

A Review on Renewable Energy in India: Mission 2022

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Abstract—India is a country with more than 1.2 billion people accounting for more than 17% of world's population. In 2008, India's energy use was the fifth highest in the world. Nevertheless, India as a country suffers from significant energy poverty and electricity deficits. A most of the Indian population does not have access to convenient energy services like LPG and electricity. In recent years, India's energy consumption has been increasing at a relatively fast rate due to change in lifestyle with an economy projected to grow at 8-9% per year. This paper shows the recent scenario of the energy and the growing opportunities in establishing a new renewable industry in India. An effort has been made to summarize current scenario, strategies, perspective and promotion of wind energy sources. In addition, major achievements of renewable energy have also been described. An ambitious target of 175 GW installed capacity of renewable energy sources by 2022 has been put forth by the Government of India.

Keywords-Renewable energy; wind; solar; biomass; waste to energy; Small Hydro Power (SHP);

I. INTRODUCTION

Now a days renewable energy sources are need of the time. With growing population and its needs, we are moving towards the world with full of pollution and less amount of conventional energy sources left for the future generations. As we know main problem with the conventional energy sources is that they are exhaustible and causing harm to the environment, although in terms of efficiency and availability conventional sources have the edge over the renewable energy sources. India is lagging behind in terms of renewable energy sources use. In India, the Ministry of New and Renewable Energy Sources is taking efforts for the development in use of renewable energy sources. India is having large potential of renewable energy sources, although all of it is not being consumed for the energy production. Main contributors of this renewable power are wind, solar and biomass and hydropower.

Ministry of New and Renewable Energy Sources has started making plans for the development of renewable energy sector with some big changes. The ministry has mission to grow electricity from renewables to massive value of 175 GW by the year 2022, which is at this time below 43 GW. This increase in renewable electricity includes solar power contributing 100 GW, wind power with 60 GW, also 10 GW and 5 GW from bio power and small hydro power

respectively. Completing these ambitious targets would take India to the leading position in green energy production, leaving back many developed countries around the world. Getting 40% aggregate electric power from the renewable energy sources is Indian government's goal.

II. COMPARISON OF RENEWABLE ENERGY POTENTIAL IN INDIA VS. INSTALLED CAPACITY VS. FUTURE GOALS

When we talk about the potential of the renewable energy, India is the country which has very large potential of producing renewable power, while considering the above discussed grid connected and off grid power also. MNRE has set a target for India to achieve 175 GW power from the renewable energy sources. Table 1 gives the exact scenario of what is the potential in India of producing the renewable power, what is the current installed capacity of each type of renewable energy source and how much we need to develop renewable energy sector to achieve the goal by 2022. It has been observed that since 2009, installed capacity of wind power is increased from 683 MW to 27.44 GW, biomass power from 131 MW to 4.8 GW and waste to energy from 4.7 MW to 115 MW by July 2016, which is big leap from the previous achievements.

TABLE I. COMPARISON OF RENEWABLE ENERGY POTENTIAL VS. INSTALLED CAPACITY VS. TARGET

Source	Estimated Potential (MW)	Installed Capacity (MW)	Target (MW)	Percentage achieved
Wind Power	102772	27441.15	60000	45.73
Small Hydro Power	19749	4304.27	5000	86.08
Solar Power	749000	8062.00	100000	8.062
Waste to Power	2556	115.08	10000	49.75
Biomass power	22538	4860.83		
Total	896615	44783.33	175000	25.59

As of April 2016

III. WIND POWER

Wind power is using the air flow to rotate the wind turbines connected with mechanical generators to produce the electricity. It is an alternative to use of the conventional energy sources. Conventional energy sources produce pollution, greenhouse gasses and are not renewable. Advantages of wind power are that it is renewable, widely distributed, clean, produces no greenhouse gasses and uses very little land. Wind power is the highest contributor to the total renewable power. It is also growing very rapidly with time.

