# CURRENT TRENDS IN RENEWABLE ENERGY: AN OVERVIEW

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## *ABSTRACT*

*The renewables-based energy system represents a unique opportunity to meet climate goals while increasing economic growth, creating new employment opportunities and enhancing human welfare. Hence the role of renewable energy has been assuming increasing significance in recent times with the growing concern for the energy security. This paper overviews the current trends of renewable energy globally and particularly in India as well as their growth and environmental issues.*

## *KEYWORDS*

*Renewable Energy Sources, Growth of renewable energy, Environmental issues*

## 1. INTRODUCTION

According to the Texas Renewable Energy Industry Alliance (TREIA), an USA based NGO; the renewable energy is defined as adopted by the Texas Legislature, ″any energy resource that is naturally regenerated over a short time scale and derived directly from the sun (such as thermal, photochemical and photoelectric), indirectly from the sun (such as wind, hydropower and photosynthetic energy stored in biomass) or from other natural movements and mechanisms of the environment (such as geothermal and tidal energy). Renewal energy does not include energy resources derived from fossils fuels, waste products from fossil sources or waste products from inorganic sources″.

Renewal energy provides energy in four important areas –

- Electricity generation
- Hot water/ space heating
- Transportation
- Rural (off-grid) energy services

As per Renewal Energy Policy Network for the 21st century ( REN21) Global Status Report 2015, the share of renewable energy are as follows –

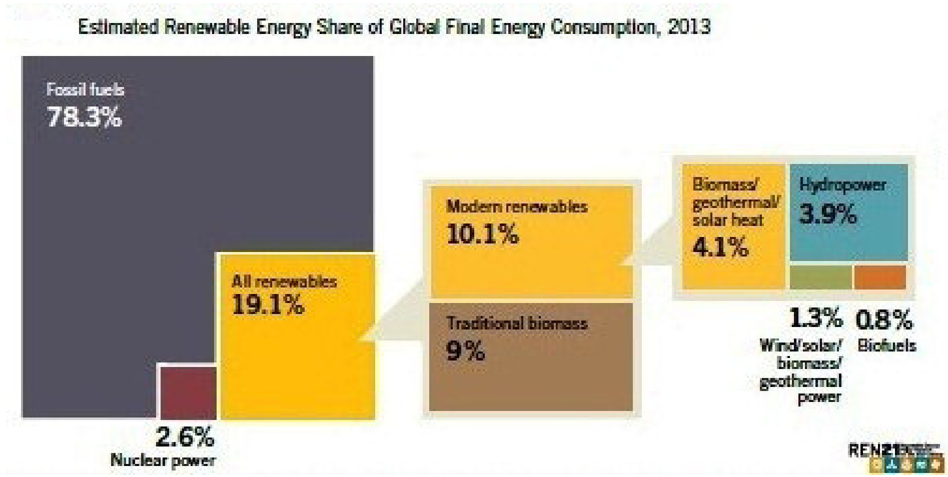


Fig 1 Share of renewable energy (Source – REN21 Global Status Report 2015)

As per REN21′s 2015 report, renewable hydroelectric provides 16.6% of the world electricity. Combined this with other renewables such as wind, solar, geothermal, biomass and waste together, they make the renewables total 22.8% of electric generation worldwide.

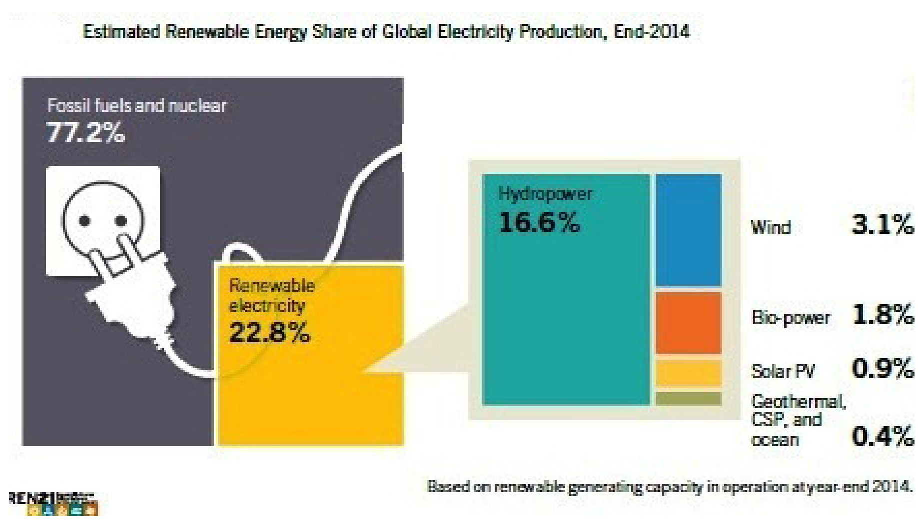


Fig 2 Share of renewable energy towards total Electric Production (Source – REN21)

Some countries get most of their power from renewables like Iceland – 100%, Norway – 98%, Brazil – 86%, Austria – 62%, New Zealand – 65% and Sweden – 54%.

Solar water heating makes an important contribution to renewable heat. China takes the lead – 70% of the global total (180 GW). Direct geothermal for heating is also growing rapidly. The newest addition to heating is from Geothermal Heat Pump which provides both heating and cooling.

There are three main entry points for renewable energy in the transport sector:

- Use of 100% liquid biofuels or blended biofuels with conventional fuels;
- Growing role of natural gas;
- Increasing electrification of transportation.

To date, however, the primary focus of policies, markets, and industries in the transport sector has been on liquid biofuels as ethanol and biodiesel.Bioethanol can be used as a fuel for vehicles in its pure form but it is usually used as a gasoline additive to increase octane and improve vehicle emissions. It is widely used in USA and Brazil. Biodiesel can also be used as a fuel for vehicles in its pure form but it is usually used as a diesel additive to reduce levels of particulates, carbon monoxide and hydrocarbons from diesel-powered vehicles. It is most common biofuel in Europe. Renewables also are used in the form of electricity for trains, light rail, trams, and both two- and four-wheeled electric vehicles. A solar vehicle is an electric vehicle powered completely or significantly by direct solar energy. Usually, photovoltaic (PV) cells contained in solar panels convert the sun′s energy directly into electric energy. The United States led the world in the size of its electric vehicle (EV) passenger fleet, but Norway led in the share of EVs in annual vehicle sales in 2014.

