



# NON-CONVENTIONAL ENERGY SOURCES – CURRENT SCENARIO AND FUTURE PROSPECTS OF INDIA

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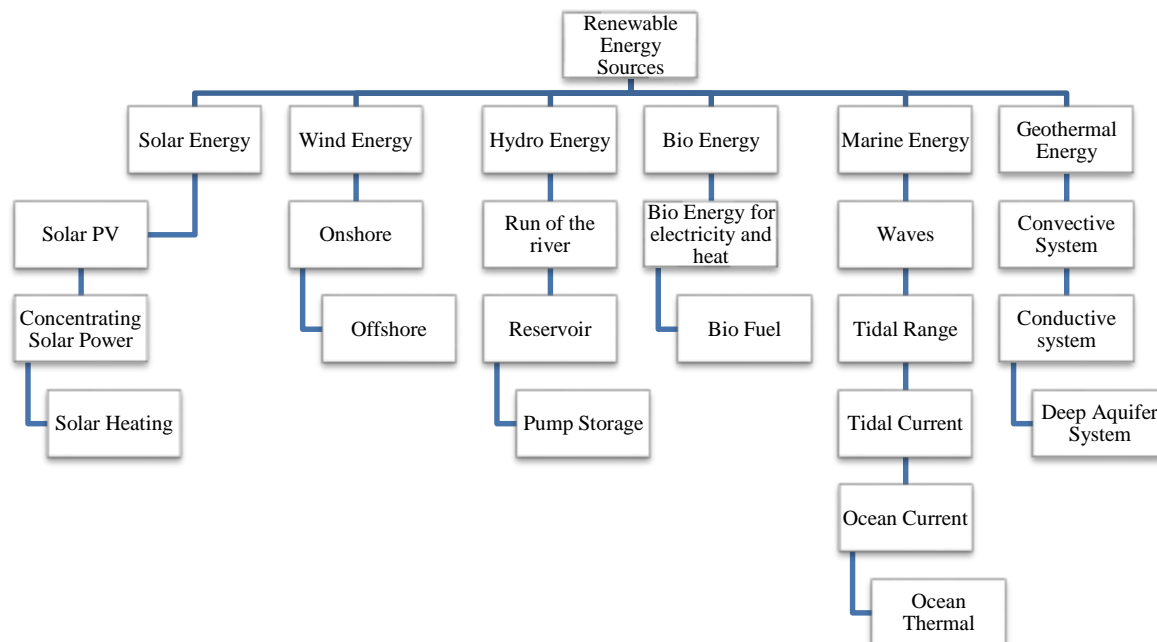
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**Abstract:** Energy has become an important and one of the basic infrastructures for economic development of a country. Every sector of the national economy-agriculture, industry, transport, commercial and domestic-needs inputs of energy. Thus, consumption of energy in all forms has been steadily rising all over the country. In this background, there is urgent need for the country to develop a sustainable path of energy development. Promotion of energy conservation and increased use of renewable energy sources are the two best options for the same. India is a country with more than 1.3 billion people accounting for more than 18% of world's population. In recent years, India's energy consumption has been increasing at a relatively fast rate due to population growth and economic development, even though the base rate may be somewhat low. In India most of the power generation is carried out by conventional energy sources, coal and mineral oil-based power plants which contribute heavily to pollution and emissions. Also, the conventional energy resources are depleting, which is a very severe problem which affects economic development of our country due to dependence on other countries for conventional resources. Thus, it is essential to tackle the energy crisis through judicious utilization of abundant the renewable energy resources. India has great potential to accelerate the use of its endowed renewable resources to power its growing economy with a secure and affordable energy supply. India, with its vast population and limited natural resources for 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 long term strategy for meeting its energy needs by 2030 and a short term goal of 175GW by 2022 which can be small steps towards attaining energy security by 2030. This paper describes the current scenario and future needs of India with respect to renewable energy resources.

