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Renewable Energy Technologies-An Effective Driving Force of Energy Independent Future India

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***Abstract—Most** of the power generation in India is carried out by conventional energy sources, coal and mineral oil-based power plants which contribute heavily to greenhouse gases emission. This focuses the solution of the energy crisis on judicious utilization of abundant renewable energy resources.*

India is on the path of rapid economic growth along with speedy overall development; simultaneously it has to face the global threat of climate change. So, India has unique renewable energy resources (RES) and development of country depends to a great extent on harnessing these sources. Renewable energy sources and technologies have potential to provide solutions to the longstanding energy problems being faced by the developing countries like India. Renewable energy is a sustainable and clean source of energy derived from nature. These technologies have long been recognized as an important part of the solution to address energy security concerns and ensure economic growth in an environment friendly manner. The renewable energy based power generating systems can play a major role towards the fulfillment of energy requirements. This paper shows the potentials of available energy technologies and its act as a driving force by increasing the utilization of renewable energy sources to reduce the energy demand and become energy independence and current progress or achievement of renewable energy in India.

Keywords—energy conservation, renewable energy sources- solar, wind, biomass, small hydro, ocean

I. INTRODUCTION

India is the fourth largest energy consumer in the world after the United States, China, and Russia . In recent years, India's energy consumption has been increasing at a relatively fast rate due to population growth and economic development. Rapid urbanization and improving standards of living for millions of Indian households, the demand is likely to grow significantly. In order to sustain the production, industries have opted for inefficient diesel-fuelled backup power. India's energy planning, which is based on the twin objectives of high economic growth and providing electricity to all, is failing to meet either.

The domestic power demand of India was 918 billion units in 2012. It is expected that at 9.8% annual growth the demand will reach 1,640 billion units by 2020. At this pace, India will require 390 GW in the next eight years which is almost double its current installed capacity of 210 gigawatts (GW). There is growing energy inequity between rural and urban areas and also between the developed and developing states. There are millions who are yet to be benefited from electricity in rural India. The scarcity of electricity in rural areas in comparison to urban areas seems to be biased in delivery through the centralized system. While the urban-rural difference in energy supply could be reduced through renewable energy, it is more complex to overcome the widening gap between developed and not so developed states.

Current centralized energy planning of India is dependent on coal and fossil fuel sources. The main concern arises on how to protect the fossil fuel for our coming generation with simultaneously utilizing the different resources of energy for high and sustained economic growth. Pressure to increase its energy supplies and the consequent negative environmental impact of fossil fuels has led India to a conscious policy toward renewable sources.

Current scenario of energy demand and supply demands the research and development activities in exploration of new reserves. There are huge amount of potential available in the renewable energy system which can be explored and Harnessed to meet the energy demand.fig.1 represents the forecast of energy demand.

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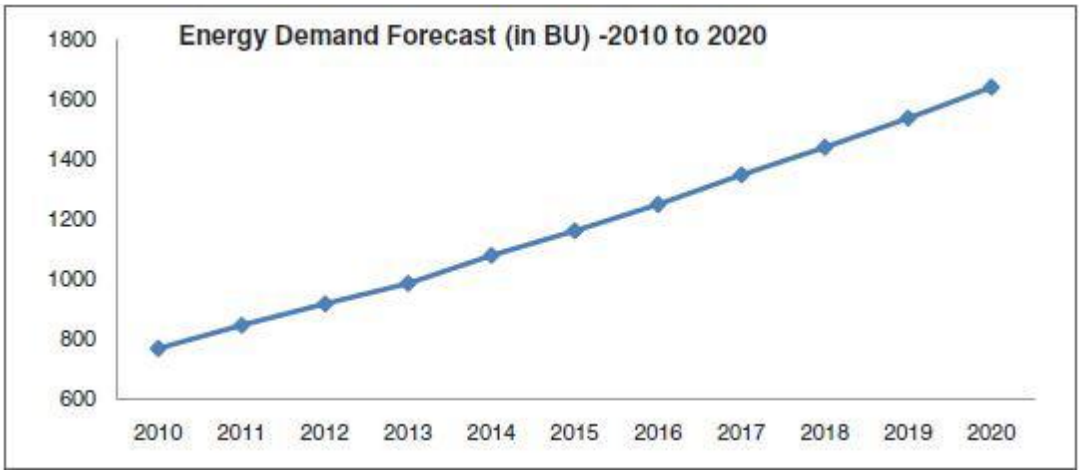


