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The Contemporary Scenario of Indian Renewable Energy Sector

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Abstract

The paper focuses on the contemporary scenario of renewable energy sources in India. Wind, biomass, small hydro and solar constitutes India's renewable energy sources. India is a large country with an area of 3,287,263 sq. kilometers. Thus, it has access to ample of renewable resources. With prevailing threats of global warming and exhaustion of conventional energy sources, it becomes mandatory to exploit renewable sources and to develop technologies for efficient extraction of power from them. India has shown remarkable growth in its renewable sector over the last decade. In India, the total installed capacity of power generation from all sources is 2,45,401 MW as on March,2014. About 31,702 MW of power is generated from renewable sources which constitutes nearly 13% of the total installed capacity. India has high capacity of power generation from wind. Nearly 67% of power is generated by wind alone from total renewable installed capacity. Comprehensively, it is increasingly essential to develop renewable energy conversion systems since they provide environmental benefits as well as other benefits to humans like energy security, job creation, economic growth and lesser dependency upon the exhaustible energy resources

Keywords: Renewable energy, power generation, wind, solar, policies, technologies, installed capacity.

Introduction

Energy security and sustainable development are important concerns for every nation of the world due their high demand, volatility and global impact. According to the United Nations, economic growth, climate stability and social equality are connected by an abstract thread of sustainable energy. In past few decades, the rate of natural resources depletion has increased considerably due to accelerated growth in population and fossil fuel consumption.

Thus, development of renewable technologies can be considered as an alternative for achieving the challenge of sustainable development.

On a global scale, the renewable energy provided an estimated 19% of final energy consumption in 2012[1]. After USA, China and Russia, India is the largest consumer of energy in the world but it does not possess profuse energy resources. Recently, the power availability in India has increased but the supply is not commensurate with the demand. Renewable energy sources play key role in power generation in addition to conventional sources. Currently, a major portion of power (about 87%)[2] in India is generated from conventional sources. This cause greater climate change and rapid exhaustion of conventional energy sources. Thus, it becomes mandatory to install myriads of environmental friendly renewable power stations for a sustainable future. Figure-1 shows the global position of India in renewable installed capacity.

In India, the main grid connected renewable energy technologies include biomass gasification, bagasse-based biomass cogeneration, non-bagassebased biomass cogeneration, onshore wind energy, grid connected solar photovoltaic, solar thermal and small hydropower plants.