**Index Terms** - Renewable energy; Solar; Wind; Bio energy, Energy Statistics

## I. INTRODUCTION

Energy is the primary and most universal measures of all kinds of work by human beings and nature. Energy sources are mainly categorized into three types- Primary, secondary and supplementary. Coal, Natural gas, oil and nuclear energy are primary energy sources. Solar, wind etc. are secondary energy sources. But, it is well known fact that the sources of fossil fuels are depleting very fast and by the turn of the century, man will have to increasingly depend upon renewable resources of energy. Renewable energy refers to energy resources that occur naturally and repeatedly in environment and can be harnessed for human benefit. Examples of renewable energy systems include solar, wind, hydro and geothermal energy (getting energy from the heat in Earth). Biomass, rivers, and even garbage (waste generated) are also source to renewable energy [8]. 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. Thus, for developing countries like India, large scale demand in domestic and commercial sectors can be meet by such non-conventional or renewable energy sources. The standard of living of any country is directly related to per capita energy consumption [1]. Thus, it is necessary to plan the energy strategies so that the country's development is not hampered. Hence, to meet the energy requirements in the future, India has better option – Renewable Energy sources. An annual growth rate of 22% of renewable energy in India was attained during the last decade. Following figure shows classification of renewable energy sources.



**Fig. 1 - Classification of Renewable Energy Sources**

## II. ROLE OF RENEWABLE ENERGY IN INDIA

India has a severe electricity shortage. It needs massive additions in capacity to meet the demand of its rapidly growing economy. As fuel prices are increasing rapidly, it affects financial strategies of India. Development of renewable energy sources, which are indigenous and distributed and have low marginal costs of generation, can increase energy security by diversifying supply, reducing import dependence, and mitigating fuel price volatility. Renewable energy development can also be an important tool for spurring regional economic development, particularly for many underdeveloped states, which have the greatest potential for developing such resources. It can provide secure electricity supply to foster domestic industrial development, attract new investments, and hence serve as an important employment growth engine, generating additional income[2]. Renewable energy is seen as the next big technology industry, with the potential to transform the trillion dollar energy industry across the world. Investing in renewable energy would enable India to develop globally competitive industries and technologies that can provide new opportunities for growth and leadership by corporate India. India's significant untapped renewable energy resources can be an important contributor to alleviating power shortages. They can also increase energy security, contribute to regional development, enhance access in remote (rural) areas, diversify fuel sources, and provide local and global environmental benefits. Recognizing these benefits, India's policymakers have given much attention to renewable energy, setting ambitious goals for the sector [9]. Meeting these goals will require significant capital investments and concerted action to solve the many issues faced by the different renewable energy sectors [3]. Renewable energy development can also be an important tool for regional economic development within India. Thus, there are many good reasons for placing high priority on renewable energy development.

Renewable energy can make a substantial contribution in each 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 vital part of the solution to the nation's energy needs. India attains global 4th and 5th positions in wind and solar power installed capacities and now at 5th global position for overall installed renewable energy capacity. A total of 101.83 billion units of power were generated in the country during the year 2017-18 from renewable energy. The Government has declared the trajectory of bidding 60 GW capacity of solar energy and 20 GW capacity of wind energy by March 2020, leaving two years' time for execution of projects [11]. India made a pledge that by 2030, 40% of installed power generation capacity shall be based on clean sources, it was determined that 175 GW of renewable energy capacity will be installed by 2022. This includes 100 GW from solar, 60 GW from wind, 10 GW from bio-power and 5 GW from small hydro power [10].

The Share of Renewable Energy in overall installed capacity in the country as on 31.10.2018 is given below:

**Table 1 - Installed Capacity (GW) of Energy Sector in India**

Source	Installed Capacity (GW)	Percentage
Thermal	221.76 GW	63.84%
Nuclear	6.78 GW	1.95%
Hydro	45.48 GW	13.09%
Renewable	73.35 GW	21.12%
<b>Total</b>	<b>347.37 GW</b>	<b>100%</b>

A total of around 73.35 GW of renewable energy capacity has been installed in the country as on October, 2018 from all renewable energy sources which includes around 34.98 GW from Wind, 24.33 GW from solar, 4.5 GW from Small Hydro Power and 9.54 GW from Bio-power [10].

