A COMPARATIVE STUDY OF ELECTRICITY GENERATION BY SOLAR AND WIND ENERGY IN INDIA

Ankit Dwivedi, Bhavishya Chandra Anand, Chetan Purohit, Dikesh Kumar Sen
UG Students, Department of Electrical Engineering, Poornima College of Engineering, Jaipur

***Abstract*– In present scenario energy resources are being used at an alarming high rate. In order to ensure that younger generation are least deprived of their energy usage. Renewable energy resources needs to get more attention and research. India now considers Wind, Solar and Piezo as an alternate source of future energy generation. In India incidence of Solar energy in land area alone is 5000 trillion kilowatt hours which exceeds energy outcome of all possible non-renewable energy reserves in India. Next higher potential after Solar comes from Wind. In India Wind flows at an average speed of 55 kmph. Also, India contains largest Railway network in the world along with network of local trains in Bombay and metro in Delhi, Jaipur, Mumbai, Pune etc. This network adds to the potential of wind energy in India. maximum energy generated in one hour is 3.86 KWh.**

***Index Terms*- Wind energy, Renewable energy, wind turbines, Stress, fuel.**

I. INTRODUCTION

Today the demand for energy has drastically increased as a result of which fossil fuels are consumed at a high rate.
Keeping in view the problems related to energy reserves, India has identified Solar and Wind as potential renewable energy sources that can mitigate the issues related to depletion of fossil fuels. India's total renewable energy capacity has reached around 33GW. The target is to achieve 175GW by 2022. India is planning to extend by 100GW of solar and 60 GW of wind capacity with nearly 25 solar parks with capacity of 1000MW.
Now taking into consideration the numerical data of wind and solar in India as on 30st September is, 28082.95MW power due to wind grid interactive power generation and 8513.23MW power due to solar grid interactive power.
Wind energy is considered as one of the most clean and easy to use energy. The cost of storing it and using it also low. In India total installed wind power capacity of India was 21136.3 MW in 2014-15 and ranks 5th in the world.

Another promising device for producing electricity power is Piezo-electric vibration based generators. Conversion of vibration to electrical energy is possible using piezoelectric, electromagnetic and electrostatic based device. It is stated in that, generally, electrostatic device is able to produce electrical energy up to 2% of efficiency while electromagnetic device according to, it can generate electrical power up to 1.4mW with 25% efficiency.
In India the goross installed capacity of solar grid intereactive power is 4879 MW. Also the grid connected solar PV power projects 3000 MW by NTPC and other PSU tenders for 2750 MW capacity.

In this paper we attempted to incorporate a hybrid system consisting of piezoelectric materials and wind turbines. Piezoelectric materials are used for energy harvesting, by utilizing pressure applied on it. On the other hand, wind energy is an excellent form of renewable energy. The storage capacity of the plant is a key feature as it results less wastage compared to conventional hybrid system.

II. EXISTING SYSTEM

Thermal power plant have been the main source of power in the world for centuries.

Source	Captive Power Capacity (MW)	Share
Coal	27,588	58.60%
Hydroelectricity	83	0.17%
Renewable energy source	Included in 'Oil'	
Natural Gas	5,215	11.08%
Oil	14,196	30.17%
Total	**47,082**	**100.00%**

Fig 1-Existing Power System of India

With our experience in Thermal and Gas power plant as a part of India's largest power generating companies the following are the Pros and Cons that come to my mind.

Needs large amount of Coal and Water so has to be placed a large water sources and coal mine. Else the

- logistics cost will be too high. A Power plant of 3000MW typically requires 35,000 to 45,000 tons of coal.
- It is the prime contributor to CO2 emissions all over the world. With the Climate change a restriction is now placed on all countries in this regard.
- Nearly 20% to 30% of coal is rejected as Ash, which is a waste and needs to be dumped. Unutilized ash is collected in Ash dykes that form the largest land usage in a typical thermal power plant. It is also detrimental to environment.