Recently, India has produced 38,822 megawatts (MW) electricity from renewable energy sources with more than 24,000 MW based on wind energy system apart from the total renewable installed capacity. The wind energy sector is one of the growing sectors for power generation in various states of India. It is having huge potential to bridge the gap between generation and demand. The Government of India has a plan for installing wind energy capacity of 32,352 MW by 2017 and 60,000 MW by 2022. The wind energy systems may not be technically adequate, at all places because of variable wind speeds. It has been observed that the environmental protection has been possible mainly by the reduction of carbon dioxide (CO₂) and Nitrous oxide (NO). An effort has been made to find out the possibility of wind energy that can help perform to meet our energy needs and alleviate the greenhouse gas (GHG) emission. The overall installed capacity of power generation in India is divided into three sectors, namely state sector, central sector and private sector having their power installed capacity of 97.951GW, 74.807 GW, and 115.248 GW respectively.

The wind power development was started in 1986 with the first wind farm set up in coastal areas of Gujarat (Okha), Tamil Nadu (Tuticorin) and Maharashtra (Ratnagiri) with 55 kW turbines. This capacity is largely increased within few years during which India was the 4th largest in wind power installed capacity. According to National Institute of Wind Energy (NIWE) potential of wind resources in India is 302 GW at 100m Hub height. The total installed capacity of wind power in India is 27.441 GW as of July 2016. North, South and West are the main regions that provide the most power. In the year 2015 India overtaken Spain and became the 4th largest producer of wind power. As of March 2015, end, East and North regions have no grid. Wind power contributes nearly 8.6% of total installed power generation capacity in India. Table 2 gives the information about the state wise potential and installed capacity of wind power in India. From the table 1 it can be seen that wind power has to be increased by up to 55% to reach the target by 2022.

TABLE II. STATE-WISE WIND POWER POTENTIAL AND WIND POWER CAPACITY (MW) IN INDIA

States	Potential (MW)	Installed Capacity (MW)
Andhra Pradesh	14497	1432.95
Gujarat	35071	3930.94
Karnataka	13593	2877.95
Kerala	837	55.8
Kerala	2931	2165.49
Maharashtra	5961	4655.25
Rajasthan	5050	4031.99
Tamil Nadu	14152	7633.27
Total	92092	26782.64

As of April 2016

IV. SOLAR POWER

Conversion of available sunlight to electrical energy by making use of photovoltaics is known as solar power. This also can be done using concentrated solar power, in which mirrors or lenses are used with tracking system to concentrate big area of sunlight in smaller beam of light. At start, only photovoltaics was in use for electricity production. Now the cost of the solar electricity has fallen to a much low value, because of which the number of grid connected solar PV systems has increased vastly. Development of commercial solar power plants was started in 1980s.

In India after wind power, solar power is the 2nd fastest growing renewable energy source with about total of 8GW installed capacity by July 2016. Indian government has considerably enlarged its solar plants with a target of increasing installed capacity of solar to 100GW by 2022.

Along with the initiative of large scale grid connected power from solar, India is also developing off grid solar power. At the end of year 2015 just 55% of rural houses and areas had electricity access. Table 3 shows the comparison of state wise potential and installed capacity of solar power.

Disadvantages of solar power include the availability throughout the day and also the power generated is reduced during the overcast conditions, requires accumulation of large area for small installed capacity.

TABLE III. STATE-WISE SOLAR POWER POTENTIAL AND SOLAR POWER CAPACITY (MW) IN INDIA

States	Potential (MW)	Installed Capacity (MW)
Andhra Pradesh	38440	935.8
Chhattisgarh	18270	123.78
Gujarat	35770	1123.36
Karnataka	2470	238.32
Madhya Pradesh	61660	790.37
Maharashtra	64320	385.76
Punjab	2810	520.7
Rajasthan	142310	1294.6
Tamil Nadu	17670	1267.4
Telangana	20410	845.84
Uttar Pradesh	22830	143.5
Total	426960	7669.43

As of 31 July 2016

V. BIOMASS POWER

Organic matter derived from living or recently living organisms is known as biomass. This biomass can be used as a good source of energy. Most of the times it refers to plants or materials obtained from plants which are not being used as food or feed. This type of biomass is called as ligno cellulosic biomass. Biomass can either be used as source of energy by its combustion or it also can be used in various other forms by its conversion to biofuels.