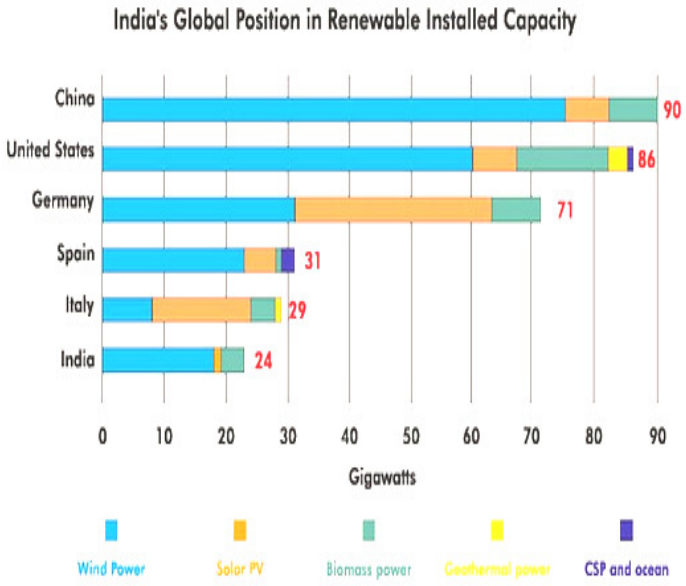
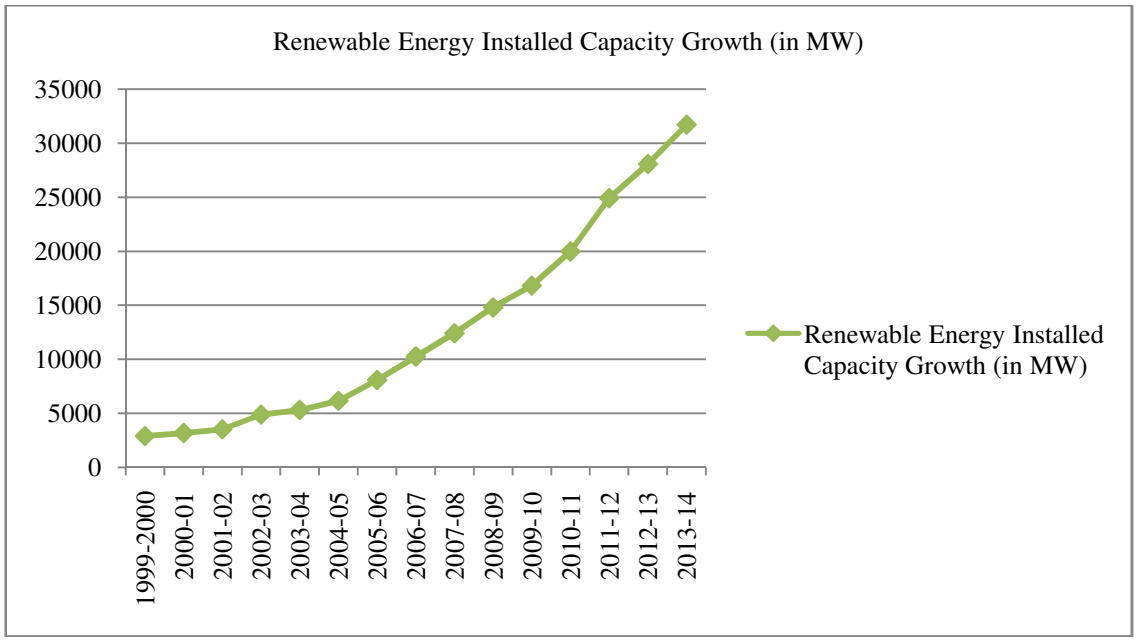


Figure-1
India's Global Position in Renewable Installed Capacity
(Source: REN 21, Global Status Report 2014)

In past few years, there has been an appreciable growth in Indian renewable energy sector that encouraged the investors to



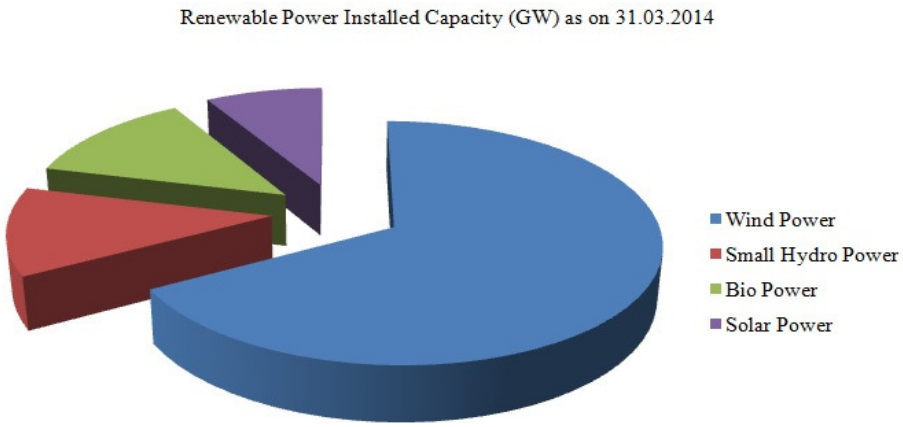
Source: MNRE, Annual Report 2013-14

Figure-2

Graph showing the Renewable Energy Installed Capacity Growth (in MW) in India from the period 1999-2000to 2013-14

invest into this region. From figure 2, it can be observed that the cumulative grid interactive power capacity of renewable energy has been increasing tremendously and the installed capacity is 31,702 MW as on 31st March, 2014[2].