## 2. ISSUES LED TO THE DEVELOPMENT OF RENEWABLE ENERGY

The global community and governments are faced with four major challenges with respect to the energy sector:

- Increasing energy demand and concern over energy security
- Combating climate change
- Reducing pollution and public-health hazards
- Addressing energy poverty.

### 2.1 Energy Security

Increasing energy demand together with rising energy prices raise concerns about energy security, which covers a range of issues, including the reliability and affordability of national sources of supply. Concerns are more relevant particularly in low income and developing countries. The International Energy Agency's Current Policies scenario, which assumes no change in policies as of mid-2010, projects a growth rate of 1.4 per cent per year up to 2035.The fastest growth is expected in non-OECD (organization for Economic Co-operation and Development) countries with a projected rate of 2.2 per cent per year, particularly in China and India and other emerging economies in Asia and the Middle East. Investing in renewable sources that are available locally over wide geographical areas – in many cases abundantly – could enhance energy security for such countries. Rapid deployment of renewable energy and energy efficiency, and technological diversification of energy sources, would result in significant energy security and economic benefits.

## 2.2 Climate Change

Burning of fossil fuels causes environmental pollution due to emission of $CO_2$, which in turn raises average global temperature. IPCC (2007) and IEA (2008c) estimate that in order to limit the rise of average global temperature to 2 degrees Celsius, the concentration of GHG should not exceed 450partsper million (ppm) $CO_2$-eq. There are still large uncertainties, however, concerning how to reach the emission reduction goals and the “two-degree” target agreed by most countries at the UN Climate Change Conference in Copenhagen in 2009. A shift from fossil fuels to renewable energy in the energy supply can contribute to achieving ambitious emissions-reduction targets, together with significant improvements in energy efficiency. To keep the concentration of GHGs at 450 ppm in 2050, the IEA projects that renewable energy should account for 27 per cent of the required $CO_2$ reductions, while the remaining part would result primarily from energy efficiency and alternative mitigation options such as carbon capture and sequestration.

## 2.3 public health hazard

The combustion of fossil and other traditional fuels has many adverse effects on human health. Studies from Asia, Africa, and the Americas have shown that indoor air pollution levels are high in households that rely on coal or traditional biomass fuel, causing a considerable disease burden (Ezzati and Kammen 2002). Indoor air pollution from burning solid fuel accounted for 2.7 per cent of the global burden of disease in 2000 and is ranked as the largest environmental contributor to health problems after unsafe drinking water and lack of sanitation. Most of the deaths occur in Africa, South-East Asia and the Western Pacific where a large majority of households prepare their meals by using traditional fuel appliances (WHO 2006). In addition to cooking, lighting with kerosene (also known as paraffin) adversely affects public health (WHO 2009).

Renewable energy generation can mitigate or avoid many of the public health risks caused by the mining, production and use of fossil fuels. Further the access to modern energy enables the deployment of technologies that can control endemic and emerging diseases by providing safe drinking water and by keeping foods and medicines refrigerated.

## 2.4 energy poverty

Expanding access to energy is a central challenge for developing countries. Reliable and modern energy services are needed to facilitate poverty reduction, education, and health improvements, as reflected in a number of Millennium Development Goals (MDGs). The scale of the challenge is massive with 1.4 billion people currently lacking access to electricity, and 2.7 billion depending on traditional biomass for cooking in developing countries as calculated by IEA, UNDP and UNIDO (IEA 2010a). Under current trends, the IEA estimates that by 2030 1.2 billion people will still lack access to electricity and the number relying on biomass will even rise slightly to 2.8 billion. Renewable energy sources offer some cost-effective solutions to solving energy poverty.

# 3. CURRENT SCENARIO

Climate change and global warming concerns, coupled with high oil prices and increasing government support, are driving increasing renewable energy legislation, incentives and commercialization. New government spending, regulation and policies helped the renewal industry. According to a 2011 projection by the International Energy Agency (IEA), solar power generators may produce most of the world's electricity within 50 years, reducing the emissions of greenhouse gases that harm the environment. At the national level, at least 30 nations around the world already have renewable energy contributing more than 20% of energy supply. National renewable energy markets are projected to continue to grow strongly in the coming decade and beyond. Some 120 countries have various policy targets for longer-term shares of renewable energy, including a 20% target of all electricity generated for the European Union by 2020. Some countries have much higher long-term policy targets of up to 100% renewables.

# 4. DETAILS OF EMERGING TECHNOLOGIES IN RENEWABLE ENERGY

## 4.1 wind energy

Airflow of wind is utilized to generate electricity according to equation$P_{wind} = \frac{1}{2} C_P \rho A V^3$.

Fig 3 Blades of Wind Turbines

### 4.1.1growth rate

From 2004 to 2014, worldwide installed capacity of wind power has been growing from 47 GW to 369 GW—a more than sevenfold increase within 10 years with 2014 breaking a new record in global installations (51 GW). In 2014 wind generated almost 4% of the world's total electricity. Wind power is widely used in Europe, China and the United States. More than 80 countries around the world are using wind power on a commercial basis. Worldwide markets for wind energy technology are expected to continue this dynamic growth trend. The US Department of

Energy estimates that the world′s wind could supply up to 580 trillion kWh of electricity each year, however the USA consumes only about 2.8 trillion kWh annually. World′s largest wind turbine of unit size 7MW is developed and installed in Germany. Current globally average installation trends is of 1.5- 2.5 MW unit size.

**Offshore Wind Power**

For large scale generation, wind turbines to be installed over large areas, particularly in areas of higher wind resources, such as offshore. As offshore wind speeds average ~90% greater than that of land, so offshore resources can contribute substantially more energy than land stationed turbines. As of 2014, offshore wind power amounted to 8,771 MW of global installed capacity. The United Kingdom is the undisputed leader of offshore power with half of the world's installed capacity ahead of Denmark, Germany, Belgium and China. As of 2012, the Alta Wind Energy Center (California, 1,020 MW) is the world's largest wind farm. The London Array(630 MW) is the largest offshore wind farm in the world.

### 4.1.2 current trend in india

The development of wind power in India began in the year 1990 and has significantly increased in the last few years. The largest wind farm of India is Muppandal in Tamil Nadu of capacity 1500MW. As per Ministry of New and Renewable Energy (MNRE) 2015 Report, the current installed capacity of wind energy is of 22645 MW and is expected to go up to 60000 MW by 2022.

