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## Full Length Research Article

### OVERVIEW OF SOLAR ENERGY IN INDIA

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#### ABSTRACT

In recent years, the renewable energy markets, industries, and policy frameworks have evolved rapidly. Solar and wind energy generation across the globe has increased substantially during past few years and shares a significant proportion of the total generation in the grid. These renewable generation is concentrated only in a few states in India marginally, to a extent and serious thought needs to be given to balance the variability of such generation. In this paper, we emphasize about the need for a smoother shift of energy from the conventional towards the renewable energy resources and developing an in-built consciousness about the necessity for a change of energy in the upcoming future. Also, in this paper we emphasize on solar power in India.

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#### INTRODUCTION

Power Generation has always been a challenge to the modern world. The status of a country's development is proportional to its energy consumption. India is the fourth largest energy consumer in the world after the United States, China, and Russia. India's economy grew at an annual rate of approximately 7 percent since 2000 and proved relatively resilient to the 2008 global financial crisis and India was the 10th largest economy in the world as measured by nominal Gross Domestic Product (GDP). In future, India and China will account for the biggest share of Asian energy demand growth through 2035. India's energy policy is focused on securing energy sources to meet the demand of its growing economy. The consumption of primary energy has doubled between 1990 and 2011. Also, among the developed countries India's per capita energy consumption remains lower. The government may not be able to deliver secure supplies to meet demand because of fuel subsidies, increasing import dependency, inconsistent energy sector reform and some sectors are relatively closed to private and foreign investment. India remains very dependent on imported crude oil despite having a healthy growth in coal reserves and natural gas. On the whole, at most of the times, power demand has exceeded the generation. This demand of power is met by either the

conventional sources of energy or the renewable energy resources. The generation of power through renewable energy source has gain more importance due to the disadvantages faced by conventional energy sources. In early 2013, Indian Government has announced some action plans to make India an energy independent country by 2030 by either increasing the energy supply or lower demand. Being a tropical country, among all the renewable sources of energy, it is largely dependent on solar energy resources which has been discussed here.

#### Renewable Energy Sources

The intrusion of renewable energy sources in producing energy is due to the disadvantages faced by conventional energy sources which overcomes its own advantages. They are rise in the pollution levels, global warming and thereby a rise in the amounts of Green-House gases, increased number of occurrence of disasters like earthquakes, danger due to explosions at the mining regions, very less availability of fuels, ruining of the sea ecosystem due to the oil spills, rock fractures due to the extraction of natural gas and so on. The main disadvantage faced conventional energy sources is the emission of CO<sub>2</sub> during energy production. The main conventional energy sources emitting CO<sub>2</sub> in different countries across the globe from conventional energy sources is listed in (<http://www.bp.com/statisticalreview>). The global investment in US Billion dollars in renewable energy sources

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or clean energy sources are increasing and is shown in Fig. 1. (www.ren21.net)

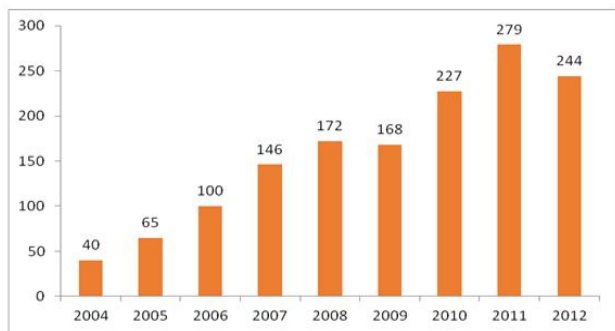


Fig. 1. Global investment in US Billion dollars

The investment in US Billion dollars in renewable energy sources or clean energy by region across the globe is given in Fig.2 and especially in USA and European countries in Fig. 3 respectively (www.ren21.net).