### III. GROWTH OF ENERGY SECTOR AND IT'S PLANNING IN INDIA

Energy is critical building block for the development of any country. To deliver sustained growth rate of 8-9% through next 25years, India needs to increase it's primary energy supply and also its energy generation capacity [4]. Electricity is the prime requirement for all facets of our life and hence it is a basic human need. Thus, electricity is the basic application of most of the energy generation in India. As India is developing country, per capita energy consumption demand is increasing at a fast rate. To fulfill these energy needs, India has to be dependable on different alternative options in the future as non-conventional energy sources.

Following Table 2 shows five year energy plans of India, since 1980 [5].

**Table 2 - Five Year Energy Plans of India**

By the end of 5 year plan	Demand	Installed capacity	Shortage
6 <sup>th</sup> (1980-1985)	52,000 MW	47,000 MW	5,000 MW
7 <sup>th</sup> (1985-1990)	75,000 MW	65,000 MW	10,000 MW
8 <sup>th</sup> (1990-92,1992-97)	1,05,000 MW	85,000 MW	20,000 MW
9 <sup>th</sup> (1997-2002)	1,32,000 MW	1,10,000 MW	22,000 MW
10 <sup>th</sup> (2002-2007)	1,46,000 MW	1,24,569 MW	21,431 MW
11 <sup>th</sup> (2007-2012)	1,75,000MW	1,46,190MW	28,810MW
12 <sup>th</sup> (2012-2017)	2,05,000 MW	1,68,210MW	36,790MW
13 <sup>th</sup> (2017-2022)	2,25,000MW	---	

Following Table 3 shows per capita energy consumption [7].

**Table 3 - Per Capita Energy Consumption**

Year	1950	1960	1970	1980	1990	2001	2005	2010	2015	2020
Per capita annual energy consumption (kWh)	16	35	84	131	238	408	592	731	1080	@1300

Following Table 4 shows growth projection of power sector (future estimation upto 2027).

**Table 4 - Growth Projection of Power Sector**

Year	2006	2012	2017	2022	2027
Total installed generating capacity (GW)	124	216	333	512	790

### IV. CURRENT ENERGY SCENARIO OF INDIA

India is said to be one of the seven largest consumers of energy, but the growing gap between consumption and domestic output is a cause of concern [5]. India is still dependent to the extent of 30 to 35 percent on noncommercial fuel sources like cow dung, firewood, agricultural waste, etc. As the country's petroleum bill grows, and future supplies look volatile or insecure, alternatives need to be explored. India has setup a target of 20000 MW of installed capacity by 2022 for harnessing solar energy [6]. Renewable Energy technologies like solar, biomass, hydro, etc are deployed both in rural and urban areas to curb the growing gap between the demand and supply of power, which is due to increase in the per capita energy consumption. Indian clean development mechanism, projects broadly cover a range of sectors viz., power generation from renewable energy, particularly wind and hydro power, biomass applications, waste heat and energy recycling. Currently, India has been endowed with adequate natural resources. According to Ministry of New and Renewable Energy, cumulative achievements upto October 2018 for different Renewable Energy Sources are shown in following Table 5.

**Table 5 – Installed Capacity of RE Sector in India**

Source	Wind	Small Hydro	Biomass-power/ Bioenergy	Solar	Total
Installed Capacity upto Oct 2018 (GW)	34.98	4.5	9.54	24.33	73.35

### V. POTENTIAL OF THE RENEWABLE ENERGY SOURCES IN INDIA

Renewable energy potential is likely to be even greater considering that sources with significant generation capacity such as off-shore wind farms are yet to be mapped. In sectors such as wind and small hydropower, application of the latest developments in engineering design and equipment technology are also likely to increase potential, as are the discovery of new small hydro power sites. The potential for solar power will also increase significantly as technology improves. This section describes potentials for various Renewable Energy Sources in India.

#### 5.1 Wind Energy

Wind energy is the fastest growing renewable energy technology for generating grid connected power amongst various renewable energy sources. The country currently has the fourth highest wind installed capacity in the world with total installed capacity of 34.98GW as on October, 2018 against a target of 60 GW by 2022. National targets for offshore wind capacity additions of 5 GW by 2022 and 30 by 2030 has been declared by Government of India.