Power from Renewable Energy Sources: In India, the renewable energy has contributed considerably during the last five years in the country's energy scenario. Census of India 2011 indicates that access to electricity stands at only around 55% of the rural households and nearly 23% of urban household still rely upon traditional fuels to meet their cooking needs[3]. The total all India installed capacity of power generation from renewable sources has witnessed 20% growth from 14.40 GW in 2009 to 31.70GW in 2014[2]. India occupies 5th position in the world with a wind power installed capacity of 21.13 GW[1]. Biomass power -generation is around 4.01 GW. Small hydro projects with a capacity of 1.71 GW have been installed in the year 2013-14. Solar power projects installations have witnessed tremendous growth with over 1.68 GW capacity solar power plants using solar photo-voltaics and solar thermal technologies being commissioned during the year 2013-14[2]. During the 12th plan, the ministry is targeting deployment of 15 GW for Wind Power, 2.10 GW for Small Hydro Power, 0.5 GW for Biomass Power, 1.40 GW for Baggase Cogeneration and 10 GW for Solar Power (Photovoltaics and Thermal). Figure 3 shows the installed renewable power generation capacity (in GW) and table 1 shows the cumulative deployment of various renewable energy systems in India as on 31.03.2014.



Source: MNRE,Annual Report 2013-14

Figure-3

Installed Power Generation Capacity (in GW) from Renewable Sources in India

Table-1
Cumulative Deployment of Various Renewable Energy Systems/Devices in India (as on 31.03.2014)

Sector	Achievements during 2013-14 (up to March, 2014)	Cumulative Achievements (as on 31.03.2014)
1. GRID-INTERACTIVE POWER (capacities in MW)		
Wind Power	2079.00	21131.83
Small Hydro Power	171.40	3803.70
Biomass Power and Gasification	101.60	1365.20
Bagasse Cogeneration	310.92	2648.40
Waste to Power	10.50	106.60
Solar Power	962.10	2647.00
Total	3635.52	31702.73
2. OFF-GRID/ CAPTIVE POWER (capacities in MW)		
Waste to Energy	17.10	132.70
Biomass (non-bagasse) Cogeneration	60.70	531.80
Biomass Gasifiers		
----*Rural*	0.60	17.50
----*Industrial*	7.10	147.20
Aero-generators/ Hybrid Systems	0.10	2.30
SPV Systems	116.20	174.40
Water Mills/ Micro Hydel	1.60	13.21
Bio-gas based energy system	0.55	3.77
Total	203.95	1089.40

Source:MNRE, Annual Report 2013-14

Wind Power

Indian Wind Energy Status: In India, the strong south-west summer monsoon, starting in May-June influences the wind. In October, cool dry air moves towards the ocean. During the period from November to March, wind speeds are relatively low in the country. Except the eastern peninsular coast, Indian Peninsula experiences uniformly strong winds during the period from March to August.

Wind energy program was commenced in India by the end of the 6th five year plan during 1983-84 and in the last few years it has increased considerably. The main objective of the program was the commercialization of wind energy production, support research and development, provide help to wind projects and to create awareness among people. Global installed wind power capacity shows India's better performance in wind energy sector (table-2). The five main wind power countries are China, USA, Germany, Spain and India and they together represent a share of 73% of the global wind capacity[4]. As per MNRE 2014, wind power accounts for the largest share of renewable power installed capacity (about 67%) as compared to the other renewable sources in India[5]. The total installed wind power capacity in the country has increased from 19,565 MW in 2013 to 21,132 MW in March, 2014.India's cumulative installed capacity up to year 2012 is shown in figure-4[4].

