year. In one day it provides additional energy than our current population would consume in 27 years [2]. Solar energy is used in many ways like water heating, ventilation, cooling, cooking, solar street lights. During the last few years' renewable energy sector in India has witnessed tremendous changes in the framework of the policy with enhanced and ambitious plans to increase the contribution of solar energy. In 2011, India installed solar capacity has been elevated from 20 MW to 6.728 GW as on March 2016. Year wise variation of solar power installed capacity is shown in Fig.4.

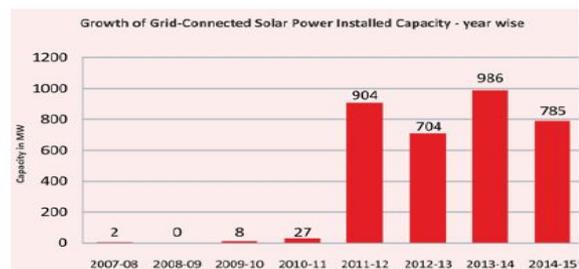


Fig.4. Year-wise growth of grid connected solar power installed capacity

It is observed that there is a continuous increase in solar power installed capacity, but there was a reduction in the year 2012-2013 as compared to 2011-2012 and again there was increase in 2013-2014 [1&3].



Fig.5. Solar power installed capacity throughout India

State wise solar power installed capacity is depicted in Fig. 5. Gujarat has the largest installed solar power followed by Rajasthan which has second highest as it receives ample all the time. Fig.6 shows the installation solar roof tops self consumption upto 2014-15. It shows greater increase in the year 2014-2015 as compared with previous years. Nowadays more space is accumulated by air conditioner units, water tanks or cafeterias. Residential rooftops are used for drying clothes or partying, so shade should be avoided. [3&17]

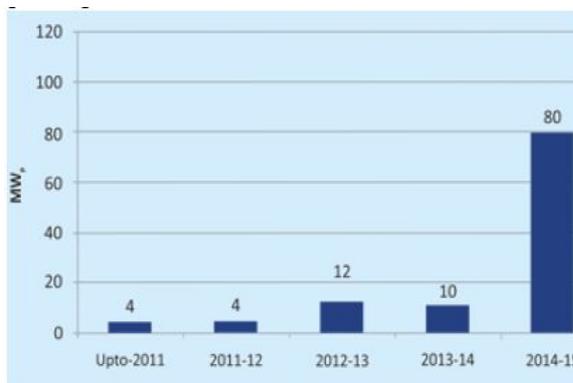


Fig.6. The installed solar roof tops for self consumptions

Solar rooftops can be put up on the factories which have large flat rooftops which are free to use and there is no issue of shadows falling on it. It is a good

way to encourage residential solar rooftops to give income tax breaks. India has abundant supply for solar plants which should be used efficiently. Government should initiate quick measures to increase solar power as it is a free source which is sustainable and is totally inexhaustible and does not emit any greenhouse gas [3, 5 & 14].

Fig.7 and Fig.8 shows the solar water pumps for agriculture as well as solar home lighting systems respectively. Solar power has a greater use in solar

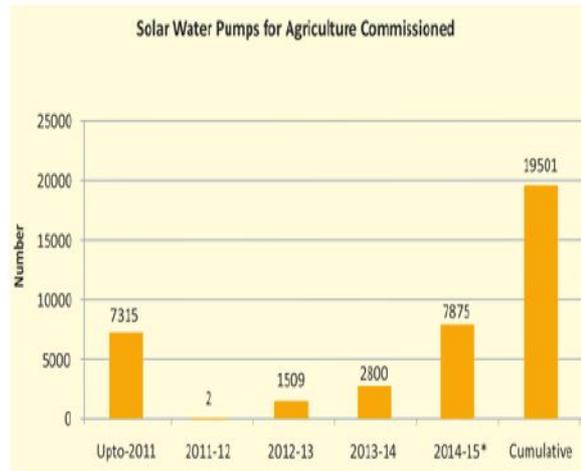


Fig.7. Number of solar water pumps for agriculture being commissioned by year-wise

pumps too.. There is a drastic increase in solar water pumps with change in time, the highest agriculture commissioned for solar water pumps was in 2014-2015 [8&3].