Figure 1: Energy demand projection in India

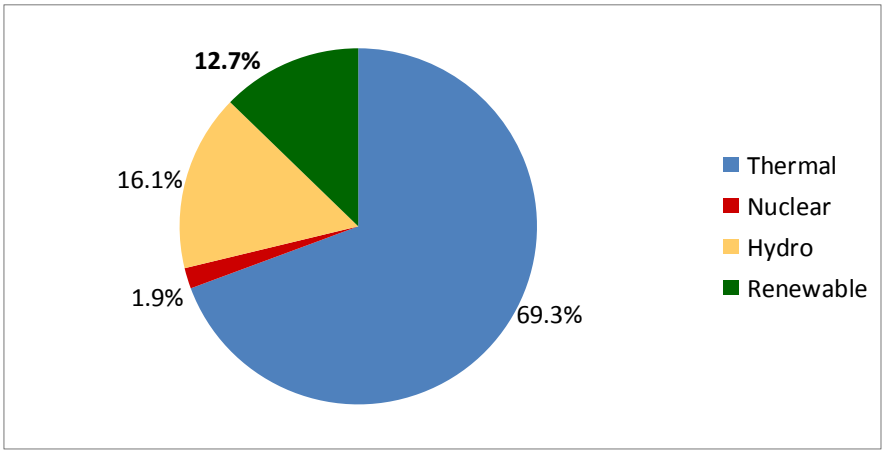
Source: www.greenpeace.org/india/Global/india/report/2013/powering-ahead-with-renewables.pdf

II. SIGNIFICANCE OF ENERGY CONSERVATION

Energy has an important function. It is the central force behind our productivity, our leisure and our environment. There is a strong correlation between energy use per person and standard of living in each economy. Higher per capita energy consumption means a higher per capita gross national product. Energy is an indispensable component of industrial product, employment, economic growth, environment and comfort. Low cost energy was abundant in the past. Energy cost was only a very small fraction of the cost of finished product. Use of low cost energy for home comfort became very predominant. The subsequent increase in oil prices increased the energy cost in every sector, domestic, commercial, industrial etc. The per capita energy consumption in India is very low as compared to that in advanced countries. However our energy resources are fast getting depleted. Thus energy saving or conservation is essential in developed as well as developing countries.

Energy conservation contributes to the security of energy-supply, economic growth and the resolution of problems of fuel-poverty. Controlling transmission losses is just one aspect of energy conservation. More critical is conservation of energy in the industrial, commercial, transportation and domestic sectors and Energy efficiency/conservation measures can reduce peak and average demand of electricity.

III. UTILIZATION OF NON RENEWABLE ENERGY SOURCES IN INDIA



Thermal	Hydro	Nuclear	Renewable	Total
176,118.6 MW	40,798.8 MW	4,780 MW	32,307.71 MW	254,005.1 MW

Figure 2

Power Installed Capacity = 253.390 GW

Resources: MNRE – Reinvest commit 15-17 feb-2015 (As of 31st August 2014)

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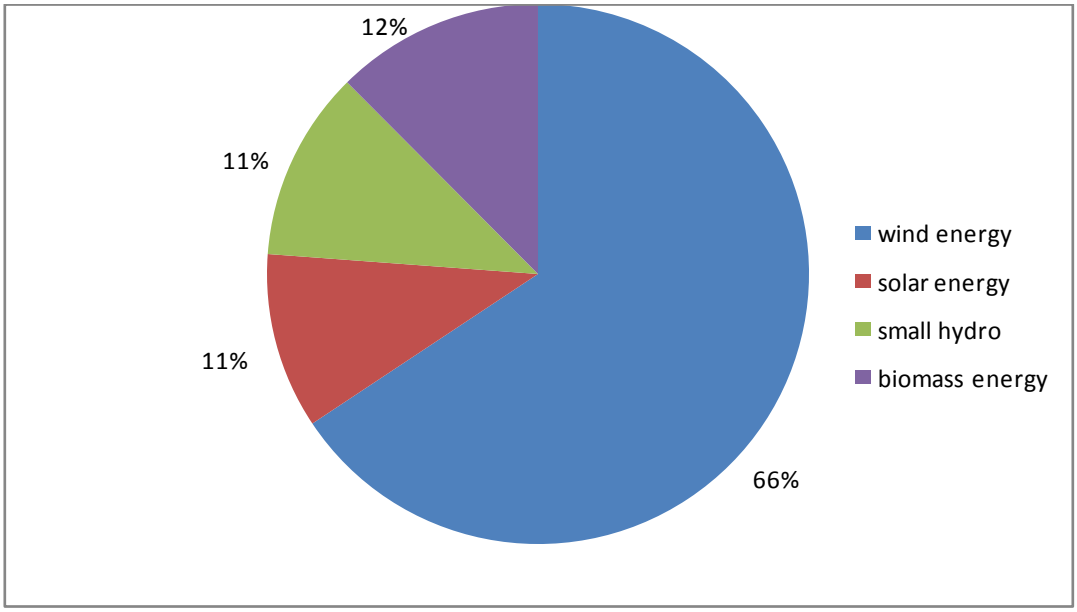
Based on the analysis of trends in conventional energy consumption and production in India over last four decades (as shown in Fig. 2), one can expect the Indian power requirements will be increased in prodigious rate in near future. India is 11th largest economy and 4th largest purchasing power in the world, yet India bagged 29th position globally in terms of the primary energy consumption. This clearly revealed that Indians are already utilizing energy efficiently.