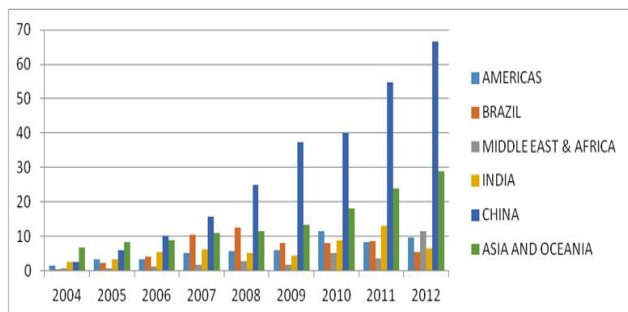


Fig. 2. Investment in US Billion dollars by region

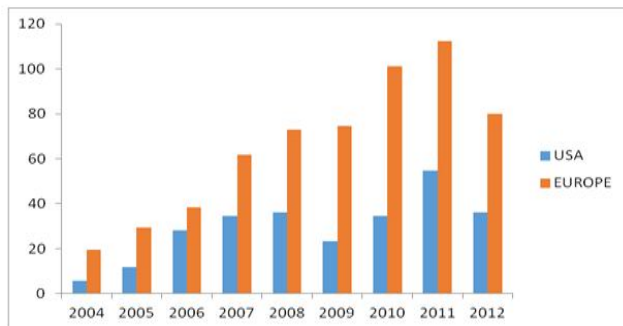


Fig. 3 Investment in US billion dolors in USA and Europe

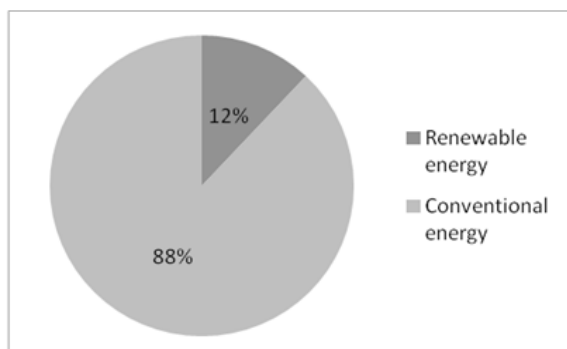


Fig. 4. Capacity of coventional and renewable energy sources

In India, till August 2013, the total installed capacity in MW is 2,27,357 MW in which the capacity from conventional and renewable energy sources is shown in Fig. 4 (www.cea.nic.in). Fig. 4 Capacity of coventional and renewable energy sources

The generation of power in certain states in India from different energy sources including conventional and renewable energy sources in MW and the percentage of renewable energy generation is given in Table 1. (www.cea.nic.in). The different methods by which the load is balanced between conventional and renewable energy sources for different states in India is described in (www.cea.nic.in). The different renewable energy sources which are available for energy production are solar energy, wind energy, geothermal energy and so on. In the Hydro power generation, the potential energy of the water stored in dams is converted to the kinetic energy during its flow from higher levels to the lower levels.

Biomass is a term to represent organic matters which can either be directly used by combustion process of heat production, or indirectly by conversion to some forms of bio-fuel. which again on combustion process generate heat which in turn can produce steam from water or any forms of gas and drive turbines to generate electricity. Geothermal energy is derived by utilizing the heat generated within the earth. The heat so generated is used to convert the water into steam and drive a turbine. This turbine in turn drives the generator shaft resulting in electricity generation. Geothermal energy falls under the category of renewable energy source because the water utilized during the entire process can be replenished by rainfall and the heat is continuously generated within the surface of the earth. Wind energy is utilized with the help of wind farms by employing the wind mills and turbines. The mechanical energy due to the movement of the blades is converted into electrical energy using the generator which can be used to charge batteries, can be connected to a building's main power or to the national power grid. Solar energy which is considered to the most abundant form of renewable energy in India is discussed in section 3.

Solar Energy

Solar is considered to be the cleanest and the most abundant form of energy in India and other parts of the world. This energy can be utilized either after conversion into electrical energy with the aid of the semiconductors in the form of Photo Voltaic (PV) cells and solar panels, or can be used in its natural form as a source of light and heat energy using the Concentrated Solar Power (CSP) or for heating and cooling purposes (www.ren21.net). The global investment in US billion dollars for renewable energy sources in developed and developing countries in 2012 is shown in Fig. 5. (www.ren21.net).

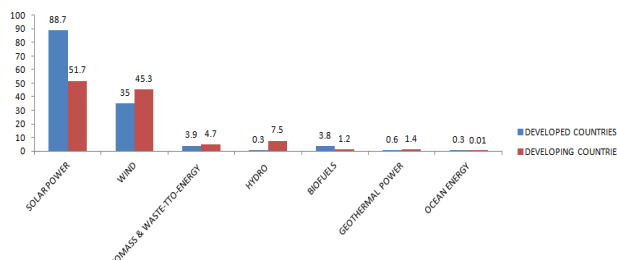
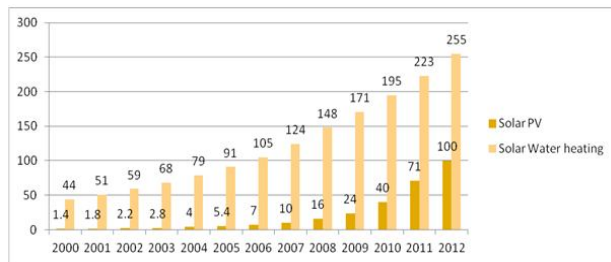


