A Review on India's Renewable Energy Potential

Reji Shaji

Abstract:

India with a population of 1.2 billion is one of the biggest and fastest growing economies in the world. There is always a very high demand for energy, which is currently met mainly by coal, oil and petroleum, which apart from being a non-renewable; it is also harmful to the environment. Thus, it is vital that India obtains energy security without affecting the ever-booming economy, which would mean that alternative energy sources be found. This would mean that the country must switch from the nonrenewable energy - crude oil and coal - to renewable energy. The Government of India has already made several provisions, and established many agencies that will help it achieve its goal of becoming one of the world's leading clean energy producers. Renewable energy is energy from a resource that is replaceable by existing flows of energy, such as sunshine, wind, water, biological processes and geothermal heat flows. These energy resources might be used directly or indirectly as forms of energy. In this paper, the potential and technological possibilities in this direction are discussed in the Indian context.

Key Words: Biomass, Electricity, Fossil fuel, Geo thermal, Renewable energy, Solar, Wind, Water

1 INTRODUCTION

Energy is one of the major inputs for the economic development of any country. In the case of the developing countries, the energy sector assumes a critical importance in view of the ever to meet them. The global production of electricity is over 20,000TWh (terawatt-hour) [1].

Fossil fuels are expected to continue supplying much of the energy used worldwide. Demand for Renewable Energy Sources accounted for 19% of global energy demand, with traditional biomass accounting for the bulk of that demand. [2]

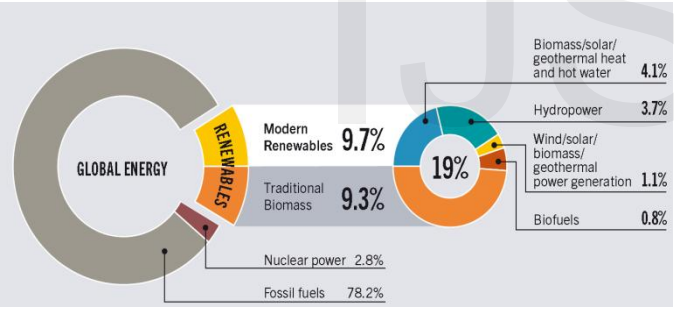

Fig. 1. Global share of Renewable energy [3]

2 ELECTRICITY IN INDIA

The electricity sector in India had an installed capacity of 233.929 GW as of December 2013[4] .Captive power plants generate an additional 34.444 GW. Non Renewable Power Plants constitute 87.55% of the installed capacity, and Renewable Power Plants constitute the remaining 12.45% of total installed Capacity.[5] The total annual generation of electricity from all types of sources was 1053.9 Terawatts-hours (TWh) in 2012.[6]

India currently suffers from a major shortage of electricity generation capacity, even though it is the world's largest energy consumer after United States, China and Russia. [7][8].

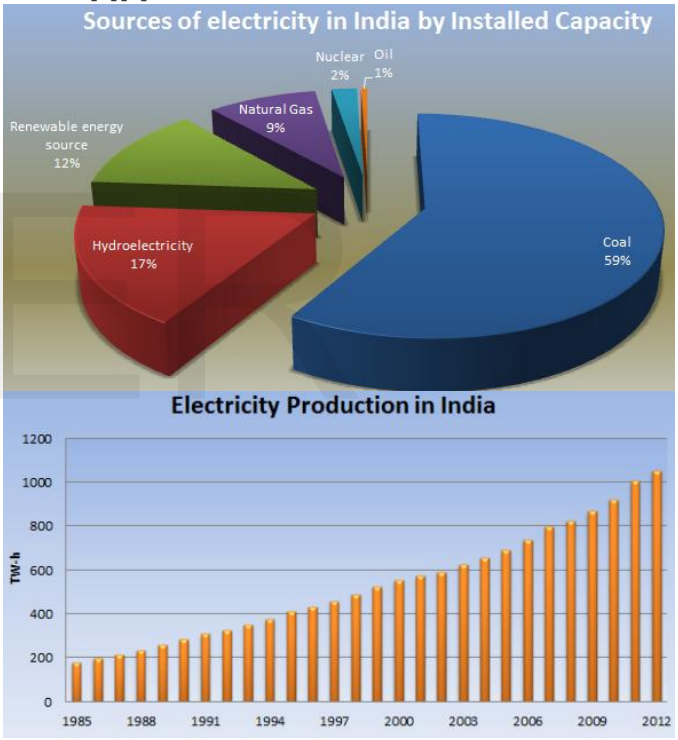

Fig. 2. (a) Sources of electricity and (b) Yearly Production in India [10][11]

The International Energy Agency estimates India will add between 600 GW to 1200 GW of additional new power generation capacity before 2050[9].