A. India's energy usage has been rapidly increasing as a result of economic growth in the last decade and the large population;
B. Per capita consumption of electricity in India (2.02kWh) is very low compared to Canada (51.5kWh), USA (39.25kWh) and other developed countries.
C. India is one of the major coal importing nations in the world
D. More than 25% of primary energy needs being met by imports mainly in the form of crude oil and gas
E. India is endowed with vast renewable energy resources including wind, solar, biomass and small hydro.
F. India needs to develop the available renewable energy to meet its growing power needs and ensure energy security

IV. UTILIZATION AND POTENTIAL OF RENEWABLE ENERGY SOURCES IN INDIA

Though India has enormous potential for renewable energy, and as of today, renewable energy based power generation constitutes 7% of the total installed capacity in the country for power generation from all sources. The Ministry of Nonconventional Renewable Energy (MNRE) has estimated an aggregate of over 150,000 MW and only 10 % installed capacity has been achieved so far as against the estimated renewable energy based grid connected power potential. This warrants the strong actions to be taken for achieving self-sustenance in energy requirements.



Wind energy	Solar energy	Small hydro	Biomass energy	Total energy
23444 MW	3744 MW	4055 MW	4449 MW	35692 MW

Figure.3
Resources:/MNRE achievements/current status wikipedia-2015 (As of March 2015)

Table 1: Renewable Power Projects Potential

Resource	Potential (MW)	Cumulative achievement
Wind	49,130(50m hub height) 102,788(80m hub height)	23444.00 MW

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Small Hydro(up to 25MW)	19,700	4055.00 MW
Biomass including bagasse cogeneration	22,500	4,449.00 MW
Solar	50MWp/km^2	3744 MW

4.1 WIND ENERGY

The development of wind power in India began in the 1990s, and has significantly increased in the last few years. Although a relative newcomer to the wind industry compared with Denmark or the United States, India has the fifth largest installed wind power capacity in the world. In 2009-10 India's growth rate was highest among the other top four countries.

The MNRE has announced a revised estimation of the potential wind resource in India from 49,130 MW assessed at 50m Hub heights to 102,788 MW assessed at 80m Hub height. The wind resource at higher Hub heights that are prevailing is possibly even more. In the year 2015, the MNRE set the target for Wind Power generation capacity by the year 2022 at 60,000 MW.

As of 31 March 2015 the installed capacity of wind power in India was 23,444 MW, mainly spread across Tamil Nadu (7,253 MW), Gujarat (3,093 MW), Maharashtra (2,976 MW), Karnataka (2,113 MW), Rajasthan (2,355 MW), Madhya Pradesh (386 MW), Andhra Pradesh (916 MW), Kerala (35.1 MW),etc. East and North east regions have no grid connected wind power plant as of March, 2015 end. No offshore wind power farm utilizing traditional fixed-bottom wind turbine technologies in shallow sea areas or floating wind turbine technologies in deep sea areas is under implementation.

4.2 SOLAR ENERGY

India is densely populated and has high solar insolation, an ideal combination for using **solar power in India**. Moreover, it's other energy resources are relatively scarce. In the solar energy sector, some large projects have been proposed, and a 35,000 km^2 (14,000 sq. mi) area of the Thar Desert has been set aside for solar power projects, sufficient to generate 700 to 2,100 GW.