Growth of Installed Capacity in India[3][4]

Installed Capacity as on	Thermal (MW)				Nuclear (MW)	Renewable (MW)			Total (MW)	% Growth (on yearly basis)
	Coal	Gas	Diesel	Sub-Total Thermal		Hydro	Other Renewable	Sub-Total Renewable		
31-Dec-1947	756	-	98	854	-	508	-	508	1,362	-
31-Dec-1950	1,004	-	149	1,153	-	560	-	560	1,713	8.59%
31-Mar-1956	1,597	-	228	1,825	-	1,061	-	1,061	2,886	13.04%
31-Mar-1961	2,436	-	300	2,736	-	1,917	-	1,917	4,653	12.25%
31-Mar-1966	4,417	137	352	4,903	-	4,124	-	4,124	9,027	18.80%
31-Mar-1974	8,652	185	241	9,058	640	8,966	-	8,966	18,664	10.58%
31-Mar-1979	14,875	188	184	15,207	640	10,833	-	10,833	26,680	12.02%
31-Mar-1985	28,311	542	177	27,030	1,095	14,460	-	14,460	42,585	9.94%
31-Mar-1990	41,236	2,343	165	43,784	1,565	18,307	-	18,307	63,656	9.89%
31-Mar-1997	54,154	6,562	294	61,010	2,225	21,658	902	22,560	85,795	4.94%
31-Mar-2002	62,131	11,163	1,135	74,429	2,720	26,269	1,628	27,897	105,046	4.49%
31-Mar-2007	71,121	13,692	1,202	86,015	3,900	34,654	7,760	42,414	132,329	5.19%
31-Mar-2012	112,022	18,381	1,200	131,603	4,780	38,990	24,503	63,493	199,877	9.00%
31 Mar 2015	169,118	23,062	1,200	188,898	5,780	41,267	35,777	77,044	271,722	11.98%
31 Mar 2016	185,172	24,508	993	210,675	5,780	42,783	42,727	85,510	301,965	11.13%

Fig 2-Growth of Installed Capacity in India

- Some liquid effluents are also discharged as the byproduct of water / chemical treatment and runoff of various oil / chemicals.
- Thermal power plant take a lot of time to start up (generally 4–8 hrs.) and don't do well in cycling that is large up and down in power generation and mostly designed for constant load. Therefore any fluctuation is power demand can be detrimental to it life cycle.
- A large quantity of ash is released from the Chimney and the coal dust that lead to a high particulate matter in the surrounding areas. Though nearly 99% is captured using ESP still a significant amount escapes.

III. RENEWABLE ENERGY POTENTIAL

India has an estimated renewable energy potential of about 900 GW of which Wind contributes 102 GW, Solar Power contributes 750 GW.

Renewable energy has a great potential to usher in universal energy access in a decentralized or standalone mode, renewable energy is an appropriate, scalable and viable solution for providing power to un-electrified or power deficient villages and hamlets. Around 1.1 million households are using solar energy to meet their lighting energy needs and almost similar numbers of the households meet their cooking energy needs. Solar Photovoltaic (PV) power systems are being used for a variety of applications such as rural electrification, railway signalling, microwave repeaters, TV transmission and reception and for providing power to border outposts. Over 10,000 remote and inaccessible villages and hamlets have been provided with basic electricity services through distributed renewable power systems.

Table1.1 : State wise renewable energy potential (in MW)

Sl. No.	States/UTs	Wind Power	Small Hydro Power	Bio-Energy			Solar	Total
				Biomass Power	Bagasse Cogeneration	Waste to Energy		
1	Andhra Pradesh	14497	978	578	300	123	38440	54916
2	Arunachal Pradesh	236	1341	8			8650	10236
3	Assam	112	239	212		8	13760	14330
4	Bihar	144	223	619	300	73	11200	12559
5	Chhattisgarh	314	1107	236		24	18270	19951
6	Goa		7	26			880	912
7	Gujarat	35071	202	1221	350	112	35770	72726
8	Haryana	93	110	1333	350	24	4560	6470
9	Himachal Pradesh	64	2398	142		2	33840	36446
10	Jammu & Kashmir	5685	1431	43			111050	118209
11	Jharkhand	91	209	90		10	18180	18580
12	Karnataka	13593	4141	1131	450		24700	44015
13	Kerala	837	704	1044		36	6110	8732
14	Madhya Pradesh	2931	820	1364		78	61660	66853
15	Maharashtra	5961	794	1887	1250	287	64320	74500
16	Manipur	56	105	13		2	10630	10811
17	Meghalaya	82	230	11		2	5860	6185
18	Mizoram		169	1		2	9090	9261
19	Nagaland	16	197	10			7290	7513
20	Orissa	1384	295	246		22	25780	27728
21	Punjab		441	3172	300	45	2810	6768
22	Rajasthan	5050	57	1035		62	142310	148518
23	Sikkim	98	267	2			4940	5307
24	Tamil Nadu	14152	660	1070	450	151	17670	34152
25	Telangana						20410	20410
26	Tripura		47	3		2	2080	2131
27	Uttar Pradesh	1260	461	1617	1250	176	22830	27593
28	Uttarakhand	534	1708	24		5	16800	19071
29	West Bengal	22	396	396		148	6260	7222
30	Andaman & Nicobar	365	8				0	373
31	Chandigarh					6	0	6
32	Dadra & Nagar Haveli						0	0
33	Daman & Diu	4					0	4
34	Delhi					131	2050	2181
35	Lakshadweep						0	0
36	Puducherry	120				3	0	123
37	Others					1022	790	1812
	Total	**102772**	**19749**	**17536**	**5000**	**2554**	**748990**	**896602**