### 5.2 Small Hydro Power Energy

A total capacity of 4.5 GW of grid connected small hydro power has been installed in the country as on October 2018 against a target of 5 GW small hydro power by 2022. Further, 126 no. of projects of capacity 0.73 GW are under various stages of implementation.

### 5.3 Solar Energy

India lies in the sunny regions of the world. Most parts of India receive 4–7 kilowatt hours of solar radiation per square meter per day with 250–300 sunny days in a year. The highest annual radiation energy is received in western Rajasthan while the north-eastern region of the country receives the lowest annual solar radiation [3]. This translates to an energy generation potential of about 30-50 MW./sq.km. of shadow-free area covered with solar collectors for most parts of the country. The Government has revised the target of Grid Connected Solar Power Projects from 20,000 MW by the year 2021-22 to 100,000 MW by the year 2021-22 under the National Solar Mission. The country currently has the fifth highest solar installed capacity in the world with total installed capacity of 24.33 GW as on October, 2018 against a target of 100 GW by 2022. Solar Parks are being set up in the country. 47 solar parks of aggregate capacity 26,694 MW has installed in 21 States in 2018. Over 1,00,000 lakh acres of land identified for various solar parks out of which over 75,000 acres have been acquired. Solar projects of aggregate capacity 4195 MW have been commissioned inside various solar parks.

### 5.4 Biomass Energy

Biomass is nothing but agro-waste in the form of straws, stalks, stems and fines; agro-industrial processing residues such as shells, husks, deoiled cakes and wood from dedicated energy plantations for power generation. As per bio-mass assessment study carried out by Indian Institute of Science, Bangalore, paddy straw, mustard stalk, cotton stalk, prosopis Julie-flora, groundnut shell are important resources for exploitation. The availability of biomass in India is estimated at about 540 million tonnes per year covering residues from agriculture, agro industrial, forestry, and plantations [6]. Principal agriculture residues include rice husk, rice straw, bagasse, sugar cane tops and leaves, trash, groundnut shells, cotton stalks, mustard stalks, etc. It has been estimated that about 70-75% of these wastes are used as fodder, as fuel for domestic cooking and for other economic purposes leaving behind 120 – 150 million tonnes of usable agro industrial and agriculture residues per year which could be made available for power generation. By using these surplus agricultural residues, more than 17,000 MW of grid quality power can be generated with presently available technologies. A cumulative capacity of 1200 MW from biomass power has so far been commissioned mainly in the states of Tamil Nadu, Uttar Pradesh, Karnataka, Andhra Pradesh, Maharashtra, Chhattisgarh, Punjab and Rajasthan [4]. A total capacity of 9.54 GW of grid connected bio-power has been installed in the country as on October 2018 against a target of 10 GW bio-power by 2022. This includes 8.73 GW from bagasse cogeneration, 0.68 GW from non-bagasse cogeneration and 0.13 GW from waste to energy.

### 5.5 Urban and Industrial Waste

The problem of urban waste management is notable not only because of large quantities involved, but also its spatial spread across the Urban Local Bodies and the enormity and variety of problems faced in setting up of systems for collection, transportation and disposal of waste and mainly non-availability of land for landfills. A large quantity of wastes, both solid and liquid, are generated in industrial sectors such as sugar, pulp and paper, fruit and food processing, starch, distilleries, dairies, tanneries, slaughterhouses, poultry, etc. Despite requirements for pollution control measures, these wastes are generally dumped on land or discharged into water bodies, without adequate treatment, and thus become a large source of environmental pollution and health hazards. This problem can be mitigated through the adoption of effective waste management systems and waste-to-energy conversion technologies. About 50 million tonnes of solid waste (1.40 lakh tonnes per day) and 6000 million cubic meters of liquid waste are generated every year by 423 Class I cities. This translates into a potential for generation of nearly 2600 MW of power from urban wastes in the country. The estimated potential for recovery of energy/generation of power from solid and liquid wastes being generated in various industrial sectors is about 1300 MW and is expected to increase to about 2000 MW by 2017 [5]. As on March 2012 a capacity of 90 MW has been installed. Three projects for energy recovery from Municipal Solid Wastes with an aggregate capacity of 17.6 MW have been set up at Hyderabad, Vijayawada and Lucknow. Other urban waste projects include a 1 MW project based on cattle dung at Haebowal, Ludhiana; a 3.5 MW projects for generation of power from biogas at four sewage treatment plants in Surat; 150 kW plant for vegetable market and slaughterhouse wastes at Vijayawada; and 300 kW project based on vegetable market wastes at Chennai [6]. The project at Lucknow is presently non-functional due to certain operational problems.