The Centre for Wind Energy Technology (C-WET)[6] in association with State Nodal Agencies has launched Wind Resource Assessment (WRA) program in which 789 wind monitoring stations, including 87 new stations have been commissioned in 28 states and 3 Union Territories of India during the year 2013-14. The Ministry of New and Renewable Energy has taken up a new initiative for implementation of wind resource assessment in new areas with an aim to assess the realistic potential at 100 m level in 500 new stations across the

Table-2
Total Global Installed Capacity of Wind Power generation (up to June 2013)

Global Wind Power Scenario	
Country	**Installed Capacity (MW)**
China	80,824
USA	60,009
Germany	32,422
Spain	22,907
India	**19,565**
UK	9,610
Italy	8,415
France	7,821
Canada	6,578
Denmark	4,578
Portugal	4,564
Sweden	4,066
Australia	3,059
Brazil	2,788
Japan	2,655
Rest of the World	26,204
Total	296,065

Source: World Wind Energy Association, 2013

Table-3
Wind Power Potential in India at Different Heights

State/ UTs	Estimated Potential (MW)	
	50 m	**80 m** *(to be validated through field measurement)*
Andaman and Nicobar	2	365
Andhra Pradesh	5394	14497
Arunachal Pradesh	201	236
Assam	53	112
Bihar	-	144
Chhattisgarh	23	314
Diu and Daman	-	4
Gujarat	10609	35071
Haryana	-	93
Himachal Pradesh	20	64
Jharkhand	-	91
Jammu and Kashmir	5311	5685
Karnataka	8591	13593
Kerala	790	837
Lakshadweep	16	16
Madhya Pradesh	920	2931
Maharashtra	5439	5961
Manipur	7	56
Meghalaya	44	82
Nagaland	3	16
Odisha	910	1384
Pondicherry	-	120
Rajasthan	5005	5050
Sikkim	98	98
Tamil Nadu	5374	14152
Uttarakhand	161	534
Uttar Pradesh	137	1260
West Bengal	22	22
Total	**49130**	**102788**

Source: MNRE, Annual Report 2013-14

country under the National Clean Energy Fund (NCEF) to be implemented through C-WET.

Potential Sites of Wind Energy in India: Some of the states located in southern and eastern parts of India namely Tamil Nadu, Maharashtra, Gujarat, Rajasthan and Karnataka contribute 94% of total wind energy generated in the country[7]. It can be observed that these five states have been leaders in wind energy generation while other states like Madhya Pradesh, Rajasthan and Kerala are also increasing their capacity. Table 4 provides state wise installed wind power capacity and growth rate of wind energy in India from 2009 to 2014. The highest wind energy installed state Tamil Nadu increased its capacity from 4304.5 MW in March, 2009 to 7275.6 MW in March, 2014 with a growth of 69% over the same period.

Wind atlas is helpful in determining promising sites for large scale wind power generation. The numerical wind atlas of India has been developed by NIWE in association with RISO DTU, Denmark. The problems pertaining to insufficient wind measurements in the nation are resolved using numerical wind atlas methodologies. The Indian Wind Atlas measures the on-shore wind power potential to be 49,130 MW at 50 m a height of 50 m and 1,02,000 MW at 80 m height. Indian Wind atlas at 50 m height has been shown in figure 5[6].

Development of Wind Power in India: Numerous renewable energy sources are available in India. Amongst all, wind energy has emerged as most successful renewable energy option and the fastest renewable technology for generating grid connected power. Many agencies have been established and numbers of programs have been laid by Government of India for facilitating and promoting the rapid development of wind power technology[2]. The Centre for Wind Energy Technology (C-WET)[6] is an Autonomous Research and Development Institution established under Tamil Nadu Societies RegistrationAct, 1975 under the Ministry of New and Renewable Energy, Government of India. C-WET's Wind Turbine Test Station (WTTS) near Kayathar in Tamil Nadu was also established with the technical assistance of RISO National Laboratory, Denmark[2]. An Offshore Wind Energy Steering Committee (OWESC) was constituted under the Chairmanship of the Secretary, MNRE to propose policy framework for offshore wind energy development in the country. Also, the MNRE supports the RandD projects through C-WET for in house RandD projects and also through research institutions, national laboratories, universities and industries[2]. It primarily emphasizes in the area of power quality issues and identification of remedial measures in grid connected wind farms. It is also responsible for development of small wind turbines.