Fig. 5. Solar energy in developed and developing countries

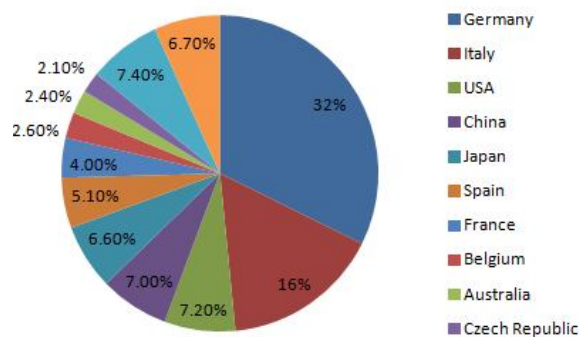
**Table 1. Generation of power in MW in India**

State	Conventional Energy Sources	Wind Energy	Solar Energy	Biomass	Bagasse	Small Hydel	% of Renewable Energy capacity from total generation capacity
Rajasthan	9,588	2,683	553	106		24	26%
Gujarat	18,479	3,164	857	31		6	18%
Maharashtra	27,137	3,008	206	127	996	332	14.7%
Karnataka	10,247	2,142	14	106	1,147	701	28.6%
Tamil Nadu	11,974	7,179	20	204	659		40.2%
Total	77,425	18,176	1,650	574	2,802	1,063	23.8%

The solar energy can be used in three ways 1. using solar PV 2. Solar water heating and concentrated solar thermal power. The global capacity of solar PV and solar water heating from the year 2000 - 2012 in GW is shown in Fig. 6. (www.ren21.net).

**Fig. 6. Global capacity of solar PV and solar water heating**

Also, global capacity of concentrated solar thermal power in MW over the years is discussed in (www.ren21.net). The shares among different countries in the world for the global capacity of solar PV in 2012 is shown in Fig. 7. (www.ren21.net).

**Fig. 7. Global capacity of solar PV**

Similarly, the shares among different countries in the world for the global capacity of solar water heating is given in (www.ren21.net). The consumption of solar power in TWh and Mtoe across different countries in the world from 1995 to 2012 is listed in (http://www.bp.com/statisticalreview). The different schemes or mission which promotes or develop solar projects in India has been listed in Table 2. (www.mnre.gov.in).

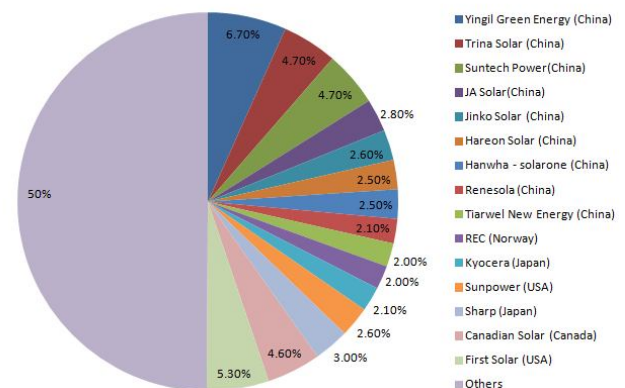
SOLAR PROJECTS IN INDIA	INSTALLED CAPACITY IN MW
Projects Under JNNSM	421.9
Projects under the State Policy	824.09
Projects Under RPSSGP/GBI Scheme	91.8
Projects Under REC Scheme	23.905
Other projects	78.91
<b>TOTAL</b>	<b>1440.065</b>

The solar power installed in India across different states in MW as on March 2013 is listed in Table (www.mnre.gov.in).

Sr. No.	States	Installed Capacity (MW)
1	Andhra Pradesh	23.15
2	Arunachal Pradesh	0.025
3	Chhattisgarh	4
4	Delhi	2.525
5	Goa & UT	1.685
6	Gujarat	824.09
7	Haryana	7.8
8	Jharkhand	16
9	Karnataka	14
10	Kerala	0.025
11	Madhya Pradesh	11.75
12	Maharashtra	34.5
13	Odisha	13
14	Punjab	9.325
15	Rajasthan	442.25
16	Tamil Nadu	17.055
17	Uttarakhand	5.05
18	Uttar Pradesh	12.375
19	West Bengal	2
<b>Total</b>		<b>1440.605</b>

Also, the name of the companies present in each state which undertakes the solar project with the capacity is given in (www.mnre.gov.in). The upcoming solar projects in India is listed in (www.mnre.gov.in).

The global manufacturers of solar PV module in 2012 is shown in Fig. 8. (www.ren21.net).

**Fig. 8. Solar PV manufactures**

## Conclusion

The generation of power is growing strongly since 2003. India had a varied and complex policy and regulatory framework which supports generation of solar energy over the last two decades. The development of wind energy in India is a response to chronic electricity shortages and to have a

independent energy. The drivers for generating solar power in India are anti-nuclear, environmental sustainability or climate change concerns which differ from other countries. The solar power when combines with other renewable energy sources or other conventional energy sources can be used in meeting the future demand.

## REFERENCES

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[www.cea.nic.in](http://www.cea.nic.in)  
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