Fig 3-State-Wise Renewable Energy Potential (MW)

IV. RENEWABLE POWER INSTALLED CAPACITY

The gross installed capacity of grid interactive renewable power in the country stood at about 33.8 GW as on 31st December 2015 as shown in **Table 1.2.** As of December 2015, solar, wind, biomass and small hydropower contribute about 13.60 per cent of the total installed capacity for electricity. Renewable energy has been witnessing over 20 per cent growth in the last five years. From the total renewable power installed capacity of 14,400 MW at the beginning of 2009, it has reached a capacity of 38,822 MW at the end of December 2015. Wind energy continues to dominate India's renewable energy industry, accounting for over 64 % of installed capacity (25,088 MW), followed by solar power (4,879 MW), biopower (4,677 MW) and small hydro power (4,177 MW).

Sector	Achievements during 2015-16 (up to December 2015)	Cumulative Achievements (as on 31.12.2015)
I. GRID-INTERACTIVE POWER (CAPACITIES IN MW)		
Wind Power	1,644.58	25,088.19
Small Hydro Power	121.55	4,178.90
Bio Power (Biomass & Gasification and Bagasse Cogeneration	132.00	4,550.55
Waste to Power	12.00	127.08
Solar Power	1,119.78	4,878.87
Total	3,029.89	38,821.59
II. OFF-GRID/ CAPTIVE POWER (CAPACITIES IN MWEQ)		
Waste to Energy	0.50	146.51
Biomass(non-bagasse) Cogeneration	10.50	602.37
Biomass Gasifiers		
-Rural	0.20	18.15
-Industrial	8.67	160.57
Aero-Genrators/Hybrid systems	0.15	2.67
SPV Systems	54.85	289.01
Water mills/micro hydel	0.00	17.21
Bio-gas based energy system	0.00	0.00
Total	74.88	1,236.64
III. OTHER RENEWABLE ENERGY SYSTEMS		
Family Biogas Plants (numbers in lakh)	0.22	0.00
Solar Water Heating – Collector Area (million m2)	48.34	8.90

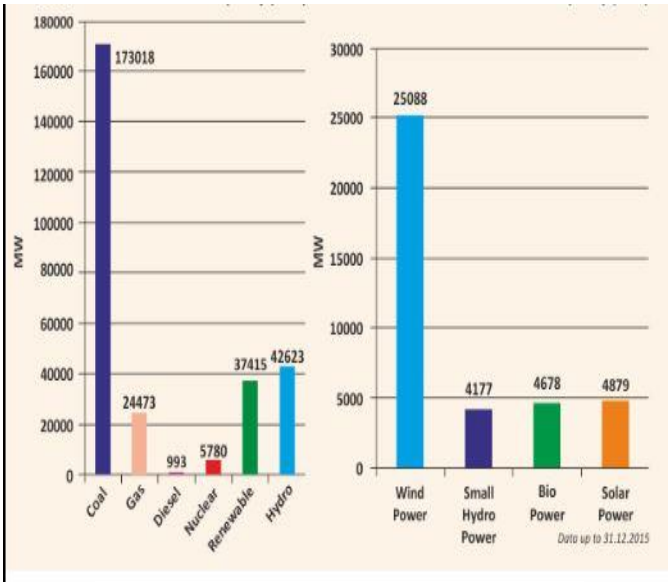

Fig 5- All India Power Installed Capacit (MW)