Solar Power

India Solar Energy Status: India has large solar energy potential as most parts of the country have about 300 clear sunny days in a year and receive on an average of 4-7 kwh (kilowatt-hour) solar radiation per square meter per day[2]. The highest annual solar radiation is received by Rajasthan whereas the north-eastern parts of the country receivethe least.

The ways in which solar energy can be utilized are as follows: The Thermal route, The Photovoltaic route.

In Solar Thermal Power systems, solar radiations are concentrated using concentrating solar collectors and thus, serves as high temperature energy source. This focused radiation produces heat which is carried by thermic fluids. Consequently, steam or hot gases are produced which are then used to drive heat engines. Thus, electricity is produced.

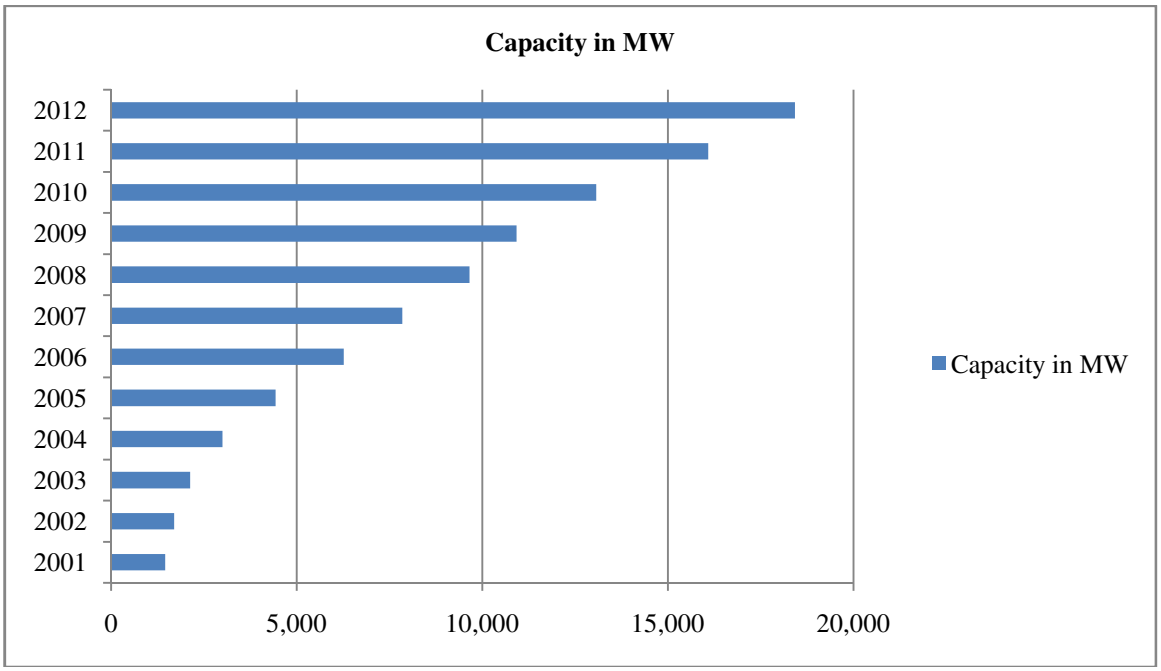
Solar photovoltaic's (SPV) convert solar radiation into electricity with the aid of a semi-conducting device known as solar cell, which is primarily made of silicon. A general feature

of solar cell is that when it is exposed to sunlight, it generates electricity. Various factors such as the exposed area of the solar cell, intensity of the solar radiation, ambient temperature and fabricating material of solar cell determine the magnitude of generated electric current. The required power is thus, obtained by forming modules of solar cells in series and parallel combinations.