3 RENEWABLE ENERGY STATUS IN INDIA

India was the first country in the world to set up a ministry of non-conventional energy resources, in early 1980s [12]. Renewable energy in India comes under the purview of the Ministry of New and Renewable Energy (MNRE).The total estimated potential for renewable power generation in the country as on 31.03.12 is estimated at 89774 MW. [13]

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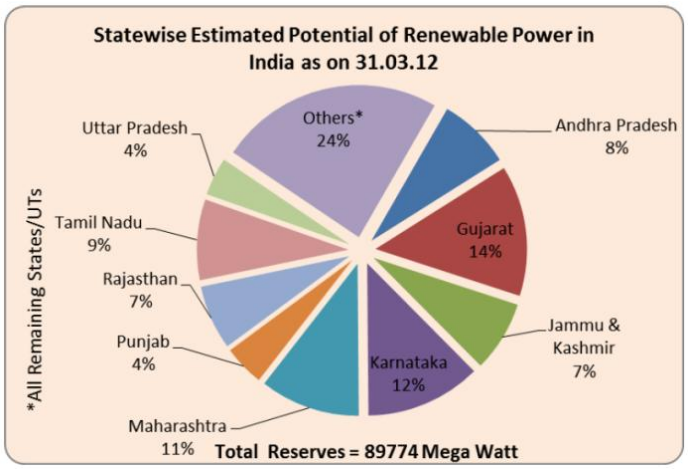
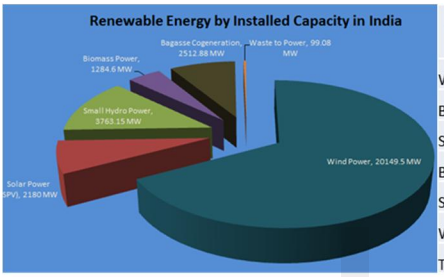


Fig. 3. Estimated potential of Renewable energy in India-2012 [13]



Total Renewable Energy Installed Capacity(MW)(Dec.2013)	
Waste to Power	99.08
Biomass Power	1,284.60
Solar Power (SPV)	2,180.00
Bagasse Cogeneration	2,512.88
Small Hydro Power	3,763.15
Wind Power	20,149.50
Total	29,989.21

Fig. 4. Renewable energy installed capacity in India-Dec2013 [14]

Outside of solar and wind, there are other renewable energy sectors are showing significant progress - notably small hydro and biomass power. Some of the segments that show little activity now –wave, tidal and geothermal, for instance – have the potential for significant growth in future.

The key drivers for the growth of the renewable energy in India are the following:

- ✓ High growth rate in overall energy needs
- ✓ Increasing reliance on imports for fossil fuels
- ✓ Need for a viable solution for rural electrification
- ✓ Electricity peak demand-supply
- ✓ Pressure on industry and polity to abate Greenhouse gas emissions.

4 PROS AND CONS

Renewable energy technologies (RETS) have several well-recognized advantages in relation to conventional, largely fossil fuels-based, energy systems. Firstly by promoting energy security and much more stability with regard to the market price volatility, secondly the renewables are scalable (as small as in few kilowatts) and also can be installed in modular designs.