### 5.6 Geo Thermal Energy

Geothermal energy is heat stored in deep interior of the earth. This heat energy can be used for producing electricity and also for direct heat applications. It has been reported that in the last few decades, there has been an increase in the use of geothermal energy all over the world. In India, Geological Survey of India has identified about 340 geothermal hot springs in the country. These springs are perennial and their surface temperatures range from 37° - 90C which is suitable for direct heat applications and reservoir temperature 1020 C – 2600 C. It has also been stated that to exploit the geothermal energy sources, mapping of the deep surface structure and demarcation of the area of geothermal heat trapped inside the surface is needed so that decisions regarding deep drilling, estimation of its potential, number of years for which the resource can be profitably tapped etc. can be taken. 340 springs have been identified by Geological Survey of India and rough estimates based on GSI studies indicate that energy generation potential is 10,000 MW [6]. The hot springs present in the country are grouped into seven geothermal provinces: (i) Himalayan – Puga, Chhumthang Province (ii) Sohana Valley (iii) Cambay Basin (iv) Son-Narmada-Tapti (SONATA) lineament belt (v) West Coast (vi) Godavari basin and (vii) Mahanadi Basin. These geothermal resources are distributed in the States of Andhra Pradesh, Chhattisgarh, Gujarat, Himachal Pradesh, Jammu & Kashmir, Jharkhand, Maharashtra, Orissa, Uttarakhand and West Bengal [7]. A geothermal exploratory study by a private consultancy firm has projected tentative geothermal potential of 1500 MW within the East Godavari Geothermal region in AP.

### 5.7 Tidal Energy

India has a long coast line of about 7500 km. with the estuaries and gulfs where tides are strong enough to move turbines for electrical power generation. The Gulf of Cambay and the Gulf of Kutch in Gujarat on the west coast have the maximum tidal range of 11m and 8m with average tidal range of 6.77m and 5.23m respectively [9]. The Ganges Delta in the Sundarbans is approximately 5m with an average tidal range of 2.97m. The identified estimated potential is of the order of 8200 MW with about 7000 MW in the Gulf of

Cambay, about 1200 MW in the Gulf of Kutch in the State of Gujarat and about 100 MW in the Gangetic Delta in the Sunderbans region in the State of West Bengal [8]. In addition to large power plants there is a very good and wide spread potential for decentralized tidal/ wave based power plants for which technologies are to be developed to suit the available tide/ wave height and speed.

## VI. RENEWABLE ENERGY TARGETS OF INDIA

The 175 GW target implies a quintupling of RE capacity from 2015 to 2022. While the mainstay of RE capacity growth in the past has been from wind power, solar power is rapidly increasing its share and is expected to grow much faster than wind in the coming years. While wind and solar power make up 63% and 16% of existing RE capacity, their capacity growth rates over the last four years have been 11.4% and 63.7% respectively. Government of India targets to developed a potential of 217 GW (Solar: 166 GW, Wind: 45 GW) in the next five years, assuming that all of the 175 GWs would be in place by 2022, the share of RE capacity would sharply rise from 14.1% to 32.2 % in just six years.