The global distribution,virtually inexhaustible supply and pollution free naturelionizes solar energy as a very attractive and efficient energy source. Efforts are being made to install solar power plants, thereby leading towards a sustainable way. It can be observed from figure 6 that the installation of solar power in India has increased tremendously from the period 2008-09 to 2013-14 with the maximum installation of 962 MW solar power in 2013-14.

Jawaharlal Nehru National Solar Mission (JNNSM): A National Action Plan on Climate Change was announced in June 2008. It incorporated eight major national missions with primary focus on solar energy. The prognosisof the mission is to comprehensively utilize solar energy for power generation and other purposes.

In 2010, the Government of India in association with State Governments launched Jawaharlal Nehru National Solar Mission (JNNSM) which is considered to be a momentous step towards the promotion and development of sustainable growth keeping in view the aspects of energysecurity in India.



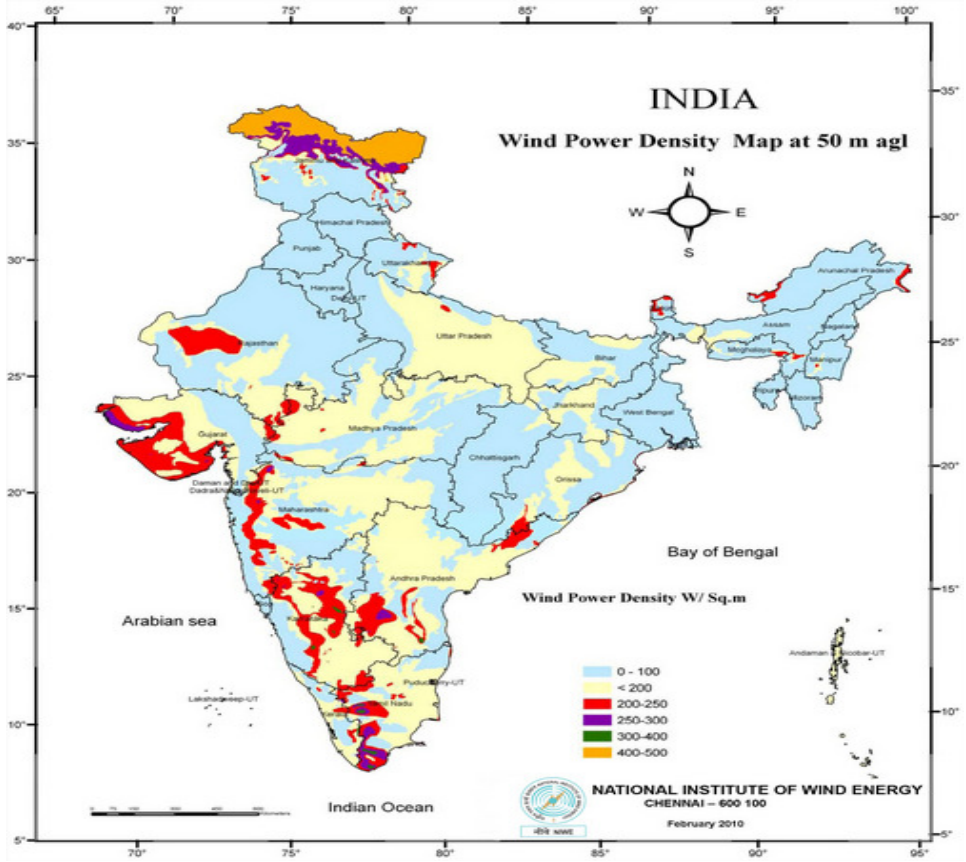
Source: GWEC, Global Wind Report 2012

Figure-4
India's Total Wind Power Installed Capacity from the year 2001 to 2012

Table-4
Installed Capacity of Wind Power in Various States of India (in MW)