On the other hand, several RETS also have disadvantages. First, some primary energy flows (e.g., solar and wind) are variable and not completely predictable, requiring hybridization with systems that are more under human control. Some renewable energy forms, such as biofuels, compete for arable land and irrigation water with food crops. If not implemented with great care, they may have adverse social and economic consequences. [15]

5 RENEWABLE ENERGY SOURCES AND ITS POTENTIAL IN INDIA

This section discusses in detail different renewable energy sources technologies/options available in the country. Details on potential and status are provided for the following renewable energy sources:

Solar, Wind, Biomass Power, Small Hydro Power Plant, Geothermal, Wave &Tidal [16]

6 SOLAR ENERGY

The surface of the Earth receives an amount of solar energy equivalent to roughly 10,000 times the world energy demand. Solar energy is considered the most abundant of all renewable resources in India. The total theoretical potential for solar power in terms of direct normal irradiance is very large as shown in fig.5. India has a vast potential for solar power generation, since India receives solar energy equivalent to over 5000 trillion KWh annually, which is far more than total energy consumption in the country [17]. Being a densely populated country with residential, agricultural and industrial priorities, availability of land for solar programs is likely to be a constraint.

Solar technologies is currently divided into main two categories,

Photovoltaic: Converts sunlight directly into electricity, based on photovoltaic effects.

Thermal: Converts the heat of the sun mainly for heating and drying.

6.1 Solar Photovoltaic (PV)

Solar photovoltaic (PV), refers to the technology of using solar cells to convert solar energy to electricity. The exploited potential is less than 150 MW, and of that only about 20 MW is grid-connected. In India the vision attempts to reach the installed capacity of 1~2 GW by 2013, 4~10 GW by 2017 and 20GW by 2022.[19]

6.2 Concentrating Solar Power (CSP)

CSP systems use mirrors to concentrate sunrays and produce heat and steam to generate electricity by a conventional thermodynamic cycle. The exploited potential is very low or negligible. The National Solar Mission has already allocated 500 MW to Indian corporate and these CSP plants are currently being commissioned.[19]

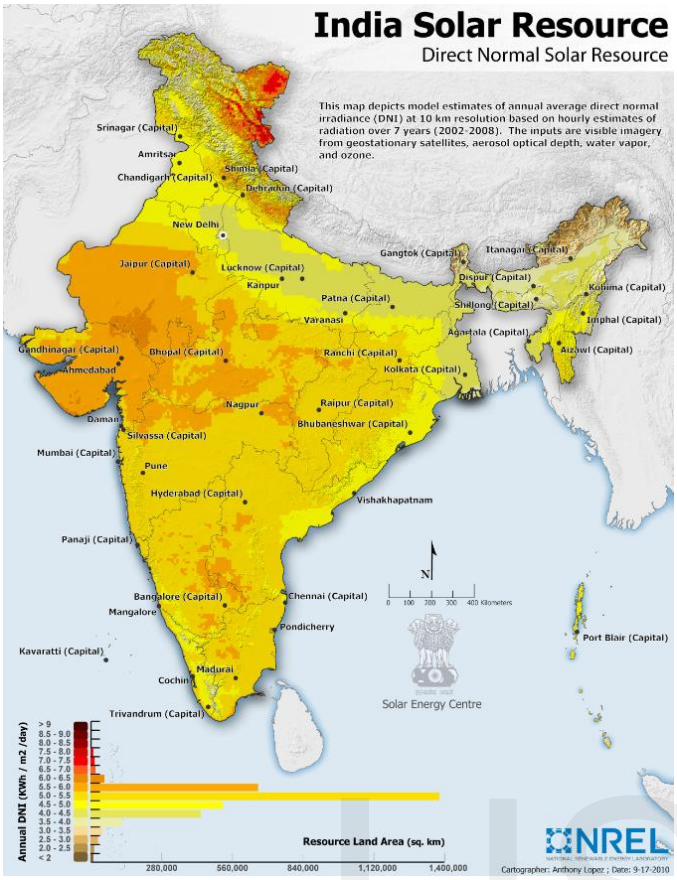


Fig. 5. Solar resource map of India. [18]

6.3 Solar Thermal for Heating Purposes

Solar thermal energy for heating and drying has significant potential in India. Studies have shown that energy from solar thermal used for industrial heating and drying can save up to 4.5 million tons of furnace oil or diesel per year. Specific industries that could find solar heating and drying applicable are food and beverages, transport, textiles and chemicals. [19]

6.4 Solar Water Heating

The total potential in India for solar water heating is about 140 million sq. meters. Of this, the total installed capacity is about 3.5 million sq. meters. Every year, over 20,000 solar water heaters are installed across India, according to some estimates. The Jawaharlal Nehru National Solar Mission targets to install 20 million square meters of solar water heating systems by 2022. [20]

7 WIND ENERGY

India has the fifth largest installed wind power capacity in the world. The main technology associated with harnessing wind energy is the wind turbine, the wind turns the blades of the wind turbine, and the rotating blades turn the shaft attached to the blades. The moving shaft can either power a pump or turn a generator, which can generate electricity.

