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A Review on the Non-conventional Energy Sources in Indian Perspective

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Abstract - ***The sources of energy which are exhaustible and being produced continuously in nature are called nonconventional energy or renewable sources of energy. Some of these sources include solar energy, wind energy and tidal energy. The conventional energy sources are basically based on fossil fuels which have finite reserves in nature and hence would extinct in future. Since the development and progress of mankind are closely related to energy sources, many countries throughout the world have engaged themselves in searching and developing non-conventional energy sources that would be very essential to sustain the life cycle of human being. Our country, India has also taken certain initiatives in this view. In this paper, a review based study has been presented regarding various non-conventional energy sources and their current status in India.***

Key Words: *Non-conventional, renewable, energy sources, solar energy, wind energy*

1. INTRODUCTION

In science, energy of a body refers to its capacity to do work. It is measured by the total amount of work that the body can do. Energy is the primary and most universal measure of all kinds work by human beings and nature. Everything what happens the world is the expression of flow of energy in one of its forms [1]. Energy is the major input to drive the life cycle and improve it. Energy consumption is closely related to the progress of the mankind. In future, improvement in the living standard of the mankind, industrialisation of the developing countries and the global demand for energy will increase with the every growing population [2]. The development of infrastructure plays a significant role to sustain economic growth. The power sector is one of the major significant constituents of infrastructure. The achievement of energy security necessitates diversification of our energy resources and the origins of their supply, also adding the measures for energy conservation in consideration.

In general, India is dependent on conventional sources of energy like thermal, hydro and nuclear. However, India is also blessed with the third largest coal supplies in the globe. Although, these are not of the best quality but these cannot be utilised indefinitely. The increase in prices of petroleum products project that petroleum resources would run out in future and the use of fossil fuel resources for political purposes will adversely affect worldwide socio-economic development. The developing countries would face such impact of the energy crisis. [3] Despite fossil fuels are the primary source of energy, its finiteness of reserves and large scale environmental degradation resulted from their widespread use, specifically global warming, urban air pollution and acid rain, strongly coins that harnessing of non-conventional, renewable and environment friendly energy resources are vital for gearing up the global energy sources in a sustainable way [2].

2. CONVENTIONAL AND NONCONVENTIONAL SOURCES OF ENERGY

The conventional sources of energy are generally nonrenewable sources of energy, which are being used since a long time. These sources of energy are being used extensively in such a way that their known reserves have been depleted to a great extent. Conventional energy sources include fossil fuel energy (coal, petroleum, natural gas), nuclear energy etc [1]. Since, the main focus of this paper deals with non-conventional energy sources, no detailed discussion is made regarding conventional energy sources. The sources of energy which are being produced continuously in nature and are in exhaustible are called nonconventional energy (or) renewable sources of energy. Figure 1 and figure 2 provides the pictorial views of different forms of non-conventional energy sources and renewable energy sources options, respectively.