Fig 6-Renewable Power Installed Capacity (MW)

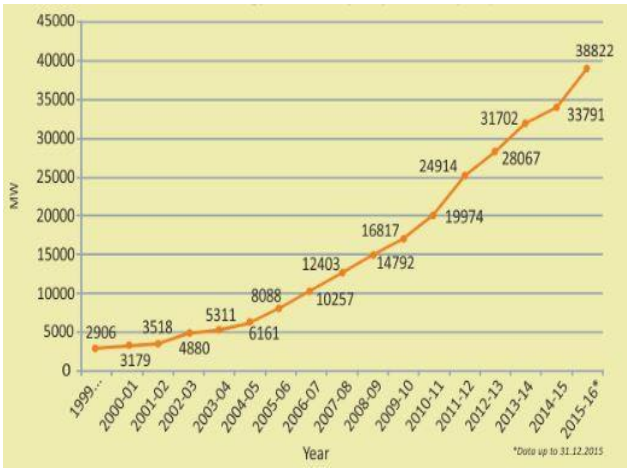

Fig 7-Renewable Energy Installed Capacity-Growth (MW)

V. RENEWABLE ENERGY FOR RURAL, URBAN, INDUSTRIAL AND COMMERCIAL APPLICATIONS APPLICATIONS

More than 37,000 biogas plants of the approved models were installed across the country with financial support of the Ministry, taking the cumulative installation to over 48.34 lakh biogas plants in all States and Union Territories of the country. The target of 1.11 lakh during the year is likely to be achieved in full.

Under the National Biomass Cookstoves Initiative, several pilot projects have been taken up during the year for deployment of improved biomass cookstoves for demonstration among domestic and large sized community cooking in Anganwadis, Mid-day meal

schemes in schools, Tribal Hostels etc. Projects taken up under Unnat Chulha Abhiyan are now eligible for Carbon Credits under the CDM mechanism with Sardar Swaran Singh National Institute of Renewable Energy (SSS-NIRE), an autonomous institute of MNRE, located at Jalandhar, Punjab has been designated as Coordinating and Managing Entity (CME). At present 40 models of improved cookstoves have been approved by the Ministry, as per the Test Reports issued by the Test Centres.

Rice husk gasifier based 12 village level projects of 32 kWe each have been installed based on sustainable business model by entrepreneurs in various villages of Bihar. In addition, 10 systems are under various stages of installation / commissioning. Off-grid power capacity from biomass gasifier in 10 rice mills and 12 other industries including bakeries for meeting captive demand of electricity and thermal applications have been added. A grid connected biomass gasifier based project of 1 MW capacity in Haryana has been installed for meeting the captive power needs of the industry. During the year 2015-16, the physical achievement under the programme is 14.1 MWeq. and cumulative achievement in the sector is 265.4 MWeq. As part of the new initiatives the Government has amended the National Tariff Policy to make Distribution Licencees to 100% procure power produced from WTE plants. A cumulative capacity of 601.87 MW has so far been commissioned mainly in the states of Tamil Nadu, Uttar Pradesh, Haryana, Karnataka, Andhra Pradesh, Uttarakhand, Punjab and Rajasthan. CEA have notified norms for determination of Generic Tariff for MSW, RDF and Biogas based WTE projects along with Generic Tariff for FY 2015-16. As a part of new initiative of supporting Bio-CNG production, two MNRE supported projects for cumulative production of 9,538kg/day of Bio-CNG, got commissioned during the financial year FY 2015-16, in Ahmedabad, Gujarat and Delawas, Jaipur.