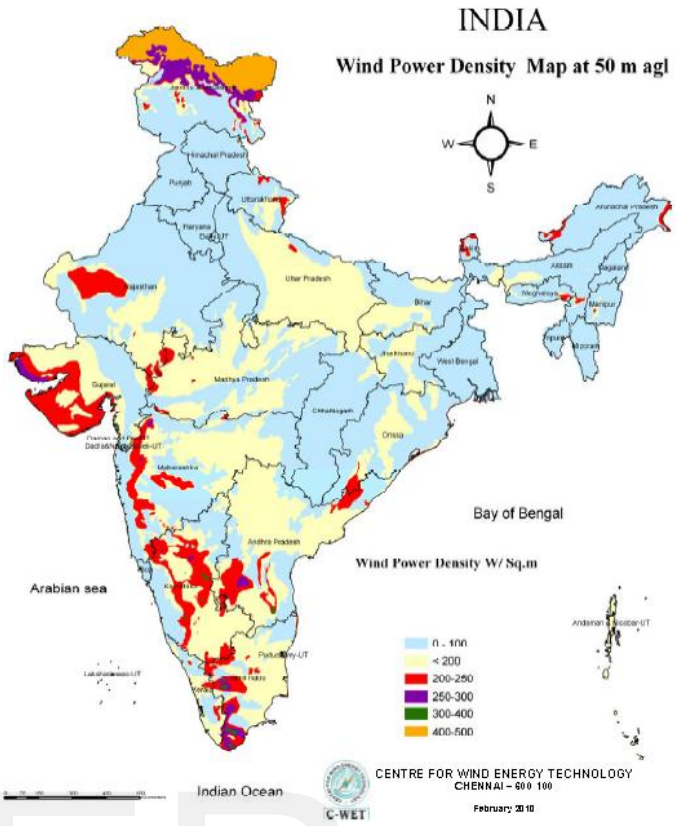


Fig. 6. Wind power density map of India. [17]

Total available potential of 100,000 MW and the exploited potential is approximately 14,000 MW. Estimates from the Energy Alternatives India-EAI Wind Research team project India having a total wind installed capacity of over 50,000 MW by 2020, [20]

The efficiency of India's existing wind plants is somewhat lower than in many of the other countries leading in wind. States with high wind power potential are Tamil Nadu, Gujarat, Andhra Pradesh, Karnataka, Kerala, Madhya Pradesh and Maharashtra. [17].

A long coastline and relatively low construction costs could make India a favored destination for offshore wind power and appreciating these factors, the government of India has decided to explore ways to tap the offshore wind energy potential.

8 BIOMASS

Traditional biomass, such as wood and cow dung, have historically played an important part in India's energy supply, and they still supply cooking energy to almost all of India's rural population.

There are approximately 4 million installed household biogas plants in India with almost 4,000 additional units supplying household clusters or villages; cattle manure is the primary feedstock for these household plants. MNRE estimates that available cattle manure could support approximately 12 million household biogas plants.

Solid biomass is used in India either in direct combustion or gasification to generate power or for cogeneration of power and heat. MNRE estimates that surplus biomass could support 25 MW of installed electricity-generating capacity and that cogeneration capabilities added to existing industries requiring process heat could add 15 GW more electricity-generating capacity to the grid. [17]

Liquid biofuels, ethanol and biodiesel, are used to substitute petroleum-derived transportation fuels. Ethanol in India is largely produced by the fermentation of molasses, a by-product of the sugar industry, and from biodiesel produced from non-edible oilseeds. India is conducting research in the area of cellulosic biomass conversion for ethanol production. [19]

The establishment of the Jatropha cultivation and local, community-based production of environmentally friendly biodiesel fuel can lead to income improvement in these regions. Establishment and ongoing improvement of a Jatropha System will benefit four main aspects of development and secure a sustainable way of life for village farmers and the land that supports them. [21].