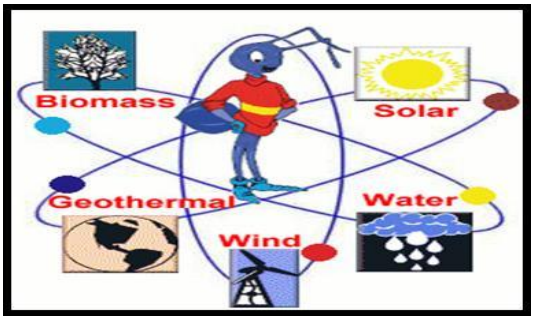

Fig -1: Non-conventional Sources of Energy

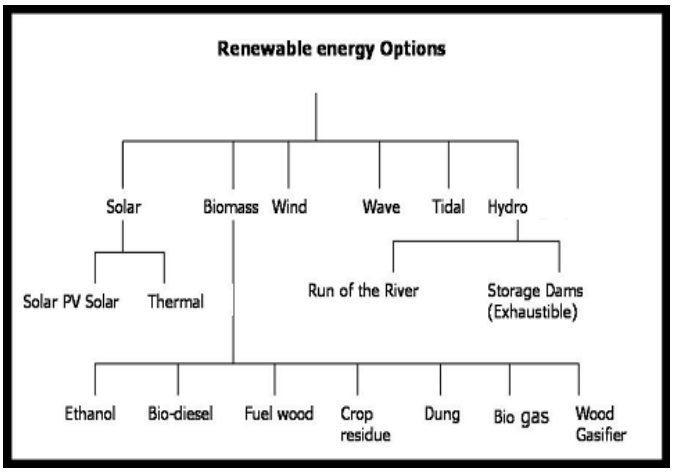

Fig -2: Renewable energy options

Different non-conventional sources are briefly discussed as follows-

2.1 Solar energy

Solar energy is the most readily available and free source of energy since prehistoric times. It is estimated that solar energy equivalent to over 15,000 times the world's annual commercial energy consumption reaches the earth every year. Solar energy can be utilised through two different routes, as solar thermal route and solar electric (solar photovoltaic) routes. Solar thermal route uses the sun's heat to produce hot water or air, cook food, drying materials etc. Solar photovoltaic uses sun's heat to produce electricity for lighting home and building, running motors, pumps, electric appliances, and lighting. In solar thermal route, solar energy can be converted into thermal energy with the help of solar collectors and receivers known as solar thermal devices [6].

2.2 Wind energy

Wind energy is basically harnessing of wind power to produce electricity. The kinetic energy of the wind is converted to electrical energy. When solar radiation enters the earth's atmosphere, different regions of the atmosphere are heated to different degrees because of earth curvature. This heating is higher at the equator and lowest at the poles. Since air tends to flow from warmer to cooler regions, this causes what we call winds, and it is these airflows that are harnessed in windmills and wind turbines to produce power. Wind power is not a new development as this power, in the form of traditional windmills -for grinding corn, pumping water, sailing ships - have been used for centuries. Now wind power is harnessed to generate electricity in a larger scale with better technology [6].

2.3 Bio energy

Bio-energy, in the form of biogas, which is derived from biomass, is expected to become one of the key energy resources for global sustainable development. Biomass is a renewable energy resource derived from the carbonaceous waste of various human and natural activities. Biomass does not add carbon dioxide to the atmosphere as it absorbs the same amount of carbon in growing as it releases when consumed as a fuel. Its advantage is that it can be used to generate electricity with the same equipment that is now being used for burning fossil fuels. Bioenergy is being used for cooking, mechanical applications, pumping, power generation etc [6].

2.4 Hydro energy

The potential energy of falling water, captured and converted to mechanical energy by waterwheels, powered the start of the industrial revolution. Wherever sufficient head, or change in elevation, could be found, rivers and streams were dammed and mills were built. Water under pressure flows through a turbine and causes it to spin. The Turbine is connected to a generator, which produces electricity.

2.5 Geothermal energy

This is the energy, which lies embedded within the earth. According to various theories the earth has a molten core. The steam and the hot water come naturally to the surface of the earth in some locations of the earth. Two ways of electric power production from geothermal energy has been suggested [2,3]. In one of this heat energy is transferred to a working fluid which operates the power cycle. This may be particularly useful at places of fresh volcanic activity, where the molten interior mass of earth vents to the surface through fissures and substantially high temperatures, such as between 450°C to 550°C can be found. In the other, the hot geothermal water and or steam is used to operate the turbines directly. At present only steam coming out of the ground is used to generate electricity, the hot water is discarded because it contains as much as 30% dissolved salts and minerals and these cause serious rust damage to the turbine [3].

2.6 Ocean energy

The ocean contains two types of energy: thermal energy from the sun's heat, and mechanical energy from the tides and waves. Ocean thermal energy is used for many applications, including electricity generation. There are three types of electricity conversion systems: closed-cycle, open cycle, and hybrid. Closed cycle systems use the ocean's warm

surface water to vaporise a working fluid, which has a low boiling point, such as ammonia. The vapour expands and turns a turbine. The turbine then activates a generator to produce electricity. Open-cycle systems actually boil the seawater by operating at low pressures. This produces steam that passes through a turbine / generator. The hybrid systems combine both closed-cycle and open-cycle systems. Ocean mechanical energy is quite different from ocean thermal energy. Even though the sun affects all ocean activity, tides are driven primarily by the gravitational pull of the moon, and waves are driven primarily by the winds. A barrage (dam) is typically used to convert tidal energy into electricity by forcing the water through turbines, activating a generator [6].

2.7 Hydrogen Energy and Fuel cells

In both Hydrogen and Fuel Cells electricity is produced through an electro-chemical reaction between hydrogen and oxygen gases. The fuel cells are efficient, compact and reliable for automotive applications. Hydrogen gas is the primary fuel for fuel cells also. Fuel cells can be very widely used once they become commercially viable [7]. Hydrogen has high-energy content, when burnt, it produces only water as a by-product and is, therefore, environmentally benign. At present hydrogen is available as a by-product from several chemical processes, plants or industries [3].