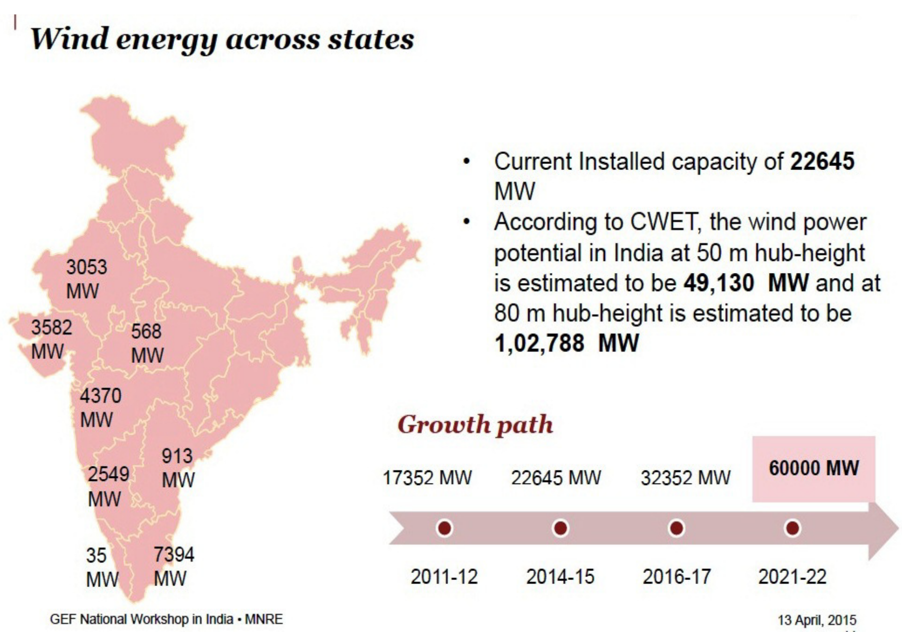


Fig 4 Wind Energy Status across Indian States (Source – MNRE 2015)

### 4.1.3 environmental impact issues

Wind is an indigenous, renewable and free energy source that generates no pollution and has few environmental impacts. It is hailed as Green Technology as it produces no global warming emissions. It takes up little ground space.

Wind turbines can disturb or kill flying creatures like birds and bats. Turbine blades cause noise. It interferes with natural beauty particularly at outstanding beautiful sites.

## 4.2 HYDRO POWER

### 4.2.1 growth rate

Since ancient times, hydropower from many kinds of watermills has been used as a renewable energy source for irrigation and the operation of various mechanical devices, such as gristmills, sawmills textile mills, trip hammers, dock cranes, domestic lifts, and ore mills. In the late 19th century, hydropower became a source for generating electricity. Cragside in Northumberland was the first house powered by hydroelectricity in 1878 and the first commercial hydroelectric power plant was built at Niagara Falls in 1879. In 1881, street lamps in the city of Niagara Falls were powered by hydropower. Since the early 20th century, the term has been used almost exclusively in conjunction with the modern development of hydroelectric power.

In 2013 hydropower generated almost 16% of the world′s total electricity. Only 25% of the worlds estimated hydroelectric potential of 14,000 TWh/year has been developed, with Africa, Asia and Latin America having the greatest potential. The Three Gorges Dam in Hubei, China, has the world's largest instantaneous generating capacity (22,500 MW), with the Itaipu Dam in Brazil/Paraguay in second place (14,000 MW). Hydropower is produced in 150 countries, with the Asia-Pacific region generating 32 percent of global hydropower in 2010. China is the largest hydroelectricity producer, with 721 TWh of production in 2010, representing around 17 percent of domestic electricity use.

### 4.2.2 current trend in india

In India Jamshed Ji Tata built the first hydroelectric power dam in the Western Ghats of Maharashtra in the early 1900 to supply power to Bombay’s Cotton and Textile Mills. He took the British Government permission to build dams, namely in Andhra, Sirowata,Valvan and Mulshi Hydel dams in the Western Ghats to generate electricity using high rainfalls in the hills as storage.

India is blessed with immense amount of hydroelectric potential and ranks 5th in terms of exploitable hydro-potential on global scale. It is endowed with economically exploitable and viable hydro-potential assessed to be about 148,701 MW. In addition, 6,780 MW from small, mini, and micro Hydel schemes (<25 MW) have been assessed. Also, 56 sites for pumped storage schemes with an aggregate installed capacity of 94,000 MW have been identified.

India is the 7th largest producer of hydroelectric power. Hydroelectric power potential of 84,000 MW at 60% load factor is one of the largest in the world. The present installed capacity as on 31 March 2016 is 42,783 MW which is 14.35% of total utility electricity generation capacity in India. In addition 4,274 MW small hydro power units are installed as on 31 March 2016. During the year 2014-15, the total hydro electricity generation in India was 129 billion kWh which works out to 24,500 MW at 60% capacity factor.

### 4.2.3 environmental impact issues

Hydro power is relatively inexpensive and leaves no harmful chemicals. It does not consume any water. After passing through turbine, it can be used for any purpose like irrigation, domestic water supply etc.

Dams can change and destroy habitats near rivers. It can also prevent themigration of fish. The reservoir may cause submergence of large areas which may cause migration of people living in the surrounding areas.

### 4.3 solar energy

Solar energy is the Sun′s rays (solar radiation) that reach the Earth.
Solar energy, radiant light and heat from the sun, is harnessed using a range of ever-evolving technologies such as solar heating, photovoltaic, concentrated solar power (CSP), concentrator photovoltaic (CPV), solar architecture and artificial photosynthesis.