Biomass is always an important source of energy while considering benefits offered by it. Biomass power consists of biomass gasification, bagasse cogeneration and also the waste to energy conversion. After solar power biomass power is the 3rd highest contributor to the total renewable power, having 4860 MW of installed capacity from biomass & gasification and bagasse cogeneration, and about 115 MW from waste to power conversion. Table 4 shows the state wise capacity of biomass power. Maharashtra is having highest share in the total biomass power production, with 1112 MW as of March 2016 and other states having respective installed capacities. As per MNRE 2022 target biomass power has to be increased from around 4.9 GW to 10 GW overall. If we consider the present condition, India is half way towards the goal of reaching to that capacity in biomass power. Downside of the using biomass as the fuel for the energy production is that it produces air pollution in form of carbon, monoxide, carbon dioxide, nitrogen oxides and particulates.

TABLE III. STATE-WISE WIND POWER POTENTIAL AND BIOMASS POWER CAPACITY (MW) IN INDIA

States	Potential (MW)	Installed Capacity (MW)
Andhra Pradesh	578	389.75
Chhattisgarh	1221	55.9
Gujarat	1333	52.3
Karnataka	1131	238.32
Madhya Pradesh	1044	737.28
Maharashtra	1364	36
Punjab	1887	112.78
Rajasthan	3172	140.50
Tamil Nadu	1039	111.3
Telangana	1070	662.3
Uttar Pradesh	1617	936.7
Total	15456	3473.13

As of 31 July 2016

VI. WASTE TO ENERGY

- The energy received in form of heat or electricity from primary treatment of waste is known as Waste to energy. Most of the waste to energy processes produce electricity or heat by direct combustion of the waste materials or converting it to combustible fuel. Most common method of getting energy from the waste materials is incineration, which includes combustion of organic materials such as waste with some amount of energy recovery. There are various techniques available for converting waste to energy without direct combustion of waste. More amount of electricity is received by some procedures than the energy received by direct combustion, due to the separation of corrosive components from converted fuel which permits attaining the higher combustion temperatures.
- About 38 billion liters of sewage and 55 million tons of solid wastes are generated from urban areas in India every year. The large amount of liquid and solid wastes are generated from industries also adds up this, and is expected that this will increase rapidly in the future. In turn this will increase the power generated from the waste. By July 2016 the amount power generated from the waste to energy is very small of about 115 MW. Combining both waste to energy and biomass power India has target to reach to 10 GW by 2022.

VII. SMALL HYDRO POWER

Small hydro is the generation from hydroelectric power on a small scale serving to a small community or industry. The capacity of the small varies from 1 to 20 MW. Small hydro is further divided into mini hydro with capacity of 100 to 1000 KW and micro hydro having capacity of 5 to 100 KW. Small hydro power plants can be built for the areas where it is not economical to provide the electricity from the grid. Since this type projects are small in size so they have minimal impact on the environment as compared to large hydro power plants which submerges large area. In 2013, the report by International Center on Small Hydro

Power found that the world potential is around 173GW while the overall installed capacity of the world is 75 GW. If we consider the small hydro power in India, it is developing at faster rate. India has the potential of 20 GW power from the small hydro. The installed capacity of small hydro power is 4.3 GW. Considering the target set by the MNRE to get 5GW from small hydro, India is almost 85% on the way of making it.

VIII. NEW TECHNOLOGIES IN RENEWABLE ENERGY SOURCES

A. HYDROGEN ENERGY

Hydrogen being a clean fuel and an energy carrier, it can be used for various applications. These applications of hydrogen energy will substitute the liquid and fossil fuels. As hydrogen fuel after the burning process gives only water as emission product. This makes the hydrogen energy a clean source. This often requires combustion or electrochemical cells for the power production, which is used to power the electrical devices and vehicles. Various research, development and demonstration projects are conducted by MNRE on different aspects of hydrogen energy with its production, storage and use of hydrogen as fuel for generation various energies such as electrical, mechanical and thermal. The application of hydrogen energy in fuel cells has been demonstrated already.

Pure hydrogen is not found naturally on earth in large quantities, it requires lot of energy to produce it. There are many ways of production of hydrogen such as electrolysis and steam-methane reforming process.

Large quantity of hydrogen is found in hydrocarbons, water and other organic matter. But it is a challenge to derive the hydrogen efficiently from these sources. Electrolysis of water can give hydrogen but this process is not energy efficient.