2.8 Energy from Wastes

An estimated 50 million tons of solid waste and approximately 6,000 million cubic meters of liquid waste are generated annually in the urban areas of India. In India, there is a great potentiality of generating approximately 2,600 MW of power from urban and municipal wastes and approximately, 1,300 MW from industrial wastes, respectively. A total of 48 projects with aggregate capacity of about 69.62 MWeq have been installed in the country thereby utilising only 1.8% of the potential that exists [13].

3. PRESENT STATUS OF NON-CONVENTIONAL ENERGY SOURCES/RENEWABLE ENERGY SOURCES IN INDIA

In India, the Department of Non-Conventional Energy Sources (DNES) was created in the Ministry of Energy in the year of 1982 to look after all the aspects relating to new and renewable energy. The Department was upgraded into a separate Ministry of Non-Conventional Energy Sources (MNES) in 1992 and was rechristened as Ministry of New and Renewable Energy (MNRE) in October, 2006. As per the information furnished by MNRE, starting with the 9th Plan, there has been consistent increase in pace of renewable energy development. Reportedly, India's renewable energy installed capacity has grown at an annual rate of 23%, rising from about 3900 MW in 2002-03 to about 24000 MW in 2011-12. Energy generated by using wind, solar, small hydro, tides, geothermal heat and biomass is known a non-conventional energy. All these sources are renewable process of energy generation and do not cause environmental pollution. Our country has been endowed with adequate natural resources. Table I shows the Plan-wise renewable power growth, as presented by Ministry of New and Renewable Energy [8].

Table -1: Plan-wise Renewable Power Growth in India

Type of Energy	Starting of 10th Plan (MW) 1.4.02	Starting of 11th Plan (MW) 1.4.07	Target 11th Plan (MW)	11th Plan Achievement as on 31.3.12 (MW)	Cumulative Achievement up to 31.3.12 (MW)
Wind	1,628	7,092	9,000	10260	17353
Small Hydro	1,434	1,976	1,400	1419	3395
Bio power	389	1,184	1,780	2042	3225
Solar	2	3	200	938	941
Total	**3,453**	**10,255**	**12,380**	**14659**	**24914**

Table -2 shows the estimated potential and installed capacity of various renewable energy sources in India (as per MNRE) [8].

Table -2: Estimated Potential and Installed Capacity of Different Renewable Energy Sources in India

Source	Estimated potential (MW)	installed capacity by end of 11th Plan 31.3.2012	Capacity addition target for 12th Plan (2012-17)	Target installed capacity at the end of 12th Plan
Wind	49,000	17353	15,000	32553
Small Hydro	15,000	3395	2,100	5495
Biomass power	17,000	1150	500	1650
Bagasse Cogeneration	5000	1985	1400	3385
Waste to power	2,600 1,300	90	500	590
Solar power	>100,000	941	10,000	10,941
Total	>1,89,900	24914	29,500	54414

3.1 Solar Energy Status

India has its potential of energy generation of about 30-50 MW/sq km. of shadow-free area covered with solar collectors for most parts of the country [8]. In solar energy sector, some large projects have been proposed, and a 35,000 km^2 area of the Thar Desert has been set aside for solar power projects, sufficient to generate 700 to 2,100 GW [9]. According to MNRE, the potential of solar energy is >100000 MWeq i.e. 30 -50 MW/sq. km and the cumulative

deployment of grid interactive solar power up to 31.03.2012 is 941 MW. In July 2009, India unveiled a $19 billion plan, to produce 20 GW of solar power by 2020. On November 18, 2009, it was reported that India was ready to launch its National Solar Mission under the National Action Plan on Climate Change, with plans to generate 1,000 MW of power by 2013 [8,10]. Table-3 furnishes the detailed state-wise solar power capacity in India (as per MNRE) [8].

Table -3: Estimated Potential and Installed Capacity of Different Renewable Energy Sources in India

Serial No.	State	Capacity (MW)
1	Andhra Pradesh	15.0
2	Chhattisgarh	4.0
3	Haryana	4.8
4	Jharkhand	2.0
5	Karnataka	1.0
6	Maharashtra	17.0
7	Orissa	4.0
8	Punjab	4.0
9	Rajasthan	123.5
10	Tamil Nadu	8.0
11	Uttarakhand	2.0
12	Uttar Pradesh	2.0
13	West Bengal	1.0
	TOTAL	**188.3**

3.2 Wind Energy Status

The development of wind power in India began in the 1990s, and has significantly increased in the last few years. India has the fifth largest installed wind power capacity in the world [9].