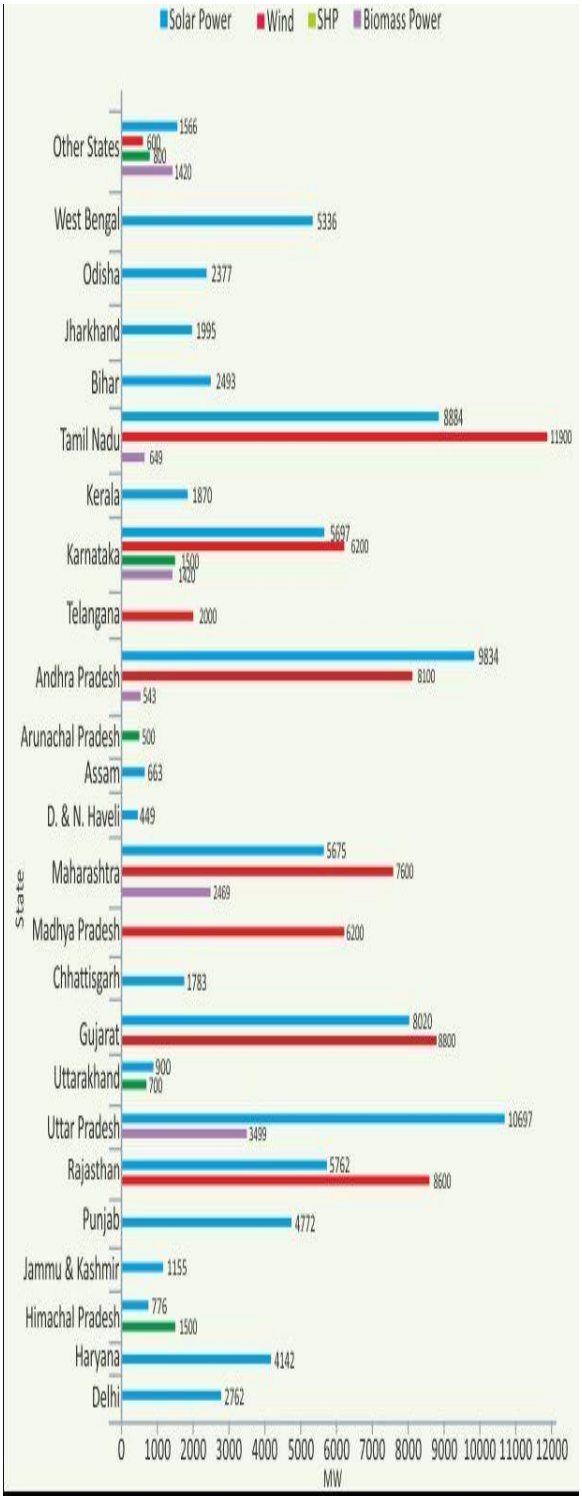

Fig 8-Tentative State-wise Break-up of Sector Wise Renewable Power Target of 175 GW by 2022

VI. SOLAR POWER IN INDIA

Solar power in India is a fast-growing industry and as of 31 December 2016, the country's solar grid had a cumulative capacity of 9,012.66 megawatts(MW) or 9.01 gigawatts (GW). In January 2015, the Indian government expanded its solar plans, targetingUS$100 billion of investment and 100 GW of solar capacity, including 40 GW's directly from rooftop solar, by 2022. The rapid growth in deployment of solar power is recorded and updated monthly on the Indian Government's Ministry of New and Renewable Energy website. Large scale solar power deployment began only as recently as 2010, yet the ambitious targets would see India installing more than double that achieved by world leaders Chinaor Germanyin all of the period up to 2015 year end.

In addition to the large-scale grid connected solar PV initiative, India is continuing to develop the use of off-grid solar power for localized energy needs. India has a poor electrification rate in rural areas. In 2015, only 55% of all rural households had access to electricity, and 85% of rural households depended on solid fuel for cooking. Solar products have increasingly helped to meet rural needs, and by the end of 2015, a cumulative total of just under 1 million solar lanternshad been sold in the country, reducing the need for expensive kerosene. In addition, a cumulative total of 30,256 solar powered water pumps for agriculture and drinking water had been installed. During 2015 alone, 118,700 solar home lighting systems were installed, and 46,655 solar street lighting installations were provided under a national program. The same year saw just over 1.4 million solar cookersdistributed or sold in India.