With about 300 clear, sunny days in a year, India's theoretical solar power reception, on only its land area, is about 5,000 trillion kilowatt-hours (kWh) per year (or 5 EWh/yr.). The daily average solar energy incident over India varies from 4 to 7 kWh/m^2 with about 1,500–2,000 sunshine hours per year (depending upon location), which is far more than current total energy consumption. For example, assuming the efficiency of PV modules were as low as 10%, this would still be a thousand times greater than the domestic electricity demand projected for 2015.

The amount of solar energy produced in India in 2007 was less than 1% of the total energy demand. The grid-connected solar power as of December 2010 was merely 10 MW. Government-funded solar energy in India only accounted for approximately 6.4 MW-yrs. of power as of 2005. However, India is ranked number one in terms of solar energy production per watt installed, with an insolation of 1,700 to 1,900 kilowatt hours per kilowatt peak (kWh/KWp). 25.1 MW was added in 2010 and 468.3 MW in 2011.

By end March 2015, the installed grid connected solar power capacity is 3,744 MW, and India expects to install an additional 10,000 MW by 2017 and a total of 100,000 MW by 2022.

Table:2

Installed PV capacity (in MW)		
Year End	Total Capacity	Yearly Installation
2010	161	
2011	461	300
2012	1,205	744
2013	2,319	1,114
Mar-14	2,632	313
Mar-15	3,744	1112

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Source: MNRE achievement

4.3 SMALL HYDRO POWER

Hydro projects in India, which are under 25 MW in capacity, are classified as "small hydropower" and considered as a "renewable" energy source. The use of small hydro power (SHP) in India goes way back in history, with the country's first SHP plant having come up in 1897. The sector has been growing rapidly for the last decade. The Number of SHP plants has doubled. SHP is by far the oldest renewable energy technology used to generate electricity in India.

The total installed capacity of SHP projects in India was 3,632 MW in March 2013. This is spread over 950 projects; hence, the average SHP project capacity is 3.8 MW. This does not include micro-hydel plants. The draft 12th Five Year Plan (2012-17) has, as its target, 2,100 MW of SHP capacity4. The total potential country-wide capacity is estimated at 19,749 MW, of which about 1,250 MW is under development. The current total installed capacity of small hydro power plants is 3746.75 MW.

India has an estimated small hydro power (less than 25 MW) potential of around 20,000 MW out of which the total installed capacity as of 31stMarch 2015 was 4055.36 MW including both off- grid and grid connected power plants.

4.4 BIOMASS & BIOGAS ENERGY

Biomass is a renewable energy resource derived from the carbonaceous waste of various human and natural activities. It is derived from numerous sources, including the by-products from the timber industry, firewood, agricultural residues such as bagasse, crop straw, animal dung and wastes generated from agro-based industries. Biomass takes carbon out of the atmosphere while it is growing, and returns it as it is burned. If it is managed on a sustainable basis, biomass is harvested as part of a constantly replenished crop. Municipal solid wastes, animal and poultry wastes are also referred to as biomass as they are biodegradable in nature.

The main biomass sources are as listed below.

A. Wood and wood waste: forest wood, wood from energy plantations, saw dust, tree branches and leaves etc.
B. Agricultural residues: rice husk, bagasse, groundnut shells, coffee husk, straws, coconut shells, coconut husk, arhar stalks, jute sticks etc.
C. Aquatic and marine biomass: algae, water hyacinth, aquatic weeds and plants, sea grass beds, kelp, coral reef etc.
D. Wastes: municipal solid waste, municipal sewage sludge, animal waste, paper waste, industrial waste etc.

In India, a total of 4,449 MW has been installed under bio energy, both in grid connected and off-grid capacities.

Table: 3

Type	Grid connected	Capacity installed (MW)
Biomass power	on-grid	1265
Bagasse cogeneration	on-grid	2337
Waste to power(urban)	on-grid	96
	off-grid	116
Biomass(non bagasse) cogeneration	off-grid	475
Biomass gasifiers(rural)	off-grid	17
Biomass gasifiers(industrial)	off-grid	143
Total		**4449**