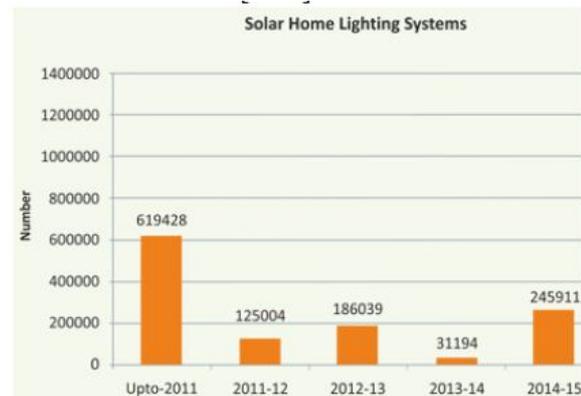


Fig.8. Year-wise details of number of solar water home lighting system being commissioned

Solar home lighting system has reduced in comparison of past years. It was the least in 2014-2015 and highest upto 2011 which shows that people are adopting new technologies for electricity and lighting [3&6].

3.3 Biomass energy

Fig.9 and Fig.10 shows the year-wise biogas plants installed under National Programme and state-wise bio-power installed capacity respectively. India is

the seventh largest country in the world for biomass production. India produces almost 450-500 million tonnes of biomass per year, which provides 32% of all the primary energy used in the country. The installed capacity for biomass energy is 4.831 GW as opposed to estimated potential of 22.5 GW. Biomass utilizes the organic matter present which can be used to produce heat, electricity, in the combustion of fossil fuels and it can also replace petroleum as source of fuel for transportation. Government has planned to meet 20% of the country's diesel requirements in biodiesel by 2020. Biomass is a pollution free resource which is naturally obtained in greater quantity [3&11]

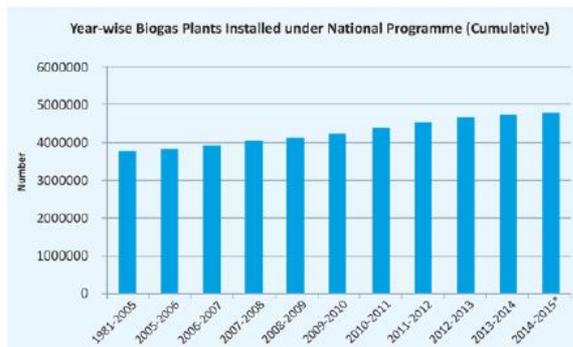


Fig.9. Year-wise Biogas plants installed under National Programme

From the bar chart it continuous increase in the biogas plants, reflects enhanced use of biogas. In 2014-2015 biogas was used the most which illustrates India's development for pollution free future [9].

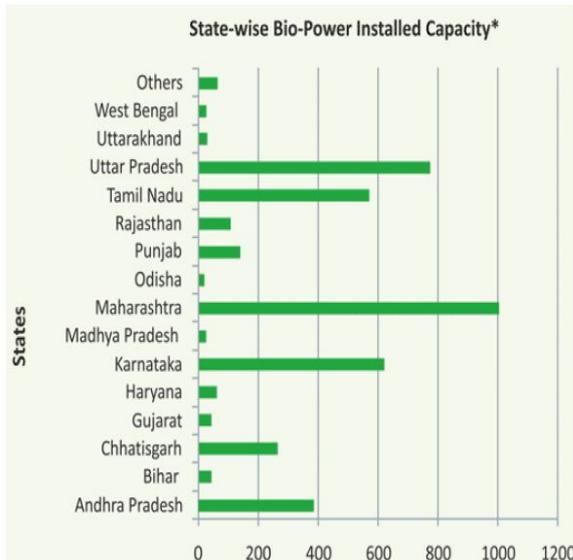


Fig.10. State-wise Bio-power Installed in the various states

In 2014-2015, the research facility for biodiesel, biomass, biomass cook stoves has been developed. Sardar Swaran Singh National Institute of Renewable Energy (SSNIRE) at wadala Kalan, District Kapurthala, Punjab is an independent institution of

ministry which focusses on reasearch and development in the field of biomass energy [3&17].