Hydrogen is also used as energy carrier or energy storing medium. Hydrogen fuel is being used as liquid propellant in rockets also it gives motive power. One more problem with hydrogen fuel is, it is difficult to store. It requires high pressure containers or cryogenic temperature.

B. CHEMICAL ENERGY

Chemical Energy is defined as the ability of chemical substance to undergo transformation through a chemical reaction and change to other chemical substances. This can also be used for electricity production. The examples of conversion of chemical energy to electrical energy is Fuel cells, which produces electricity through reaction of hydrogen with air or oxygen along with production of heat and water.

MNRE has developed a program named Chemical Sources of Energy Program. The development of various uses of fuel cell technology is the main objective of this program. Greater modularity, noise-less operation, compactness and conversion efficiency can be achieved by this fuel cell technology. These types of cells are environment friendly. Hydrogen is used as the primary fuel. Different types of other fuels also can be used in production of hydrogen gas using reformers. Because of the compact nature of the fuel cells, they are useful in decentralized power generation as well as in automotive application. Phosphoric Acid Fuel Cells (PAFCs) and Polymer Electrolyte Membrane or Proton Exchange Membrane Fuel Cells (PEMFCs) prototypes in sizes of kW have been developed in India.

These samples are demonstrated for power generation and transport sector along with their use in hybrid vehicles. Various developments are done to improve technology for production of fuel cell systems.

C. BATTERY OPERATED VEHICLES

Battery operated vehicles (BOV) are the type of electric vehicles that uses chemical energy stored in rechargeable batteries for their operation. BOV have motors installed in them instead of internal combustion engines and get power from the battery packs. Vehicles which use both battery power and internal combustion engine are considered as hybrid vehicles not BOV.

MNRE is promoting the development, research and demonstration projects in the field of battery operated vehicles. In which demonstration program promotes the nonpolluting

BOVs in country, which doesn't harm the nature in any form. That's how India is concentrating on the power from battery operated vehicles.

D. GEO-THERMAL ENERGY

The thermal energy which is stored inside the earth is known as geo-thermal energy. This thermal energy can be used for the production of the electricity. Heat inside the earth is produced from radioactive decay and due to geothermal gradient, which is the difference in temperature between the core of the planet and its surface. Temperature near the core-mantle boundary can reach over 4000°C. This much temperature and high pressure causes rock to melt and the solid mantle of the earth behaves plastically. This mantle transfers the heat upwards which causes the heating of the water near to it. There are two ways of using heat produced from the geothermal. Either steam generated under the earth's surface can be directly used in turbines or the heat from the earth used to convert the water into steam and then to the turbines to produce the electricity.

Geothermal power is very reliable, cost-effective, sustainable and environment friendly in nature. Since last 25 years MNRE is supporting research and development and expansion of the geothermal energy. MNRE has targeted to get about 1000 MW from the geothermal energy by 2022. Resource assessment is being planned for harnessing the potential of geothermal resources.

Downside of the geothermal energy is that it is site specific. Some points are available very remotely and transmitting energy from that far is costly affair. Also, the capital cost of the geothermal is much higher compared to other renewable resources.

E. OCEAN ENERGY

Almost 70 percent of the earth's surface is covered by the water containing very large amount of energy in many forms such as wave, tidal, marine current and thermal gradient. Energy potential contained by seas and oceans is way more than our present energy needs. India already has long coastline where enough tides are available to rotate the turbine and in turn produce the energy. Various technologies for production of energy from ocean are currently under development. The movement of water present in the ocean produces large amount of kinetic energy, this energy also can be used for the production of electricity. Ocean energy mainly includes wave power i.e. power generated from the

surface waves, tidal power which includes the power obtained from the kinetic energy which is produced by large bodies of moving water.

Ocean energy has very high amount of renewable energy potential. Ocean energy will also help India in reaching the 2022 target of 175 GW from renewable energy sources.

F. Biofuels

Biofuel is a fuel which is produced from the various biological processes including agricultural and anaerobic digestion. While conventional fuels are produced from geological process which requires many years for the process.