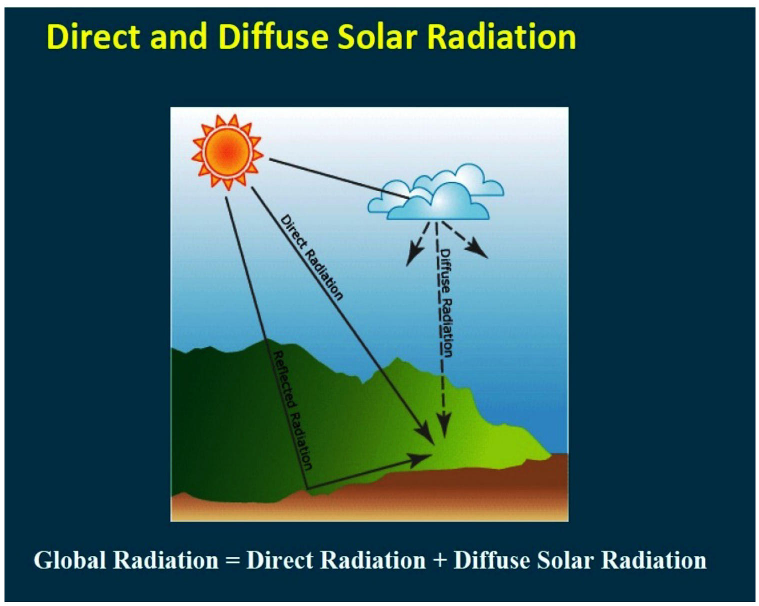


Fig 5 Direct and Diffuse Solar Radiation

### 4.3.1 growth rate

Photovoltaic (PV) grew fastest in China, followed by Japan and the United States, while Germany remains the world's largest overall producer of photovoltaic power, contributing about 7% to the overall electricity generation. Italy meets 7.9 percent of its electricity demands with photovoltaic power—the highest share worldwide. By 2018, worldwide capacity is projected to reach as much as 430 GW. This corresponds to a tripling within five years.

Solar power is forecasted to become the world's largest source of electricity by 2050, with solar photovoltaic and concentrated solar power contributing 16% and 11%, respectively. This requires an increase of installed PV capacity to 4,600 GW, of which more than half is expected to be deployed in China and India. Commercial concentrated solar power plants were first developed in the 1980s. As the cost of solar electricity has fallen, the number of grid-connected solar PV systems has grown into the millions and utility-scale solar power stations with hundreds of MW are being built.

Solar PV is rapidly becoming an inexpensive, low-carbon technology to harness renewable energy from the Sun. Many solar photovoltaic power stations have been built, mainly in Europe, China and the USA. The 579 MW Solar Stars, in the United States, is the world's largest PV power station. Many of these plants are integrated with agriculture and some use tracking systems that follow the sun's daily path across the sky to generate more electricity than fixed mounted systems. There are no fuel costs or emissions during operation of the power stations.

The United States conducted much early research in photovoltaic and concentrated solar power plant. The USA is among the top countries in the world in electricity generated by the Sun and several of the world's largest utility-scale installations are located in the desert Southwest.The oldest solar thermal power plant in the world is the 354 MW SEGS thermal power plant, in California. The Ivanpah Solar Electric Generating System is a solar thermal power project in the California Mojave Desert, 64 km southwest of Las Vegas, with a gross capacity of 377 MW. The 280 MW Solana Generating Station is a solar power plant near Gila Bend, Arizona, about 110 km southwest of Phoenix, completed in 2013. When commissioned it were the largest parabolic trough plant in the world and the first USA solar plant with molten salt thermal energy storage.The solar thermal power industry is growing rapidly with 1.3 GW under construction in 2012 and more planned.Spain is the epicenter of solar thermal power development with 873 MW under construction, and a further 271 MW under development.

### 4.3.2 current scenario in india

With about 300 clear, sunny days in a year, India's theoretically calculated solar energy incidence on its land area alone is about 5,000 trillion kilowatt-hours (kWh) per year (or 5 EWh/yr.). The solar energy available in a year exceeds the possible energy output of all fossil fuel energy reserves in India. The daily average solar power plant generation capacity over India is 0.25 kWh per $m^2$ of used land area, which is equivalent to about 1,500–2,000 peak (rated) capacity operating hours in a year with the available commercially proven technologies.

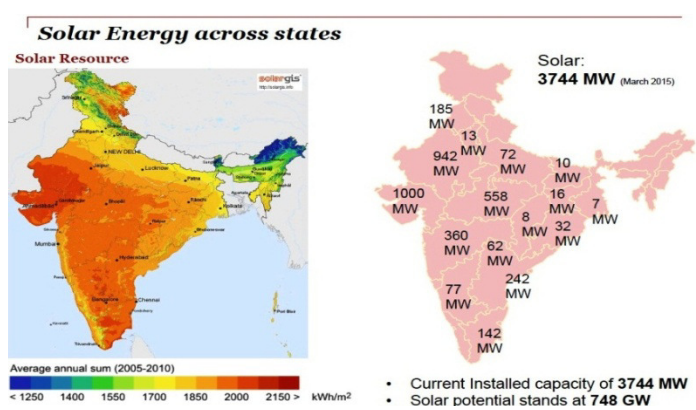


Fig 6 Solar Energy across Indian States (Source- MNRE 2015)

As per Ministry of New and Renewable Energy (MNRE) 2015 Report, the current installed capacity of solar energy is of 3744 MW and solar potential stands at 748 MW.

### 4.4biomass energy

Biomass is biological material derived from living, or recently living organisms. It most often refers to plants or plant-derived materials which are specifically called lignocellulosic biomass. As an energy source, biomass can either be used directly via combustion to produce heat, or indirectly after converting it to various forms of biofuel.

#### 4.4.1growth rate

In developing countries, biomass is still the dominant energy source, accounting for roughly 35% of energy consumption overall, and contributing up to 70% of total energy consumption in some countries.

This energy, used primarily in the form of fuel-wood for cooking, is produced and consumed in a very inefficient manner. Many efforts are still underway throughout the developing world to promote more efficient production and use of biomass energy.

Biofuels provided 3% of the world's transport fuel in 2010. Mandates for blending biofuels exist in 31countries at the national level. According to the International Energy Agency, biofuels have the potential to meet more than a quarter of world demand for transportation fuels by 2050.
Since the 1970s, Brazil has had an ethanol fuel program which has allowed the country to become the world's second largest producer of ethanol after the United States and the world's largest exporter.Brazil's ethanol fuel program uses modern equipment and cheap sugarcane as feedstock, and the residual cane-waste (bagasse) is used to produce heat and power.There are no longer light vehicles in Brazil running on pure gasoline. By the end of 2008 there were 35,000 filling stations throughout Brazil with at least one ethanol pump.Nearly all the gasoline sold in the United States today is mixed with 10% ethanol, and motor vehicle manufacturers already produce vehicles designed to run on much higher ethanol blends. Ford, Daimler AG, and GM are among the automobile companies that sell "flexible-fuel" cars, trucks, and minivans that can use gasoline and ethanol blends ranging from pure gasoline up to 85% ethanol.