India is ranked number one in solar electricity production per watt installed, with an insolation of 1700 to 1900 kilowatt hours per kilowatt peak (kWh/KWp). On 16 May 2011, India's first solar powerproject (with a capacity of 5 MW) was registered under the Clean Development Mechanism. The project is in SivagangaiVillage, Sivagangadistrict, Tamil Nadu. India saw a sudden rise in use of solar electricity in 2010, when 25.1 MW was added to the grid, and the trend accelerated when 468.3 MW was added in 2011. Recent growth has been over 3,000 MW per year(see table below)and is set to increase yet further. Government-funded solar electricity in India was just 6.4 MW per year in 2005.

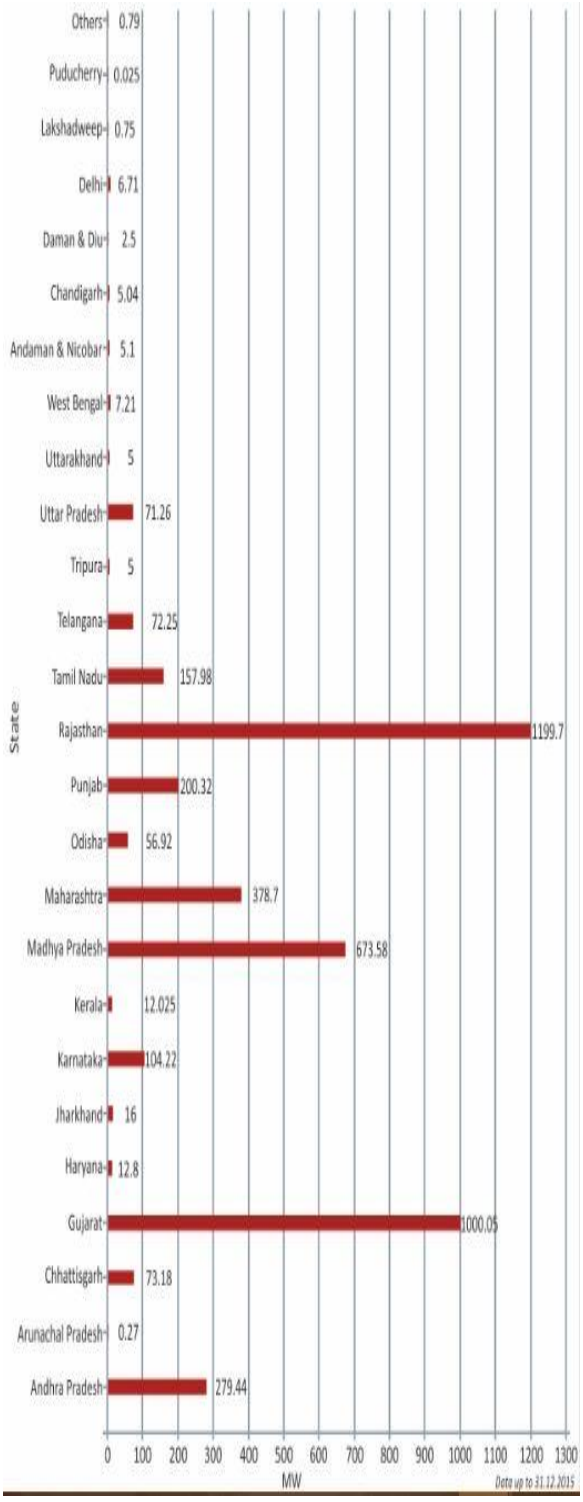

Fig 9-State-Wise Solar Power Installed Capacity

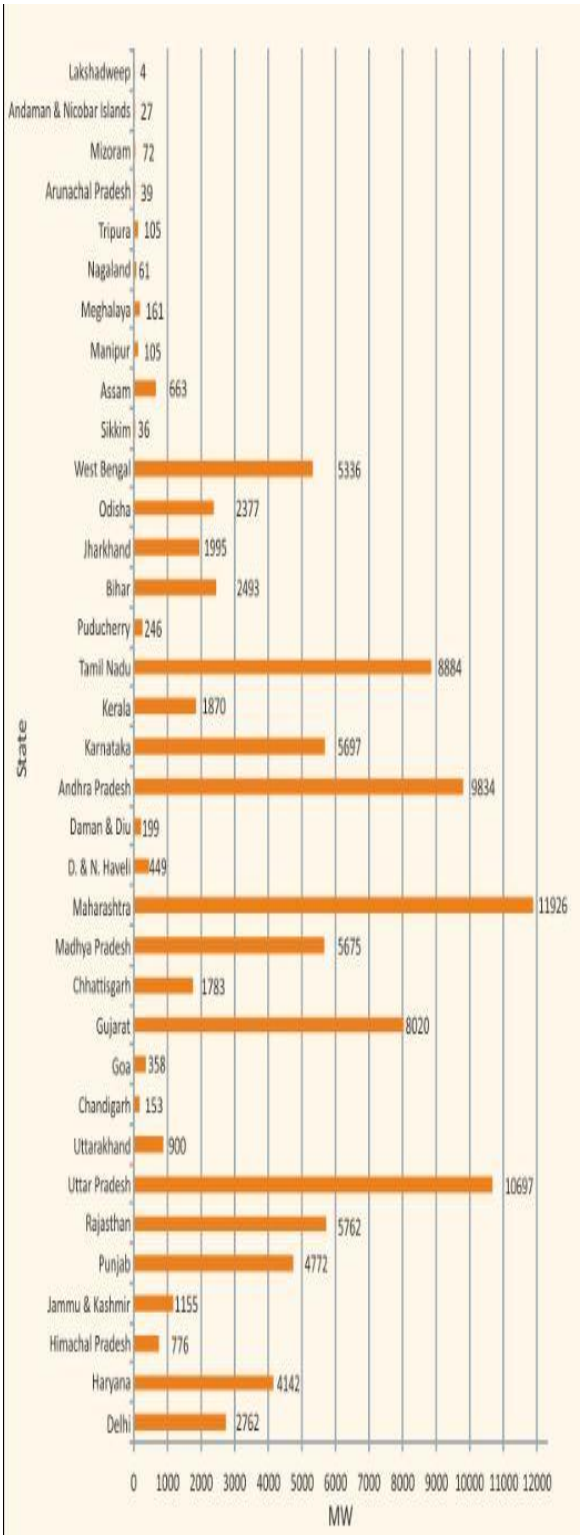

Fig 10-Tentative State-wise Break-up of 100 GW Solar Power (Ground Mounted & Roof Top)

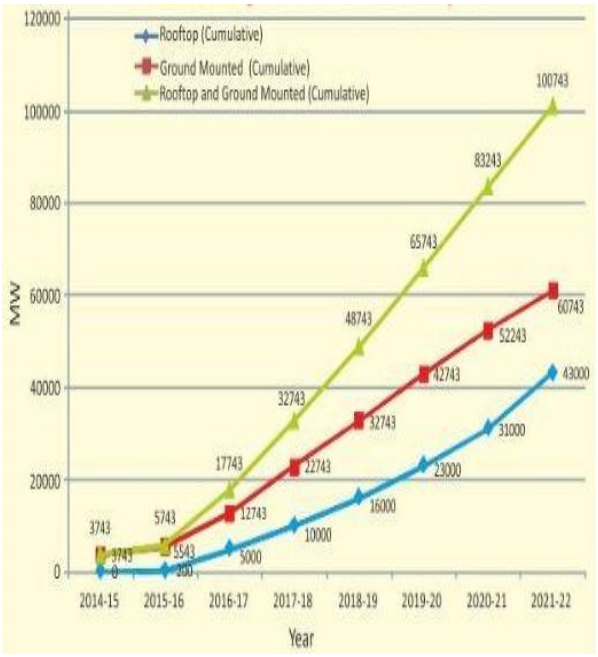

Fig 11-Tentative Year-wise Cumulative Targets of 100 GW Solar Power Under Renewable Energy Target of 175 GW

The development ofwind power in Indiabegan in the 1986 with first wind farmsbeing set up in coastal areas of Maharashtra(Ratnagiri), Gujarat(Okha) and Tamil Nadu(Tuticorin) with 55 kW Vestas wind turbines. These demonstration projects were supported by the Minstry of New and Renewable Energy (MNRE). The capacity has significantly increased in the last few years and as of 31 Aug 2016 the installed capacity of wind power in India was 27,676.55 MW, mainly spread across the South, West and North regions. [1]Although a relative newcomer to the wind industry, compared with countries such as Denmarkor the United States, by year end 2015 India had the fourth largest installed wind power capacity in the world. (behind 1. China, 2. USAand 3. Germany), having overtaken 5. Spainin 2015 and ahead of 6. UK.