3.4. Small Hydro Power

Fig.11and Fig.12 elucidates state wise small hydro power being installed and year-wise variation of small hydro power installed capacity respectively. India has immense amount of hydro electric potential and scores 5th position in terms of exploitable hydro potential on global scale. Small hydro power can produce 50 MW of power from hydroelectric power installations. Hydroelectric power has a potential of 84,000 MW at 60% load factor which is one of the largest in the world. The present installed capacity as on 31st March 2016 is 42,783 MW which is 14.35% of overall service generated in India. The small hydropower units are 4,274 MW as on 31st March 2016. Funding large scale hydropower plants has served to increase pollution and destroy the surrounding ecosystems. There are about 27 equipment manufacturers of small hydro power Turbine manufacturing almost the entire range and equipments of small hydro power in MNRE. The estimated capacity of which is 400 MW per year.[3] Karnataka has the highest installed hydro power in India which is more than 1100 MW, but building large scale hydro power plants may be polluting and damaging to eosystem.[17]. The major upcoming challenges are pollution.

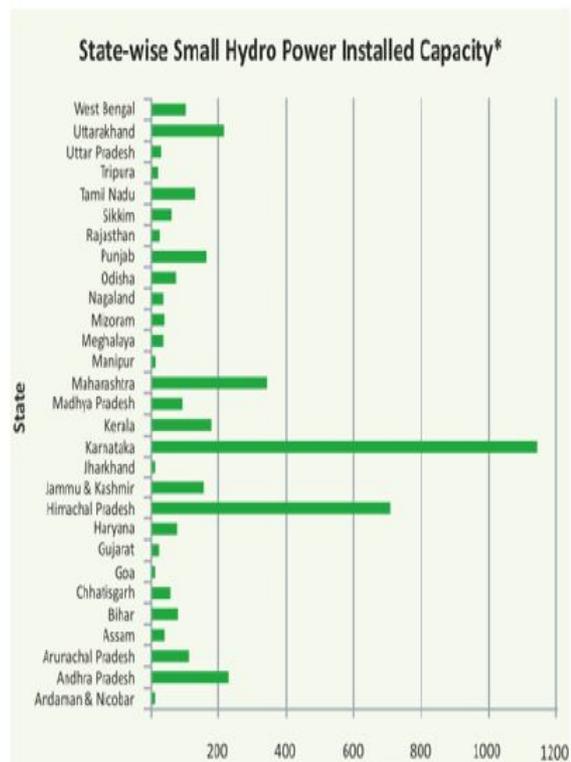


Fig.11. State wise small hydro power Installed capacity in India

green house gases, depletion of ozone layer, methyl mercury contamination and sedimentation. Too much sediment leads to loss of Farmland.

Measures to mitigate these challenges:

- (i) Developed planned infrastructure for the appropriate use of resources.
- (ii) reinforce planning and investigation to diminish construction delays [3&10].

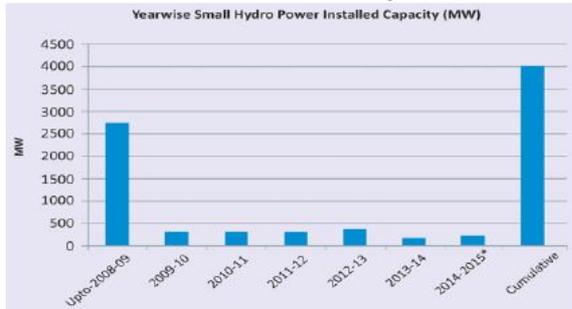


Fig.12. The variation of small hydro power installed capacity by year-wise.

IV. FORECASTS AND PREDICTION FOR UPCOMING DECADES

The Government of India has set up targets which will increase the total renewable capacity to almost 175 GW by the end of 2022. This includes 60 GW of windpower, 100 GW of solar power, 10 GW of biomass power and 5 GW of small hydro power. The Government plays an active part in promoting the implementation of renewable energy resources by offering various incentives such as Generation Based Incentives (GBIs), capital and interest subsidies, concessional finance and fiscal incentives.

4.1. Prediction for upcoming Solar power

Prediction for upcoming solar power installation in India is illustrated in Fig.13. Maximum solar power is to be installed in northern region. India’s annual solar energy is predicted to grow by four times by 2017. Almost 10.86 GW of utility scale solar will be added by 2016-2017. The JNNSM (Jawaharlal Nehru National Solar Mission) aims to generate 1,00,000 MW of solar power by 2022, which creates a positive environment among investors [11].