#### 4.4.2 current scenario in india

India is very rich in biomass. It is renewable, widely available, carbon-neutral and has the potential to provide significant employment in the rural areas. About 32% of the total primary energy use in the country is still derived from biomass and more than 70% of the country’s population depends upon it for its energy needs. Ministry of New and Renewable Energy has realized the potential and role of biomass energy in the Indian context and hence has initiated a number of programs for promotion of efficient technologies for its use in various sectors of the economy to ensure derivation of maximum benefits.

Biomass power generation in India is an industry that attracts investments of over Rs.600 crores every year, generating more than 5000 million units of electricity and yearly employment of more than 10 million man-days in the rural areas. For efficient utilization of biomass, bagasse based cogeneration in sugar mills and biomass power generation have been taken up under biomass power and cogeneration Programme.

The current availability of biomass in India is estimated at about 500 million metric tons per year. Studies sponsored by the Ministry have estimated surplus biomass availability at about 120 – 150 million metric tons per annum covering agricultural and forestry residues corresponding to a potential of about 18,000 MW. This apart, about 7000 MW additional power could be generated through bagasse based cogeneration in the country's 550 Sugar mills, if these sugar mills were to adopt technically and economically optimal levels of cogeneration for extracting power from the bagasse produced by them.

The current share of biofuels in total fuel consumption is extremely low and is confined mainly to 5% blending of ethanol in gasoline, which the government has made mandatory in 10 states. Currently, biodiesel is not sold on the Indian fuel market, but the government plans to meet 20% of the country's diesel requirements by 2020 using biodiesel. Plants like Jatropha curcas, Neem, Mahua and other wild plants are identified as the potential sources for biodiesel production in India. There are about 63 million ha waste land in the country, out of which about 40 million ha area can be developed by undertaking plantations of Jatropha. India uses several incentive schemes to induce villagers to rehabilitate waste lands through the cultivation of Jatropha. Jatropha oil is produced from the seeds of the Jatropha curcas, a plant that can grow in wastelands across India and the oil is considered to be an excellent source of biodiesel. The Indian government is targeting a Jatropha plantation area of 11.2 million ha by 2012.

### 4.5 geothermal energy

High Temperature Geothermal energy is from thermal energy generated and stored in the Earth. Earth's geothermal energy originates from the original formation of the planet and from radioactive decay of minerals. The geothermal gradient, which is the difference in temperature between the core of the planet and its surface, drives a continuous conduction of thermal energy in the form of heat from the core to the surface.

#### 4.5.1 growth rate

Geothermal power is cost effective, reliable, sustainable, and environmentally friendly, but has historically been limited to areas near tectonic plate boundaries. Recent technological advances have dramatically expanded the range and size of viable resources, especially for applications such as home heating, opening a potential for widespread exploitation. As per the Geothermal: International Market Overview Report of the Geothermal Energy Association, "As of May 2012, approximately 11,224 MW of installed geothermal power capacity was online globally. Geothermal Energy Association (GEA) data shows a total of 21 new power plants came online in 2014 adding about ~610 MW of new capacity to electricity grids globally. According to GEA statistics this is the most capacity to come online in one year since 1997. This is the third year in a row the global geothermal industry has sustained a growth rate of 5%. The global market is at about 12.8 GW of operating capacity as of January 2015, spread across 24 countries. This year the global geothermal market was developing about 11.5-12.3 GW of planned capacity spread across 80 countries. Based on current data the global geothermal industry is expected to reach between 14.5 GW and 17.6 GW by 2020. Overall if all countries follow through on their geothermal power development goals and targets the global market could reach 27-30 GW by the early 2030s.

**4.5.2current scenario in india**

In India, exploration and study of geothermal fields started in 1970. The GSI (Geological Survey of India) has identified 350 geothermal energy locations in the country. The most promising of these is in Puga valley of Ladakh. The estimated potential for geothermal energy in India is about 10000 MW. There are seven geothermal provinces in India: the Himalayas, Sohana, West coast, Cambay, SonNarmadaTapi (SONATA), Godavari, and Mahanadi.

# 5. CONCLUSION -POTENTIAL OF RENEWABLE ENERGY IN INDIA

Renewable energy in India comes under the purview of the Ministry of New and Renewable Energy. India was the first country in the world to set up a ministry of nonconventional energy resources, in early 1980s. India's cumulative grid interactive or grid tied renewable energy capacity (excluding large hydro) has reached about 42 GW, of which 66% comes from wind, while solar PV contributed nearly 14.59% along with biomass and small hydro power of the renewable energy installed capacity in India.

There is high potential for generation of renewable energy from various sources- wind, solar, biomass, small hydro and cogeneration bagasse. The total potential for renewable power generation in the country as on 31.03.14 is estimated at 147615 MW. This includes wind power potential of 102772 MW (69.6%), SHP (small-hydro power) potential of 19749 MW (13.38%), Biomass power potential of 17,538 MW (11.88%) and 5000 MW (3.39%) from bagasse-based cogeneration in sugar mills.