9 SMALL HYDRO POWER PLANTS (SHP)

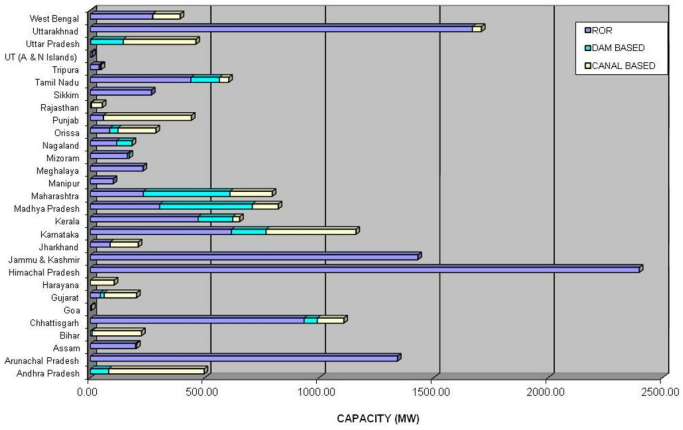
Government of India defines the hydropower plants up to 25 MW as small hydro power plants. MNRE has estimated India's small hydro potential at more than 15,000 MW and is constantly revising this number upwards as new sites are identified; more than 40% of this potential has been identified in four northern, mountainous states.

The biggest advantage of SHP is that it is the only clean and renewable source of energy available round the clock. Small hydro projects or run-of-the-river projects do not involve building of dams and have little environmental impacts. In India, medium and smaller hydro projects are under the purview of the MNRE. [19]

Other benefits of small hydro are user-friendliness, low cost, and short gestation period. In some cases, rural dwellers have been able to manage the switch from firewood for cooking to electricity, thus limiting deforestation and also cutting down on carbon emissions. [17][19].

Some conventional hydropower projects are described as run-of-the-river (ROR). These ROR projects are smaller in size; have a smaller, or no, reservoir; and are most often placed downstream of large hydropower projects.

SHP plants with a total capacity of 3,421 MW had been set up in various parts of the country (MNRE). A total of 261 private-sector SHP projects had been set up with an aggregate capacity of 1,326 MW. In addition, around 270 projects of about 914 MW were in various stages of implementation.[17].There is significant potential for hydro projects in the country as the chart below shows: [22]



SHP potential of different states in India (2010)

10 GEOTHERMAL ENERGY

Heat energy continuously flows to the Earth's surface from its interior, where the temperature at the core is about 6,000°C. The outward transfer of heat occurs by means of conductive heat flow and convective flows of molten mantle beneath the earth's crust. This results in heat flux at the Earth's surface. This heat flux, however, is not distributed uniformly over the surface; rather, it is concentrated along active tectonic plate boundaries, where volcanic activity transports high-temperature molten material to the near surface. [17].

Geothermal power generation is currently based on five technology options that are briefly as Dry steam plants, Flash plants, Binary plants, Combined –cycle or hybrid plants and Geothermal combined heat and power[19].

India has reasonably good potential for geothermal and the potential geothermal provinces as in the figure below can produce 10,600 MW of power. But yet geothermal power projects has not been exploited at all, owing to a variety of reasons, the chief being the availability of plentiful coal at cheap costs

Deep wells can be drilled into underground reservoirs to tap steam and very hot water that drive turbines that drive electricity generators. The main cost drivers are the drilling and the subsequent transmission of steam or hot water. Geothermal Energy Potential in India is detailed in below Fig.7. [24]. In India nearly 400 thermal springs occur and the Puga valley in the Ladakh region has the most promising geothermal field.