These fuels can be derived from various materials such as plants, agricultural and domestic wastes. Renewable biofuels are derived from the conversion of biomass which is done in 3 distinctive methods. These involve chemical conversion, biochemical conversion and thermal conversion which will give the fuel in solid, liquid or gas form that may be directly used as biofuels thus playing a key role in meeting the country's energy demand. National policy on biofuels was announced in December 2009, having major goals of development and utilization of non-food.

IX. RECENT INVESTMENTS IN WIND POWER SECTOR IN INDIA

Around 293 global and domestic companies have committed to generating 266 GW of solar, wind, mini hydro and biomass-based power in India over the next 5-10 years. Some major investments and developments in the Indian power sector are as follows:

- Sun Edison is the largest renewable energy company in the world which planned to continue its focus on 'Make in India' for further reducing the cost of solar energy and developing over 15 GW of the wind and solar projects in the country by 2022.
- Sterlite Grid is India largest private operator of transmission systems which is joining hands with United State major Burn & McDonnell for its Rs 3000 crore power transmission project in the Kashmir valley.
- Inox Wind Ltd is a subsidiary of Gujarat Fluor Chemicals which provides a wind energy solutions and plans to two-time increase its invent capacity to 1,600 MW at a total investment of Rs 200 crore (US\$ 31.6 million) by the end of the next financial year.
- Reliance Power Limited has signed a grant with the Government of Rajasthan for making 6,000 MW of solar power projects in the next 10 years.
- Hilliard Energy has planned to invest Rs 3,600 crore (US\$ 600 million) in Ananthapur, Andhra Pradesh in the solar and wind power sector for the generation power of 650 MW.
- Sun Edison signed an agreement to acquire continuum wind energy, with assets in India. The company would take over 242 MW of wind power operating that continuum owns and operates in Maharashtra and Gujarat with 170 MW of assets under construction.

X. IMPACT OF POLICY AND VISION 2022

During the last many years the share of renewable energy has steadily increased due to the initiative taken by Government of

India and as indicated in Table 5. The share of various types of renewable energy is indicated in Table 6. All figures are in MW. It is estimated that total share of renewable energy will be 15.9% by 2022. In the larger perspective of grid power an innovative scheme is being tried in India called as tail-end grid.

So far the emphasis has been on large plants whether they are wind, solar, hydro or biomass. Locations for wind and hydro are fixed. However, for biomass the difficulties of ensuring collection and transportation of fuel are leading towards smaller plants. For solar PV, a total of 100 MW capacity is being set up with smaller plants of 100 KW to 2 MW, which are connected to grid through 11 kV feeders. It is expected that small plants would reduce the transmission losses by 5-7% with respect to large capacity plants of 50 - 100 MW size and improve both voltage and frequency at the tail end. The same approach is being planned for biomass based power plants of up to 2 MW capacity as the logistics of fuel management would become much more manageable and more environmentally friendly. It is envisaged that hundreds of such plants will be built in the next few years thus improving the transmission infrastructure.

XI. CONCLUSION

The present energy scenario in India is not satisfactory. The power supply position prevailing in the country is characterized by persistent shortages and unreliability and also high prices for industrial consumers.

India, with its vast population and limited natural resources or meeting its energy requirements, needs to maintain its momentum of growth and this can be made possible only with a clear strategy for use of best possible energy options available.

India needs to have a strategy for meeting its energy needs by 2022. The broad vision behind energy policy must be to meet energy demands reliably with energy which is clean and affordable and this must be done in an environmentally sustainable manner using different forms of energy.

Increasing population of the world has to meet the increasing energy demands. Fulfillment of this energy cannot be done only by conventional energy sources. Renewable energy sources play a major role in energy fulfillment as well as the development of any country. It can be seen that India has enormous amount of potential in renewable energy sources. It is needed to use this potential in right way in order to achieve the energy demands. Ministry of New and Renewable Energy sources (MNRE) has already taken few steps towards the developing renewable energy sources and set up the target for year 2022. This will be achieved by utilizing the potential in wind, solar, biomass, small hydro and waste to energy power. Wind power is reached up to 50% near the target of getting 60 GW from it. While solar is only 8% on track of getting 100 GW. While small hydro power has almost reached the target of 5GW, and biomass is also half through to the target of getting 10 GW. If India is able to achieve this amount capacity in coming years, it will be in world leaders for renewable energy production.

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