Following figure shows India's 2022 Renewable Energy Target:

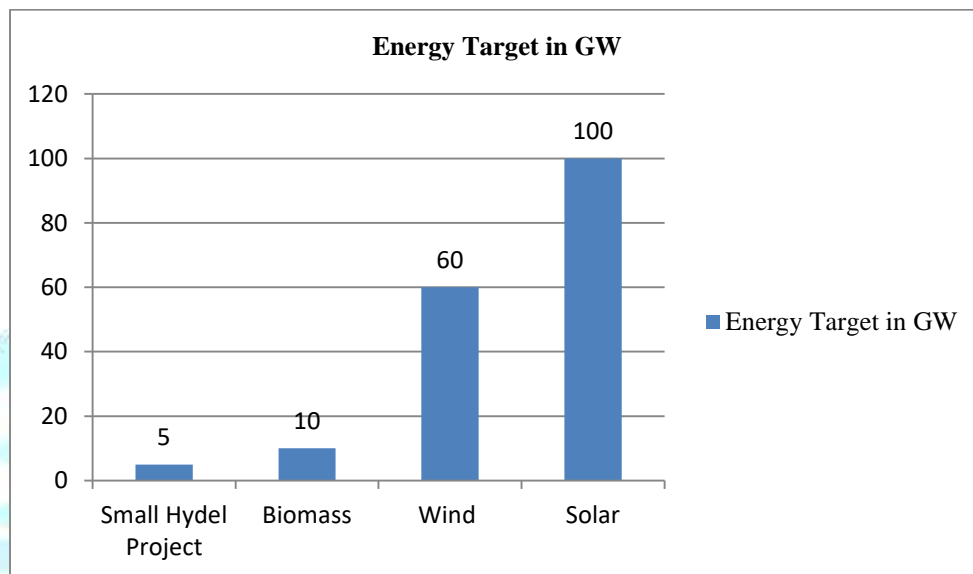


Fig.2 - India's 2022 Renewable Energy Target

## VII. FUTURE STRATEGIES FOR RENEWABLE ENERGY IN INDIA

Energy requirement is vital component and directly related to the economic growth of a country. Currently, installed capacity of electricity generation in the country is 1,90,516 MW and out of this 25,000 MW comes from renewable sources like wind, solar, etc. As per the Approach Paper for the 13th Five Year Plan, energy availability has been identified as a potential challenge that needs to be addressed to a substantial degree. It is estimated that for the GDP, to grow at 9%, commercial energy supplies will have to grow at a rate between 6.5-7% per year and suggests a need for 1,00,000 MW power capacity addition during the plan period [6]. India has an energy supply shortage of 10.2%. It is expected that country's peak demand will rise to 350 GW by 2022 and there is an urgent need to build up its energy infrastructure fast enough to keep pace with the economic and social changes and to ensure sustainable GDP growth and access to electricity for all [10].

Following Table 6 shows the target installed capacity at the end of 13<sup>th</sup> Energy plan (2017-2022) of India [11].

Table 6 - Target Installed Capacity at the End of 13<sup>th</sup> Energy Plan

Source	Wind	Small Hydro	Biomass-power	Urban and Industrial waste	Solar	Total
Target installed capacity at the end of 13 <sup>th</sup> plan, (MW)	38500	6600	7300	890	20000	73290

During the last many years the share of renewable energy has steadily increased due to the initiative taken by Government of India. 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 envisaged that hundreds of such plants will be built in the next few years thus improving the transmission infrastructure.

Following are the future plans for next 5 years with respect to some Renewable Energy Sources of India –

#### 7.1 Wind Energy

The wind power program is the fastest growing renewable energy program and is almost entirely coming through private sector investments. India has a potential of around 48,500 MW. With a capacity addition of 12,800 MW, it contributes to around 75% of the grid-connected renewable energy power installed capacity. The major wind power capacity is in the states of Tamil Nadu, Gujarat, Maharashtra, Karnataka and Rajasthan. Wind electric generators of unit sizes between 225 kW and 2.10 MW have been deployed across the country.

#### 7.2 Small Hydro Power Energy

India has set target of 2100 MW capacity addition during 12th Plan and about 3000 MW during the 13th Plan period which would take the total installed capacity from SHP Projects to about 8500 MW in the year 2021-22 (about 60% of the existing potential) [10].