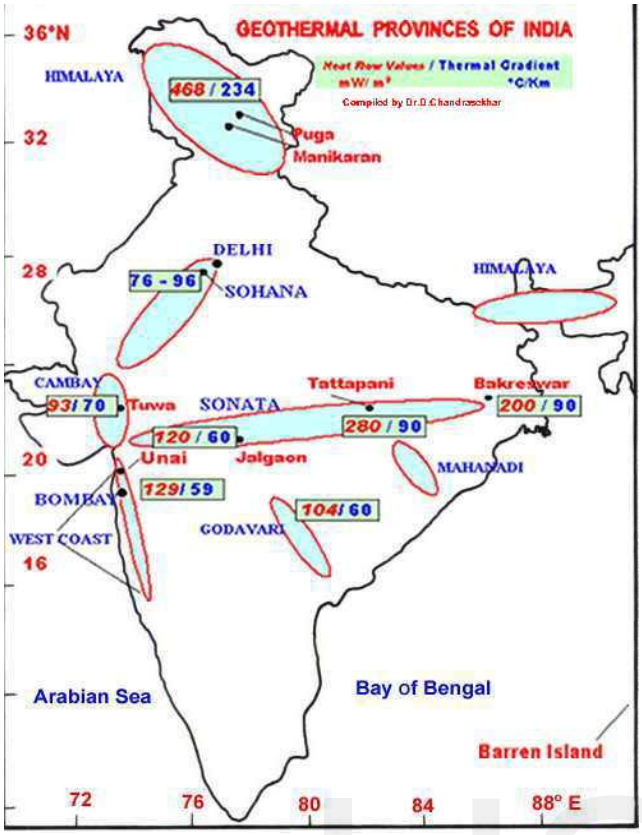


Fig. 7. Geothermal Energy Potential in India [24].

11 TIDAL AND WAVE ENERGY

Ocean can produce two types of energies like mechanical energy from the tides and waves and thermal energy from the sun's heat.

11.1 Tide energy

Tides are generated through a combination of forces exerted by the gravitational pull of the sun and the moon and the rotation of the earth. Energy can be extracted from tides by creating a reservoir or basin behind a barrage and then passing tidal waters through turbines in the barrage to generate electricity. Since India is surrounded by sea on three sides, its potential to harness tidal energy is huge. The identified economic tidal power potential in India is of the order of 8000-9000 MW.

11.2 Wave energy

Ocean wave energy is captured directly from surface waves or from pressure fluctuations below the surface. Wave power systems convert the motion of the waves into usable mechanical energy which in lump can be used to generate electricity. Primary estimates indicate that the annual wave energy potential along the Indian coast is between 5 MW to 15 MW per meter, thus a theoretical potential for a coast line works out to 40000-60000 MW approximately.

11.3 Ocean Thermal Energy

The Ocean Thermal Energy Conversion (OTEC) is to turn the solar energy trapped by the ocean into useable energy. OTEC systems use the ocean's natural thermal gradient the fact that the ocean's layers of water have different temperatures to drive a power-producing cycle. OTEC in India has a potential installed capacity of 180,000 MW. [23]

12 ENABLERS

Organizations and institutional aid is of utmost important part for potential collaboration for renewable energy. This list includes existing organizations that play a role in supporting renewable energy development in India currently and may be interested in future collaboration, such as government agencies and organizations, financial institutions, science & technology groups, non-governmental organizations, and public/private utilities.

- ✓ Ministry of Power (Mop),
- ✓ Ministry of New and Renewable Energy (MNRE)
- ✓ Centre for Wind Energy Technology (CWET).
- ✓ Indian Renewable Energy Development Agency (IREDA).
- ✓ Central Electric Regulatory Commission (CERC)
- ✓ World Institute of Sustainable Energy (WISE),
- ✓ The Energy Research Institute (TERI),
- ✓ Center for Science Energy Technology and Policy (CSTEP)
- ✓ Financial institutions, such as IDFC, ICICI, Yes Bank, as well as development financial organizations such as World Bank.
- ✓ Indian Institute of Technology (IIT).[25]

13 CONCLUSION

Other than creating national level awareness regarding efficient renewable energy options, efforts are required for promoting research and development in these alternative technologies and resources. Developments in renewable technologies are, however, progressing rapidly both in India and across the world, and higher levels of regional cooperation can play a key role in accelerating the pace and spread of renewable energy development.