4.4 OCEAN THERMAL ENRGY

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OTEC, Ocean Thermal Energy Conversion is an energy technology that converts solar radiation to electric power.OTEC systems use the ocean's natural thermal gradient, consequently the temperature difference between the warm surface water and the cold deep water below 600 meters by about 20 C, an OTEC system can produce a significant amount of power. The oceans are thus a vast renewable resource, with the potential to help us produce billions of watts of electric power. The cold seawater used in the OTEC process is also rich in nutrients and it can be used to culture both marine organisms and plant life near the shore or on land. The total influx of solar energy into the earth is of thousands of times as great as Mankind's total energy use. All of our coal, oil and natural gas are the result of the capture of solar energy by life of the past. There have been many projects for harnessing solar energy, but most have not been successful because they attempt to capture the energy directly. The problem with this is that huge collectors must be deployed to do this, and resulting in large costs. The idea behind OTEC is the use of all natural collectors, the sea, instead of artificial collector .Unlike wind and solar, the Plant Load Factor (PLF) of these plants may be around 80 percent. India has built a 1MW floating OTEC pilot plant near Tamil Nadu. a pilot plant of capacity 14 MW is proposed to be set up in the State

V. CONCLUSION

Renewable energy sector growth in India during the last few years has been significant, even for electricity generation from renewable sources. The need to increase the use of renewable energy sources for sustainable energy development has been recognized by the Government. The Government has given significant thrust to the research, development and induction of renewable energy technologies in different sectors. India is blessed with an abundance of sunlight, water, biomass and biofuels resources.

Renewable energy is experiencing new enthusiasm and vibrancy all across, and the foundation of a new economy is being laid that is inclusive, sustainable and aspires for de-carbonization of energy in a definite time frame. Increased recognition of the contribution renewable energy makes to rural development, lower health costs (linked to air pollution), energy independence, and climate change mitigation is shifting renewable energy from the fringe to the mainstream of sustainable development. For renewable development in India, the renewable energy program has been in existence for more than three decades, the popularity of renewable technologies canbe noted by continued rapid growth, despite economic breakdown and financial crisis. Renewable energy on a large scale will help in tackling issues like energy scarcity, variations in fuel prices and help India to be self-sustainable.

The Ministry of New and Renewable Energy to exploit the abundant renewable energy resources of India has launched a multifaceted renewable energy programme. India is set to emerge as a hub of wind, solar, biomass and biofuels related manufacturing and exports because of its very strong manufacturing and R&D orientation. The Government of India to accelerate the pace of renewable energy in the country has announced The National Solar Mission under the National Action Plan on Climate Change which envisages a 20,000MW solar capacity addition by 2022. India's renewable growth so far has been financed domestically and conservatively. Majority of financing has been asset financing in the area of wind where captive power generators have been investing to expand wind-manufacturing capacity and project development.

India has set a target of achieving overall renewable energy installed capacity of 41,400 MW by 2017 and 72,400 MW by 2022. To achieve this target, India will have to add 40,130.39 MW of renewable energy installed capacity. India has the world's fifth-largest electricity generation capacity which currently stands at 243 GW. Renewable energy including large hydro constitutes for only 28.8% of overall installed capacity in India. The total renewable energy potential from various sources in India is 2,49,188 MW.

Up until 31st March 2015 India has been able to achieve only 13% of its renewable energy potential. The untapped market potential for overall renewable energy in India is 216918.39 MW which shows huge growth potential for renewable energy in India. India is fast emerging as a country with a vibrant renewable energy ecosystem that is expanding rapidly.

India is betting on solar and wind energy to boost power generation, reduce dependence on fossil fuels, and strengthen negotiating position at global climate change.Renewable energy has the possibility of becoming the foundation for the country's future energy requirements.

The current targets and Achievements of renewable energy by MNRE are:

Sector	FY- 2014-15		
	Target	**Achievement**	**Cumulative Achievements**
I. GRID-INTERACTIVE POWER (CAPACITIES IN MW)			
Wind energy	2000.00	2312.00	23444.00
Small Hydro Power	250.00	251.61	4055.36
Biomass Power & Gasification	100.00	45.00	1410.20

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Bagasse Cogeneration	300.00	360.00	3008.35
Waste to Power	20.00	8.50	115.08
Solar Power	1100.00	1112.07	3743.97
Total	**3770.00**	**4089.18**	**35776.96**
II. OFF-GRID/ CAPTIVE POWER (CAPACITIES IN MW_{EQ})			
Waste to Energy	10.00	21.78	154.47
Biomass(non-bagasse) Cogeneration	80.00	60.05	591.87
Biomass Gasifiers	0.80	0.61	17.95
-Rural	8.00	6.15	152.05
-Industrial			
Aero-Generators/Hybrid systems	0.50	0.27	2.53
SPV Systems	60.00	60.00	234.35
Water mills/micro hydel	4.00	4.00	17.21
Bio-gas based energy system	0.00	0.30	4.07
Total	**163.30**	**93.16**	**1174.50**

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