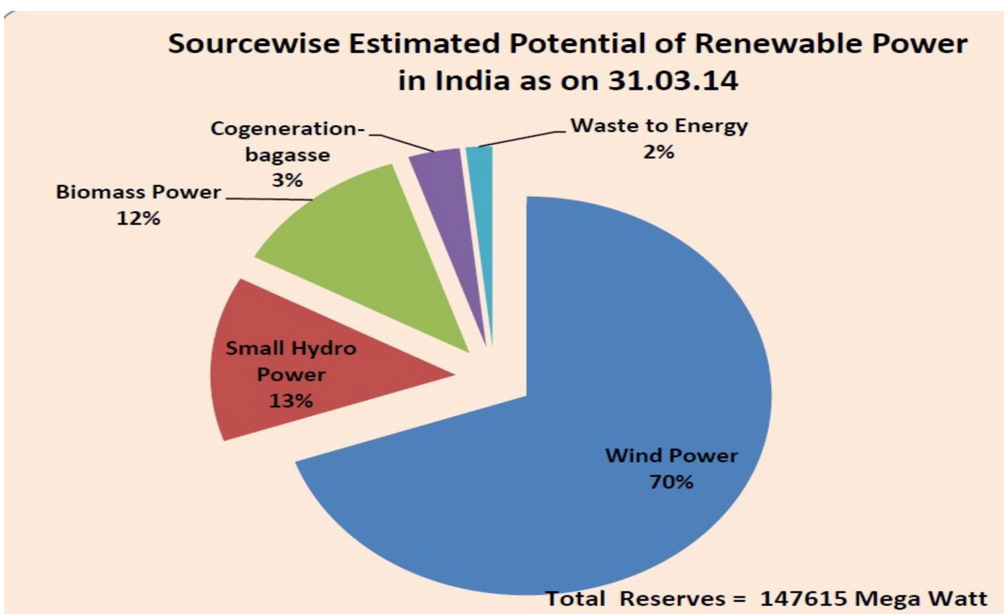


Fig 7 Source wise estimated Potential of Renewable Energy in India

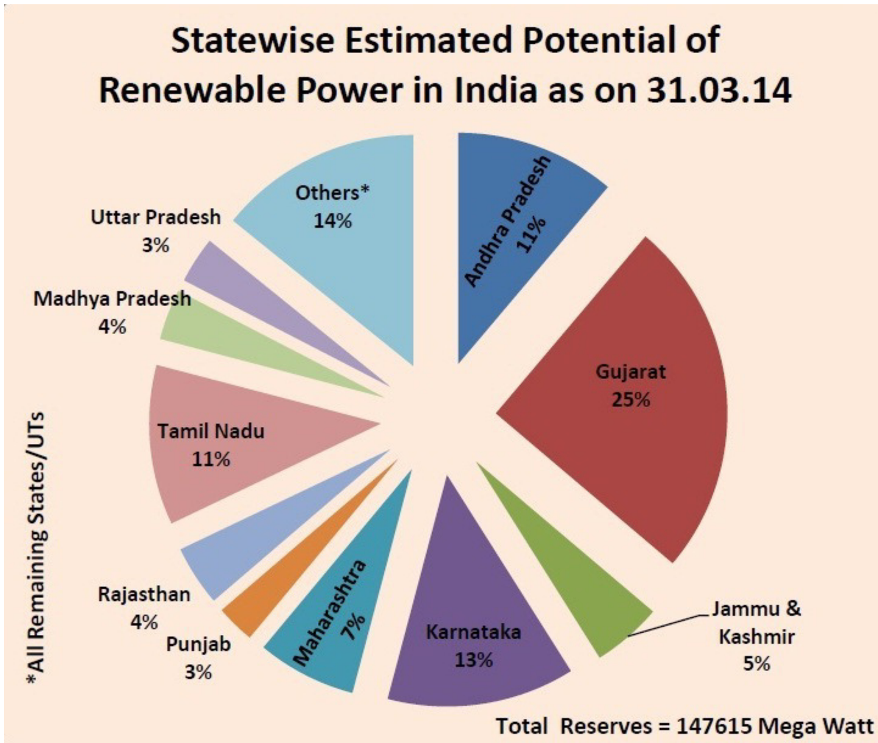


Fig 8 Estimated Potential of Renewable Energy in States of India

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## Appendix

Table 1 Estimated Potential of Renewable Energy in States of India ( Source – MNRE 2015)

(in MW)

| States/ UTs | Wind Power | Small Hydro Power | Biomass Power | Cogeneration -bagasse | Waste to Energy | Total | |
|---|---|---|---|---|---|---|---|
| | | | | | | Estimated Potential | Distribution (%) |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| Andhra Pradesh | 14497 | 978 | 578 | 300 | 123 | 16476 | 11.16 |
| Arunachal Pradesh | 236 | 1341 | 8 | 0 | 0 | 1585 | 1.07 |
| Assam | 112 | 239 | 212 | 0 | 8 | 571 | 0.39 |
| Bihar | 144 | 223 | 619 | 300 | 73 | 1359 | 0.92 |
| Chhattisgarh | 314 | 1107 | 236 | 0 | 24 | 1681 | 1.14 |
| Goa | 0 | 7 | 26 | 0 | 0 | 33 | 0.02 |
| Gujarat | 35071 | 202 | 1221 | 350 | 112 | 36956 | 25.04 |
| Haryana | 93 | 110 | 1333 | 350 | 24 | 1910 | 1.29 |
| Himachal Pradesh | 64 | 2398 | 142 | 0 | 2 | 2606 | 1.77 |
| Jammu & Kashmir | 5685 | 1431 | 43 | 0 | 0 | 7159 | 4.85 |
| Jharkhand | 91 | 209 | 90 | 0 | 10 | 400 | 0.27 |
| Karnataka | 13593 | 4141 | 1131 | 450 | 0 | 19315 | 13.08 |
| Kerala | 837 | 704 | 1044 | 0 | 36 | 2621 | 1.78 |
| Madhya Pradesh | 2931 | 820 | 1364 | 0 | 78 | 5193 | 3.52 |
| Maharashtra | 5961 | 794 | 1887 | 1250 | 287 | 10179 | 6.90 |
| Manipur | 56 | 109 | 13 | 0 | 2 | 180 | 0.12 |
| Meghalaya | 82 | 230 | 11 | 0 | 2 | 325 | 0.22 |
| Mizoram | 0 | 169 | 1 | 0 | 2 | 172 | 0.12 |
| Nagaland | 16 | 197 | 10 | 0 | 0 | 223 | 0.15 |
| Odisha | 1384 | 295 | 246 | 0 | 22 | 1947 | 1.32 |
| Punjab | 0 | 441 | 3172 | 300 | 45 | 3958 | 2.68 |
| Rajasthan | 5050 | 57 | 1039 | 0 | 62 | 6208 | 4.21 |
| Sikkim | 98 | 267 | 2 | 0 | 0 | 367 | 0.25 |
| Tamil Nadu | 14152 | 660 | 1070 | 450 | 151 | 16483 | 11.17 |
| Tripura | 0 | 47 | 3 | 0 | 2 | 52 | 0.04 |
| Uttar Pradesh | 1260 | 461 | 1617 | 1250 | 176 | 4764 | 3.23 |
| Uttarakhand | 534 | 1708 | 24 | 0 | 5 | 2271 | 1.54 |
| West Bengal | 22 | 396 | 396 | 0 | 148 | 962 | 0.65 |
| Andaman & Nicobar | 365 | 8 | 0 | 0 | 0 | 373 | 0.25 |
| Chandigarh | 0 | 0 | 0 | 0 | 6 | 6 | 0.00 |
| Dadar & Nagar Haveli | 0 | 0 | 0 | 0 | 0 | 0 | 0.00 |
| Daman & Diu | 4 | 0 | 0 | 0 | 0 | 4 | 0.00 |
| Delhi | 0 | 0 | 0 | 0 | 131 | 131 | 0.09 |
| Lakshadweep | 0 | 0 | 0 | 0 | 0 | 0 | 0.00 |
| Puducherry | 120 | 0 | 0 | 0 | 3 | 123 | 0.08 |
| Others* | 0 | 0 | 0 | 0 | 1022 | 1022 | 0.69 |
| All India Total | 102772 | 19749 | 17538 | 5000 | 2556 | 147615 | 100.00 |
| Distribution (%) | 69.62 | 13.38 | 11.88 | 3.39 | 1.73 | 100.00 | |