By 2050, some estimates put India's power generation requirements at one terawatt, or one trillion watts. This would be a six fold increase in India's current installed power capacity. It is a big challenge. But it is a big opportunity too, for Indian companies, for the creation of Indian jobs, for greater Indian prosperity. India is already home to Suzlon, the third leading wind energy installer worldwide, with almost 10% of the total global market. Other innovative companies in solar energy, biomass energy production, and energy efficiency are growing in India's vibrant entrepreneurial sector. Because most of

India's power plants have yet to be built, India has options that many countries can only dream of. Instead of being locked into following a high carbon energy track, India can lead the way to a lower carbon, renewable energy path.

REFERENCES

[1] Electricity generation From Wikipedia, the free encyclopedia http://en.wikipedia.org/wiki/Electricity_generation

[2] Market Share 2010 Extracts from http://www.solarbuzz.com/facts-and-figures/markets-growth/market-share

[3] OECD Factbook 2013: Economic, Environmental and Social Statistics Extracts from http://www.oecd -ilibrary.org/ sites/factbook-2013

[4] Executive summary of month of December 2013". Central Electricity Authority, Ministry of Power, GoI. Nov. 2013. http://cea.nic.in/reports/monthly/executive_rep/dec13.pdf

[5] Renew India Campaign. Renewindians.com (2012-12-14) http://www.renewindians.com/2012/12/Renewable-energy-contribution-in-india.html

[6] Statistical Review of world energy http://www.bp.com/ content/dam/bp/excel/Statistical-Review/statistical_ review_of_world_energy_2013_workbook.xlsx

[7] For India, a Power Failure Looms". The Wall Street Journal. 2 January 2012.http://online.wsj.com/article/ SB10001424052970203550304577136283175793516.html

[8] India: Overview, Data & Analysis". U.S. Energy Information Administration. 2011: http://www.eia.gov/countries/cab.cfm?fips=IN

[9] Uwe Remme et al. "Technology development prospects for the Indian power sector". International Energy Agency France; OECD

[10] Sources_of_electricity_by Installed Capacity_2013.png http://en.wikipedia.org/wiki/File

[11] Electricty_India_1985-2012.png http://en.wikipedia. org/wiki/File

[12] Renewable energy achievements: http://www.mnre.gov.in/ mission-and-vision-2/achievements/

[13] Energy statistics 2013(twentieth Issue) Central Statistics office, Ministry of statistics and Programme implementation, Government of India.

[14] Renewable_energy_share_India_ 2013.png http://en.wikipedia.org/wiki/File

[15] The energy report–India 100% Renewable energy by 2050-WWF-India.Teri.awsassets.panda.org/downloads/energy_ report_061213_1_.pdf

[16] EAI - Catalyzing Clean Technology in India.www.eai.in &http://en.wikipedia.org

[17] Tejinder Kumar Jindal, "Energy and clean environment – Indian perspective "Aerospace Engineering Department, PEC University Of Technology Chandigarh ISSN: 2278-7461 www.ijeijournal.com

[18] Solar-resources , 2012http://www.mnre.gov.in/sec/solar-resources.html

[19] "Highlights of Indian Renewable Energy Industry for Investors"-EAI. Site URL: www.eai.in

[20] D.S.Arora et.al. "Indian Renewable Energy Status Report-Background Report for DIREC 2010" NREL/TP-6A20-48948 Oct-2010, Site URL: www.nrel.gov

[21] Renewable Energy Resources 2014 http://www.geni.org/globalenergy/library/renewable-energy-resources/world/Asia/bio-Asia/bio-india.shtml

[22] ASEAN-India Workshop on Cooperation in New and Renewable Energy. Arun Kumar. Small hydro resource assessment. IIT, Roorkee. Nov 06, 2012

[23] Pillai IR, Banerjee R, Renewable energy in India: Status and potential, Energy (2009), doi:10.1016/j.energy.2008.10.016

[24] Renewable Energy Resources 2007 http://www.geni.org/globalenergy/library/renewable-energy-resources/world/asia/geo-asia/geo-india.shtml

[25] Vikas Khare et.al" Status of solar wind renewable energy in India"-Department of Electrical Engineering, Maulana Azad National Institute of Technology, Bhopal 462007,M.P.,India RenewableandSustainableEnergyReviews:www.elsevier.com/locate/rser