MNES estimates total available wind-generated capacity in India to be at least 20,000 MW. The distribution of wind farms is concentrated in Tamil Nadu and Kutch (Gujarat), those two states accounting for over 750 MW of the installed capacity. The large majority of all wind farms (accounting for 775 MW of the total19) are commercial undertakings. In Maharastra, four demonstration wind farms are currently operational. I was able to visit only one of these sites, a grid-connected 2.77-MW installation at Chalkiwadi, built and operated by the Maharastra Energy Development Agency [11].

Reportedly, a total capacity of 17353 MW Wind Power has been established up to 31st March, 2012 in the country, which is about 70% of the cumulative deployment of the grid interactive Renewable Power. The Ministry has informed that against the 11th Plan target of 9,000 MW wind power, the achievement is 10,260 MW. Further, the capacity addition target for wind power for 12th Plan (2012-17) is 15,000 MW. Thus the aggregate capacity of 32553 MW is likely to be harnessed by the end of 12th Plan [8].

3.3 Hydro Energy Status

The reported estimated potential for power generation in the country from small /mini hydel projects is about 15,000 MW from 5718 identified sites. Out of this potential, about 50% lies in the States of Himachal Pradesh, Uttarakhand, Jammu & Kashmir and Arunachal Pradesh. In the plain regions Maharashtra, Chattisgarh, Karnataka and Kerala have sizeable potential. So far 837 small hydropower projects aggregating to 3163 MW up to January, 2012 have been set up in various parts of the country and 364 projects of about 1149 MW are in various stages of implementation. The Ministry 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) [8].

3.4 Biomass Energy Status

India is very rich in biomass and has a potential of 16,881MW (agro-residues and plantations), 5000MW (bagasse cogeneration) and 2700MW (energy recovery from waste) [9,12]. The availability of biomass in India is estimated at about 540 million tons per year covering residues from agriculture, agro industrial, forestry, and plantations. 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 MWeq of grid quality power can be generated with presently available technologies. A cumulative capacity of 1200 MW (as on 31.03.2012) 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. The biomass power/cogeneration programme was initiated by the Ministry at the end of 8th Plan and had achieved 86 MW capacity against the target of 25 MW. Capacity addition target for the 12th Five Year Plan for this sector is 1900 MW [8].

3.5 Geothermal Energy Status

Geological Survey of India (GSI) has identified about 340 geothermal hot springs in the country. The rough estimates based on GSI studies indicate that energy generation potential is 10,000 MW. These springs are perennial and their surface temperatures range from 37 °C - 90 °C which is suitable for direct heat applications and reservoir temperature 102 °C – 260 °C. So far the Ministry has been able to undertake only shallow bore hole drilling at some of the geothermal fields. These geothermal resources are distributed in the States of Andhra Pradesh, Chhattisgarh,

Gujarat, Himachal Pradesh, Jammu & Kashmir, Jharkhand, Maharashtra, Orissa, Uttarakhand and West Bengal [8, 9].

3.6 Tidal Energy Status

According to the MNRE, 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 Kuchchh 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. 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 Kuchchh in the State of Gujarat and about 100 MW in the Gangetic Delta in the Sunderbans region in the State of West Bengal [8].

3.7 Ocean Energy Status

Ocean-energy development in India is presently limited to a handful of projects in the proposal stage, and a few experimental stations [11]. The Indian OTEC program started in 1980 with the proposal of General Electrical Co. of USA to install a 20 MW plant off the Tamil Nadu coast and subsequently in 1982, an OTEC cell was formed in the Indian Institute of Technology, Madras. A preliminary design was also done in 1984. After a survey, a land based 1 MW capacity OTEC plant was suggested in Lakshadweep [14].

In 1993, National Institute of Ocean Technology (NIOT) was formed by the Department of Ocean Development (DOD), Government of India to pursue the research activities on ocean energy as part of their various mission-based activities. An MOU was signed in 1997 between NIOT and Saga University, Japan for a joint development of OTEC in India. NIOT conducted detailed surveys at the proposed OTEC site near Tuticorin, South India. Based on the temperature and bathymetric profiles, the optimisation of the closed loop systems was done with the help of Saga University in 1998.[14] Integration of the plant and stage qualification tests was carried out in 2000-02. The plant was reported to be ready for demonstration of the technology [15].

3.8 Urban & Industrial Waste to Energy Status

The MNRE has been implementing a programme for Energy Recovery from Urban and Industrial Wastes. The MNRE has reported that about 50 million tons of solid waste (1.40 lakh tons 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. As on 31st March, 2012 a capacity of 90 MW has been installed. Ministry informed that about 80 projects for energy recovery from variety of industrial waste with an aggregate capacity of 145 MWeq have been installed in the country [8].