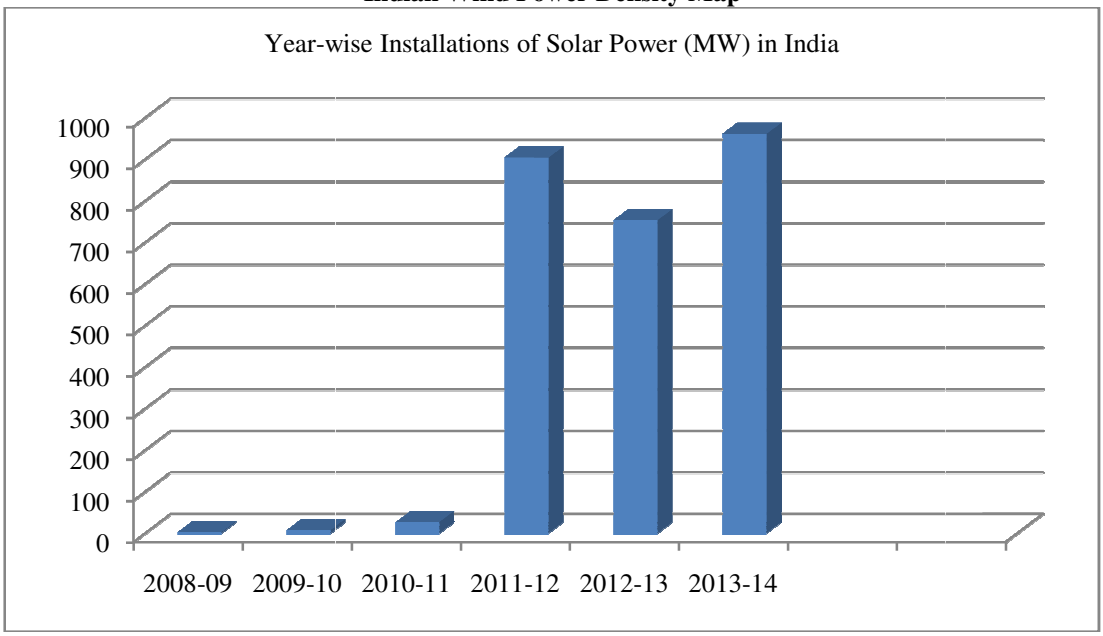
State	March 2014	March 2013	March 2012	March 2011	March 2010	March 2009
Tamil Nadu	7275.6	7162.1	6987.6	5904.4	4907.0	4304.5
Karnataka	2323.8	2135.1	1933.5	1730.0	1473.0	1327.4
Maharashtra	4064.9	3021.8	2733.3	2310.8	2078.0	1938.9
Rajasthan	2783.45	2684.6	2070.7	1524.8	1088.0	738.4
Andhra Pradesh	783.35	447.6	245.5	200.2	236.0	122.5
Madhya Pradesh	423.4	386.0	376.4	275.5	229.0	212.8
Kerala	35.1	35.1	35.1	32.8	28.0	27.0
Gujarat	3447.2	3174.5	2966.3	2175.5	1864.0	1566.5
Others	4.3	4.3	3.2	0.0	4.0	1.1
Total	**21141.3**	**19051.4**	**17365.0**	**14158.0**	**11807.0**	**10242.3**

Source: Indian Wind Energy Association, 2014



Source: Centre for Wind Energy Technology, 2010

Figure-5
Indian Wind Power Density Map



Source: Ministry of New and Renewable Energy, Government of India, Annual Report 2013-14

Figure-6
Year-wise Installation of Solar Power in India from the period 2008-09 to 2013-14

a major initiative to promote ecologically sustainable growth while ensuring India's energy security. The objectives of the mission are[2,9] : By the year 2022, establishment of 20,000 MW of grid-connected solar power, To meet Off-grid solar demand of about 2,000 MW, encompassing 20 million solar lights by 2022, To cover a solar thermal collector area of 20 million square meters.