#### 7.3 Solar Energy

The Government of India had approved the policy framework and announced “Jawaharlal Nehru National Solar Mission” recently, with an objective to establish India as a global leader in solar energy by creating policy conditions for its diffusion across the country quickly and achieve a scale to drive down costs to levels required to achieve grid parity by 2022. The Mission targets include (i) deployment of 20,000 MW of grid connected solar power by 2022, (ii) 2,000 MW of off-grid solar applications including 20 million solar lights by 2022, (iii) 20 million sq. m. solar thermal collector area, (iv) to create favorable conditions for developing solar manufacturing capability in the country; and (v) support R&D and capacity building activities to achieve grid parity by 2022.

#### 7.4 Biomass Energy

The current potential for power generation from surplus agro and agro-industrial residues is estimated at 17000 MW. With efficient power cogeneration plants in new sugar mills and modernization of existing ones, the potential of surplus power generation through bagasse cogeneration in sugar mills is estimated at 7300 MW. Thus the total estimated biomass power potential is about 22,000 MW.

#### 7.5 Urban and Industrial Waste to Energy

Capacity addition target for the 13th Five Year Plan for this sector is 890 MW.

### VIII. FUTURE PLANS OF INDIA WITH RESPECT TO SHORT, MEDIUM AND LONG TERM GOALS FOR RENEWABLE SOURCES

Following are some of the future strategies of India with respect to Short, medium and long term goals for renewable energy sources:

#### 8.1 India's Short Term Plan by 2020 -

##### 8.1.1 Deployment of renewable energy for meeting energy needs in rural areas –

8.1.1.1 Target 1 lakh family type biogas plants per year

8.1.1.2 Target biomass gasifiers for village energy supply in 25 villages per year

8.1.1.3 Installation of decentralized SPV systems – 50,000 Solar lighting systems and 20,000 Irrigation pumps

8.1.1.4 Target installation of 500 Micro Hydel Projects/watermills with capacity of approximately 4 MW each year

8.1.1.5 Installation of 20 projects utilizing Aero generators and SPV-Wind hybrid systems with a cumulative capacity of 20 kW per year

##### 8.1.2 Deployment of renewable energy to supplement energy needs in urban areas

8.1.2.1 Installation of solar thermal systems in urban households/buildings covering approximately 5 lakh m<sup>2</sup> area

8.1.2.2 50 MW of Rooftop SPV grid connected systems per year

8.1.2.3 Disbursement of Solar cookers 25,000 solar cookers per year

#### 8.2 India's Medium Term Plan by 2030 –

##### 8.2.1 Promote initiatives for increasing deployment of renewables

8.2.1.1 Promote Ultra mega solar projects and solar projects for canals

8.2.1.2 Integrate ongoing programs such as rooftop, solar cities with smart city program

##### 8.2.2 Develop resource base for enhancing the potential of renewable energy sources

8.2.2.1 Reassessment of wind potential at 100 m hub height

8.2.2.2 Assessment of off-shore wind potential and prepare a policy on off-shore wind power

##### 8.2.3 Continuing improvements in regulatory and policy initiatives to promote renewable energy technologies

8.2.3.1 Address issues relating to tariff for renewable energy technology based power projects, renewable purchase obligations and measures like renewable energy certificates and other market based mechanisms, market and grid connectivity issues, inter-state exchange of renewable energy.

8.2.3.2 Pursue the compliance of renewable energy purchase obligations with regulatory authorities and states

8.2.3.3 Setting up transmission systems required primarily for renewable energy projects. Assistance may also be required for Solar Parks.



**8.2.4 Other interventions****8.2.4.1** Promote funding of innovative clean energy projects through the National Clean Energy Fund (NCEF)**8.2.4.2** Promote effective systems for monitoring performance of programs/installed projects**8.2.5 Human Resource Development****8.2.5.1** Establish R&D facilities within academia, research institutions, industry, government and private entities to guide technology development.**8.2.5.2** Develop training programs for specific and highly specialized areas related to science & technology, and management**8.2.5.3** Training for financial sector on the issues relating to project financing of renewable energy projects.**8.3 India's Long Term Plan by 2047 -****8.3.1 Incubating technologies with high future potential****8.3.1.1** Initiate move to electrify automotive transportation or develop electric vehicles — plug-in hybrids. Adopt nationwide charging of electric cars from solar panels on roofs and solar-powered electric vehicle charging stations around the country. These recharging connections could be deployed at highly-concentrated areas including shopping malls, motels, restaurants, and public places where vehicles are usually parked for extended periods.**8.3.1.2** Develop large-scale solar manufacturing in India to transform India into a global solar manufacturing hub.**8.3.1.3** Promote and establish utility-scale Renewable Energy Zones (REZs) utilizing solar and wind generation**IX. CONCLUSION**