4. ADVANTAGES OF NON-CONVENTIONAL ENERGY TECHNOLOGIES / RENEWABLE ENERGY TECHNOLOGIES

The various advantages of non-conventional/renewable energy technologies are as follows:

a) Non-conventional/renewable energy is an indigenous source available in considerable quantities to all developing nations and capable, in principle of having a significant local, regional or national economic impact.

b) Several renewable options are financially and economically competitive for certain applications.

c) There is a great scope of research and development in non-conventional/renewable energy sectors regarding its future development and scientific utilisation.

d) The power plants based on renewable do not have any fuel cost and hence negligible running cost.

e) Renewable have low energy density and more or less there is no pollution or ecological balance problem. Provide energy in environmentally benign manner.

f) The use of non-conventional/renewable energy could help to conserve foreign exchange and generate local employment if conservation technologies are designed, manufactured, assembled and installed locally.

g) Short gestation period and low investment.

5. BOTTLENECKS AND CONSTRAINTS

There are several hurdles concerned with the development of non-conventional/renewable energy sectors in developing countries. These are:

A. Non-conventional/renewable energy Technologies are capital intensive and require high initial investment.

B. The power purchase policy has not been encouraging for private entrepreneurs and suitable policy initiatives.

C. Technologies for several non-conventional/renewable energy sources have not fully stabilised.

D. The cost of non-conventional/renewable energy gadgets/ devices such as solar cooker, biogas, solar geysers, solar lanterns etc., is high.

E. Fiscal incentives namely 100% depreciation attracted several private investors.

F. Adequate number of professionally skilled manpower has not been developed in the non-conventional/renewable energy sector.

6. STEPS FOR THE BETTER AND EFFICIENT USE OF NON-CONVENTIONAL/RENEWABLE ENERGY TECHNOLOGIES

For development, dissemination and better and efficient use of renewable energy technologies in the country, following steps may be suggested:

a) Setting up biomass/solar/wind power generation systems and energy saving in every government office to encourage and inspire people.

b) Strenuous exaltation of non-conventional/renewable energy by government agencies, public sector, corporate, academic institutions etc.

c) Foundation of national-level body to increase awareness of non-conventional/renewable energy at comprehensive level.

d) Research and development of non-conventional/renewable energy technologies get provided the financial support and sponsorship.

e) Development of technically trained man-power for non-conventional/renewable energy sectors.

f) Establishing aspiring goals and targets for power generation non-conventional/renewable sources.

g) Making it compulsory to install solar water heating systems for all urban residential and commercial establishments.

h) Imperative non-conventional/renewable energy systems provision for new residential, commercial and industrial buildings.

i) Restricting use of large battery energy storage systems and promoting use of biofuels in vehicles.

j) Abrogating duties / taxes on import of small-scale non-conventional/renewable energy generating equipment and providing manageable loans for setting up non-conventional/renewable energy enterprises.

k) Handsome incentives and subsidies for installation and successful operation of non-conventional/renewable energy equipment and additional incentives for buyers and manufacturers of renewable energy equipments in rural areas.

l) Cultivation of energy crops on marginal and degraded land.

6. CONCLUSIONS

The sustainable economic development and growth of any country are closely related to the development and security of its energy sectors. Concerning the finite and limited reserves of conventional energy sources and their impact on environment, a great emphasis should be given to the development of non-conventional energy sectors and their proper utilisation for the benefit and betterment of mankind. Such initiatives would also be helpful to create many employment opportunities at all levels, especially in rural areas. Thus, mainstreaming of non-conventional and renewable energy technologies is becoming very essential for the developing countries.

In India, there is great scope for the development of non-conventional and renewable energy sectors. India is the only country that has an exclusive Ministry for New and Non-Conventional Energy Sources. India possesses the largest decentralised solar energy programme, the second largest biogas and improved stove pogrammes, and the fifth largest wind power programme in the world. However, India Government and different NGOs have spread their hands to promote the development of non-conventional energy sectors in India by implementing different policies and strategies. These include innovation and basic research in non-conventional/renewable energy technologies, establishing courses on non-conventional/renewable energy in higher education, resolving the barriers to development and commercial deployment of biomass, hydropower, solar and wind technologies, promoting the development and manufacture of small wind electric generators, and enhancing the regulatory/tariff regime in order to main stream non-conventional and renewable energy sources in the national power system.

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