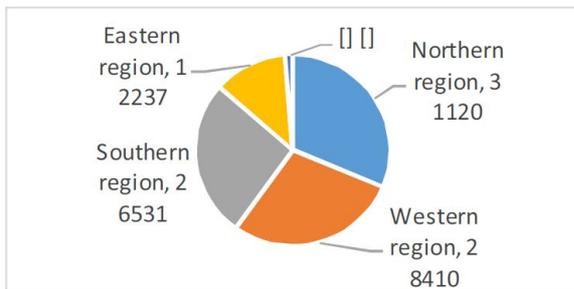


Fig.13. Prediction for upcoming solar power installation

4.2. Prediction for upcoming Wind power

India’s global position in the wind energy may be enhanced since nature has bestowed enormous resources of wind energy. Wind energy with an average of 30% is the fastest growing renewable

energy in the world. Prediction for upcoming wind power installation in India is shown in Fig.14 [11].

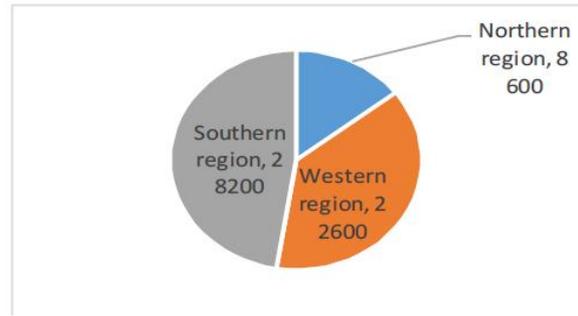


Fig.14. Prediction for upcoming wind power installation

It is to be noticed that the highest wind power is to be installed in southern region.

4.3. Prediction for upcoming Biomass power

Prediction for upcoming wind power installation in India is shown in Fig.15. From the pie chart it may be inferred that huge biomass power may be installed in northern region [15].

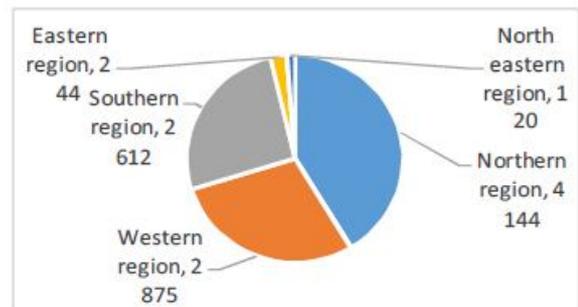


Fig.15. Prediction for upcoming Biomass power installation

3.5. Prediction for upcoming hydro power

Fig.16 depicts the prediction for upcoming hydro power installation in India. From the pie chart it may be elucidated that the small hydro power may be installed is in northern region [9].

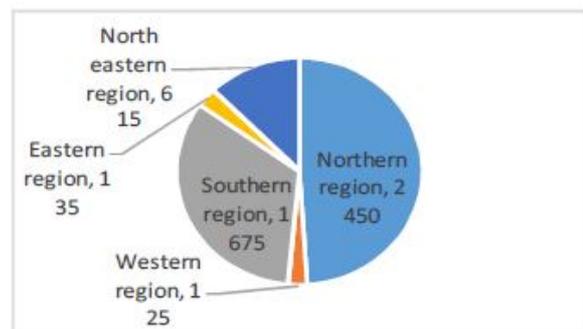


Fig.16. Prediction for upcoming Hydro power installation

CONCLUSION

India is currently experiencing strong economic growth in renewable energies. It supplies one third of hydropower and is blessed with abundant resources

of renewable energy in solar, wind, biomass, small hydro power. Wind and solar energy do not require water to operate which does not pollute any water resources, whereas biomass and small hydro power require water for cooling. In fact, the technical potential of these renewable energies exceeds the present installed generation capacity. India has dedicated one sole ministry for the development of renewable energies which is Ministry of New and Renewable Energy. The acceleration of renewable energy development is to meet the unaddressed needs of millions of rural residents and the growth in the demand of energy. India may accomplish “Grid Parity” in solar energy in 2017 as well as in wind energy in 2022. [19] Addition of more weather variables as an input data vector increases the accuracy of prediction of the forecasting by using time series analysis model NARX, feed forward neural network with tapped delay lines [20]. It is anticipated that in India the renewable energy sources shall escalate from megawatts to gigawatts by the year 2020.

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