India is blessed with vast resources of renewable energy in solar, wind, biomass and small hydro. In fact, the technical potential of these renewables exceeds the present installed generation capacity. Unique in the world, India has the only Ministry that is dedicated to the development of renewable energies: the Ministry of New and Renewable Energy. This bodies are performing well for the acceleration of renewable development throughout the nation, both to meet the underserved needs of millions of rural residents and the growing demand of an energy hungry economy. The development and deployment of renewable energy, products, and services in India is driven by the need to decrease dependence on energy imports, sustain accelerated deployment of renewable energy system and devices, expand cost-effective energy supply, augment energy supply to remote and deficient areas to provide normative consumption levels to all section of the population across the country and finally, switch fuels through new and renewable energy system/ device deployment. India is currently experiencing strong economic growth, while at the same time attempting to extend modern power services to millions still in poverty. Renewable energy remains a small fraction of installed capacity, yet India is blessed with over 150,000MW of exploitable renewable. There is an urgent need for transition from petroleum-based energy systems to one based on renewable resources to decrease reliance on depleting reserves of fossil fuels and to mitigate climate change. In addition, renewable energy has the potential to create many employment opportunities at all levels, especially in rural areas. India's quest for energy security and sustainable development rests a great deal on the ability to tap energy from alternate sources or the renewable sources. Last but not the least, it is for the citizens of India to believe in the power of renewable energy sources, and understand it's necessity and importance.

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**REFERENCES**

- [1] Arun Kumar Singh Tomar, K. K. Gautam, June 2018, "Renewable energy in India: current status and future prospects", International Journal of Engineering Science Invention (IJESI), ISSN2319-6734.
- [2] Sourabh Shrivastava, Harshit Saxena, Yogesh Papat, June 2018, "Current scenario and future scope of solar energy in India", SAR Journal, Vol-1, Issue-2, ISSN 2619-9955, 57-66.
- [3] Shibani Jha, Harish Puppala, 2017, "Prospects of renewable energy sources in India: prioritization of alternative sources in terms of energy index", Elsevier Journal, 116 -127.
- [4] M.R. Kolhe, P.G. Khot, 2015, "India's Energy Scenario- current & future", International Journal of Management (IJM), Volume 6, Issue 7, ISSN: 0976-6502, 47-66.
- [5] Dinesh Talwar, Renu Lata, 2014, "Status and potential of renewable energy sources in India", IJSET - International Journal of Innovative Science, Engineering & Technology, Vol. 1 Issue 10, ISSN 2348 – 7968, December 2014, 704-712.
- [6] Shyam Lal Verma, Ajay Bangar, Ankit Soni, Shravan Gajendragadkar, 2012, "Renewable and Non-Conventional Energy Sources and Engineering System", Mechanical Engineering Department, Maharana Pratap College of Technology, India, International Journal of Mechanical and Industrial Engineering (IJMIE), ISSN No. 2231 –6477, Volume-1, Issue-3.
- [7] B. H. Khan, Non-conventional Energy Resources, 2nd Edition, Mc Graw Hill Publication, New Delhi, 2012.
- [8] G. D. Rai, Non-conventional Energy Sources, 5<sup>th</sup> Edition, Khanna Publishers, New Delhi, 2012.
- [9] D. P. Kothari, K. C. Singhal, Rakesh Ranjan, "Renewable Energy Sources & Emerging Technologies", 2<sup>nd</sup> Edition, PHI Publications, ISBN – 978-81-203-4470-9
- [10] Energy Statistics Report 2018, 25<sup>th</sup> Issue, Central statistics office, Ministry of Statistics & Program Implementation, Govt. of India, New Delhi.
- [11] <http://www.mnre.gov.in>