There are three phasesof JNNSM, covering 15 years for achieving its goals. The first phase comprises of three years (up to March, 2013), the second till March

2017 and the third phase will continue till March, 2022. The first phase targets to set up 1,100 MW grid connected solar plants which includes 100 MW of small androof topsolar plants and 200 MW capacity equivalent off-grid solar applications[9,10]. The detailed information regarding grid solar power projects under JSSN is shown in table-5.

Challenges in Power Generation by Solar Energy: The generation of power from solar energy is greatly unfeasible due to the high cost involved. However, a number of RandD departments and research centers have been established by the government for accomplishment of efficient technologies in order to exploit indefinite solar energy.

Land Scarcity: Land is a scarce resource in India. Also, the per capita land availability is very low. This leads to the increment of solar cells installation problem since land dedication near substations are rare.

There is a need for improving financing infrastructure and models to foster the growth of PV industry, resulting in the increased consumption of PV products.

Convoluted subsidy structure and too much involvement of various agencies like IREDA, MNRE, SNA etc needs to be attenuated and simplified for enhanced exploitation of solar energy resource.

Conclusion

The exhaustive nature of conventional energy sources coerces the nations to shift its vision towards the exploration and development of technologies for power generation from renewable energy sources.

Table-5
List of solar power projects selected under the JNNSN (State-wise)

Details of Grid Solar PV Power Projects under JNNSN								
I. Solar PV Projects								
	New NVVN		**Migration**		**IREDA**		**Total**	
State	**Numbers**	**MW**	**Numbers**	**MW**	**Numbers**	**MW**	**Numbers**	**MW**
Andhra Pradesh	4	20			11	10.5	15	30.5
Chhattisgarh					2	4	2	4
Gujarat							0	0
Haryana					10	9.8	10	9.8
Jharkhand					8	16	8	16
Karnataka	2	10					2	10
Madhya Pradesh					3	5.25	3	5.25
Maharashtra	1	5	3	11	3	5	7	21
Odisha	1	5			8	8	9	13
Puducherry					1	1	1	1
Punjab			2	7	7	8.5	9	15.5
Rajasthan	21	105	8	36	12	12	44	153
Tamil Nadu	1	5			7	7	8	12
Uttarakhand					3	5	3	5
Uttar Pradesh					5	8	5	8
Total	30	150	13	54	80	100.05	126	304.05
II. Solar Thermal Projects								
	New NVVN		**Migration**		**Total**			
State	**Number**	**MW**	**Number**	**MW**	**Number**		**MW**	
Andhra Pradesh	1	50			1		50	
Gujarat	1	20			1		20	
Rajasthan	5	400	3	30	8		430	
Total	7	470	3	30	10		500	

(NVVN=NTPC VidyutVyapar Nigam, IREDA= Indian Renewable Energy Development Agency Ltd.)
Source: India Energy Book, 2012

India has vast availability of coal and other conventional sources but the rate of consumption is alarming. Therefore, Government of India is investing in augmentation of technologies and allocation of resources for renewable power generation through various organizations for a sustained future. Efforts made by research centers like The Energy and Resource Center (TERI), Solar Energy Center (SEC), Center for Renewable Energy and Environment Development (CREED), Auroville Centre for Scientific Research (CSR) etc has increased India's grid-interactive power supply to nearly 32 GW. In terms of wind power generation, India has reached to the fifth position. Additionally, the large scale installation of solar PV will also contribute towards the sustainable future of India. Thus, over the period of time, India's energy policies need to be shaped to ensure energy security and attaining energy self-sufficiency.

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