Table 2.1 Installed Capacity of Grid Interactive renewable Energy in States of India (Source – MNRE 2015)

(in MW)

| States/ UTs | Biomass Power | | Waste to Energy | | Wind Power | |
|---|---|---|---|---|---|---|
| | 31.03.13 | 31.03.14 | 31.03.13 | 31.03.14 | 31.03.13 | 31.03.14 |
| Andhra Pradesh | 380.75 | 380.75 | 43.16 | 50.66 | 447.65 | 746.20 |
| Arunachal Pradesh | - | - | - | - | - | - |
| Assam | - | - | - | - | - | - |
| Bihar | 43.30 | 43.42 | - | - | - | - |
| Chhattisgarh | 249.90 | 264.90 | - | - | - | - |
| Goa | - | - | - | - | - | - |
| Gujarat | 30.50 | 43.90 | - | - | 3174.58 | 3454.30 |
| Haryana | 45.30 | 45.30 | - | - | - | - |
| Himachal Pradesh | - | - | - | - | - | - |
| Jammu & Kashmir | - | - | - | - | - | - |
| Jharkhand | - | - | - | - | - | - |
| Karnataka | 491.38 | 603.28 | 1.00 | 1.00 | 2135.15 | 2318.20 |
| Kerala | - | - | - | - | 35.10 | 35.20 |
| Madhya Pradesh | 16.00 | 26.00 | 3.90 | 3.90 | 386.00 | 423.40 |
| Maharashtra | 756.90 | 940.40 | 9.72 | 12.72 | 3021.85 | 4100.40 |
| Manipur | - | - | - | - | - | - |
| Meghalaya | - | - | - | - | - | - |
| Mizoram | - | - | - | - | - | - |
| Nagaland | - | - | - | - | - | - |
| Odisha | 20.00 | 20.00 | - | - | - | - |
| Punjab | 124.50 | 140.50 | 9.25 | 9.25 | - | - |
| Rajasthan | 91.30 | 101.30 | - | - | 2684.65 | 2784.90 |
| Sikkim | - | - | - | - | - | - |
| Tamil Nadu | 538.70 | 571.30 | 8.05 | 8.05 | 7162.18 | 7269.50 |
| Tripura | - | - | - | - | - | - |
| Uttar Pradesh | 776.50 | 776.50 | 5.00 | 5.00 | - | - |
| Uttarakhand | 10.00 | 30.00 | - | - | - | - |
| West Bengal | 26.00 | 26.00 | - | - | - | - |
| Andaman & Nicobar | - | - | - | - | - | - |
| Chandigarh | - | - | - | - | - | - |
| Dadar & Nagar Haveli | - | - | - | - | - | - |
| Daman & Diu | - | - | - | - | - | - |
| Delhi | - | - | 16.00 | 16.00 | - | - |
| Lakshadweep | - | - | - | - | - | - |
| Puducherry | - | - | - | - | - | - |
| Others | - | - | - | - | 4.30 | 4.30 |
| **All India Total** | **3601.03** | **4013.55** | **96.08** | **106.58** | **19051.46** | **21136.40** |
| **Distribution (%)** | **12.83** | **12.66** | **0.34** | **0.34** | **67.88** | **66.69** |

Table 2.2 (contd.) Installed Capacity of Grid Interactive renewable Energy in States of India( Source – MNRE 2015)

(in MW)

| States/ UTs | Small Hydro Power | | Solar Power | | Total | | Growth* Rate(2012-13 to 2013-14) |
|---|---|---|---|---|---|---|---|
| | 31.03.13 | 31.03.14 | 31.03.13 | 31.03.14 | 31.03.13 | 31.03.14 | |
| Andhra Pradesh | 219.03 | 221.03 | 23.35 | 131.84 | 1113.94 | 1530.48 | 37.39 |
| Arunachal Pradesh | 103.91 | 103.91 | 0.03 | 0.03 | 103.93 | 103.93 | 0.00 |
| Assam | 31.11 | 34.11 | - | - | 31.11 | 34.11 | 9.64 |
| Bihar | 70.70 | 70.70 | - | - | 114.00 | 114.12 | 0.11 |
| Chhattisgarh | 52.00 | 52.00 | 4.00 | 7.10 | 305.90 | 324.00 | 5.92 |
| Goa | 0.05 | 0.05 | - | - | 0.05 | 0.05 | 0.00 |
| Gujarat | 15.60 | 15.60 | 857.90 | 916.40 | 4078.58 | 4430.20 | 8.62 |
| Haryana | 70.10 | 70.10 | 7.80 | 10.30 | 123.20 | 125.70 | 2.03 |
| Himachal Pradesh | 587.91 | 638.91 | - | - | 587.91 | 638.91 | 8.68 |
| Jammu & Kashmir | 130.53 | 147.53 | - | - | 130.53 | 147.53 | 13.02 |
| Jharkhand | 4.05 | 4.05 | 16.00 | 16.00 | 20.05 | 20.05 | 0.00 |
| Karnataka | 963.76 | 1031.66 | 14.00 | 31.00 | 3605.29 | 3985.14 | 10.54 |
| Kerala | 158.42 | 158.42 | 0.03 | 0.03 | 193.55 | 193.65 | 0.05 |
| Madhya Pradesh | 86.16 | 86.16 | 37.32 | 347.17 | 529.38 | 886.63 | 67.49 |
| Maharashtra | 299.93 | 327.43 | 100.00 | 249.25 | 4188.40 | 5630.20 | 34.42 |
| Manipur | 5.45 | 5.45 | - | - | 5.45 | 5.45 | 0.00 |
| Meghalaya | 31.03 | 31.03 | - | - | 31.03 | 31.03 | 0.00 |
| Mizoram | 36.47 | 36.47 | - | - | 36.47 | 36.47 | 0.00 |
| Nagaland | 28.67 | 29.67 | - | - | 28.67 | 29.67 | 3.49 |
| Odisha | 64.30 | 64.63 | 13.00 | 30.50 | 97.30 | 115.13 | 18.32 |
| Punjab | 154.50 | 156.20 | 9.33 | 16.85 | 297.58 | 322.80 | 8.48 |
| Rajasthan | 23.85 | 23.85 | 552.90 | 730.10 | 3352.70 | 3640.15 | 8.57 |
| Sikkim | 52.11 | 52.11 | - | - | 52.11 | 52.11 | 0.00 |
| Tamil Nadu | 123.05 | 123.05 | 17.11 | 98.36 | 7849.09 | 8070.26 | 2.82 |
| Tripura | 16.01 | 16.01 | - | - | 16.01 | 16.01 | 0.00 |
| Uttar Pradesh | 25.10 | 25.10 | 17.38 | 21.08 | 823.98 | 827.68 | 0.45 |
| Uttaranchal | 174.82 | 174.82 | 5.05 | 5.05 | 189.87 | 209.87 | 10.53 |
| West Bengal | 98.40 | 98.40 | 2.05 | 7.05 | 126.45 | 131.45 | 3.95 |
| Andaman & Nicobar | 5.25 | 5.25 | 5.10 | 5.10 | 10.35 | 10.35 | 0.00 |
| Chandigarh | - | - | - | 2.00 | - | 2.00 | - |
| Dadar & Nagar Haveli | - | - | - | - | - | - | - |
| Daman & Diu | - | - | - | - | - | - | - |
| Delhi | - | - | 2.56 | 5.15 | 18.56 | 21.15 | 13.98 |
| Lakshadweep | - | - | 0.75 | 0.75 | 0.75 | 0.75 | 0.00 |
| Puducherry | - | - | 0.03 | 0.03 | 0.03 | 0.03 | 20.00 |
| Others | - | - | 0.79 | 0.82 | 5.09 | 5.12 | - |
| **All India Total** | **3632.25** | **3803.70** | **1686.44** | **2631.96** | **28067.26** | **31692.18** | 12.92 |
| **Distribution (%)** | **12.94** | **12.00** | **6.01** | **8.30** | **100.00** | **100.00** | |

Table 3 Installation of Off Grid/ Decentralized Renewable Energy in States of India (Source – MNRE 2015)

| Sl. No. | State/UT | Aerogen. Hybrid System | Solar Cooker # | Waste to Energy | Remote Village Electrification Villages | |
|---|---|---|---|---|---|---|
| | | | | | Villages | Hamlets |
| | | (KW) | (MW) | (MW) | (Nos.) | (Nos.) |
| 1 | 2 | 12 | 13 | 14 | 15 | 16 |
| 1 | Andhra Pradesh | 16.00 | 23.15 | 10.61 | - | 13 |
| 2 | Arunachal Pradesh | 6.80 | 0.03 | - | 297 | - |
| 3 | Assam | 6.00 | - | - | 1,952 | - |
| 4 | Bihar | - | - | 1.00 | - | - |
| 5 | Chhattisgarh | - | 4.00 | 0.33 | 568 | - |
| 6 | Goa | 163.80 | 1.69 | - | - | 19 |
| 7 | Gujarat | 20.00 | 824.09 | 14.64 | 38 | - |
| 8 | Haryana | 10.00 | 7.80 | 4.00 | - | 286 |
| 9 | Himachal Pradesh | - | - | 1.00 | 21 | - |
| 10 | Jammu & Kashmir | 15.80 | - | - | 334 | 15 |
| 11 | Jharkhand | - | 16.00 | - | 493 | - |
| 12 | Karnataka | 39.20 | 14.00 | 9.64 | 16 | 14 |
| 13 | Kerala | 8.00 | 0.03 | - | - | 607 |
| 14 | Madhya Pradesh | 24.00 | 11.75 | 0.48 | 577 | - |
| 15 | Maharashtra | 1422.10 | 34.50 | 20.45 | 340 | - |
| 16 | Manipur | 140.00 | - | - | 237 | 3 |
| 17 | Meghalaya | 191.50 | - | - | 149 | - |
| 18 | Mizoram | - | - | - | 20 | - |
| 19 | Nagaland | - | - | - | 11 | - |
| 20 | Odisha | - | 13.00 | 0.02 | 1,495 | 14 |
| 21 | Punjab | 50.00 | 9.33 | 4.78 | - | - |
| 22 | Rajasthan | 14.00 | 222.90 | 3.00 | 292 | 90 |
| 23 | Sikkim | 15.50 | - | - | - | 13 |
| 24 | Tamil Nadu | 24.50 | 17.06 | 11.42 | - | 131 |
| 25 | Tripura | 2.00 | - | - | 60 | 782 |
| 26 | Uttar Pradesh | - | 12.38 | 46.18 | 113 | 222 |
| 27 | Uttarakhand | 4.00 | 5.05 | 4.02 | 476 | 118 |
| 28 | West Bengal | 74.00 | 2.00 | 1.17 | 1,177 | 2 |
| 29 | Andaman & Nicobar | - | - | - | - | - |
| 30 | Chandigarh | - | - | - | - | - |
| 31 | Dadar & Nagar Haveli | - | - | - | - | - |
| 32 | Daman & Diu | - | - | - | - | - |
| 33 | Delhi | - | 2.53 | - | - | - |
| 34 | Lakshaadweep | - | - | - | - | - |
| 35 | Puducherry | 5.00 | - | - | - | - |
| 36 | Others* | - | - | - | - | - |
| | Total | 2252.20 | 1221.26 | 132.74 | 8666.00 | 2329.00 |