The potential for wind farms in the country was first assessed by Dr. Jami Hossain using a GIS platform to be more than 2,000 GW in 2011. This was subsequently re-validated by Lawrence Berkley National Laboratory, US (LBNL) in an independent study in 2012. As a result, the MNREset up a committee to reassess the potential and through the National Institute of Wind Energy (NIWE, previously C-WET) has announced a revised estimation of the potential wind resource in India from 49,130 MW to 302,000 MW assessed at 100m Hub height. The wind resource at higher Hub heights

that are prevailing is possibly even more. In the year 2015, the MNREset the target for Wind Power generation capacity by the year 2022 at 60,000 MW. East and North east regions have no grid connected wind power plant as of March 2015. No offshore wind farm utilizing traditional fixed-bottom wind turbine technologiesin shallow sea areas or floating wind turbinetechnologies in deep sea areas are under implementation. However, an Offshore Wind Policy was announced in 2015 and presently weather stations and LIDARsare being set up by NIWE at some locations.

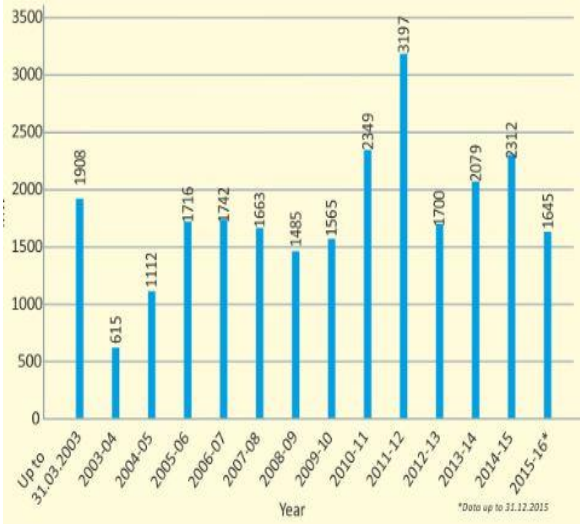

Fig 12-Year-Wise Wind Power Installed Capacity (MW)

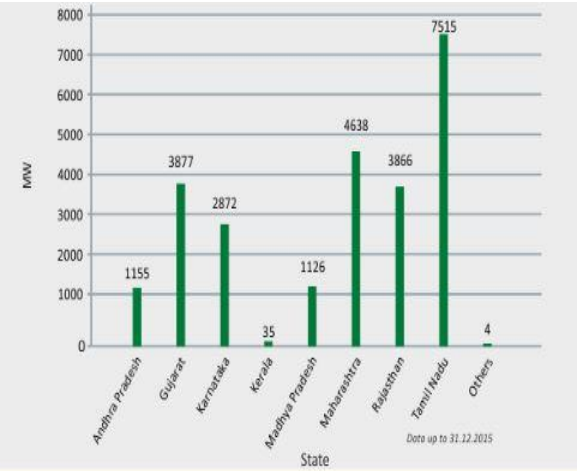

Fig 13-State-Wise Wind Power Installed Capacity (MW)

Wind power accounts nearly 8.6% of India's total installed power generation capacity and generated 28,604 million Kwh(MU) in the fiscal year 2015-16 which is nearly 2.5% of total electricity generation. [7]The capacity utilisation factoris nearly 14% in the fiscal year 2015-16 (15% in 2014-15). 70% of wind generation is during the five months duration from May to September coinciding with Southwest monsoon duration.

Month	North	West	South	East	North East	Total (MU)
April, 2015	331	859	338	-	-	1,528
May, 2015	373	1,265	924	-	-	2,562
June, 2015	348	1,342	2,030	-	-	3,720
July, 2015	510	2,527	3,122	-	-	6,157
August, 2015	472	1,605	2,328	-	-	4,405
September, 2015	319	792	1,344	-	-	2,455
October, 2015	307	414	393	-	-	1,113
November, 2015	250	734	414	-	-	1,061
December, 2015	156	801	522	-	-	1,480
January, 2016	149	462	553	-	-	1,164
February, 2016	220	728	463	-	-	1,411
March, 2016	293	830	425	-	-	1,548
Total (MU)	3,728	12,359	12,856	-	-	28,604

Fig 14-Monthly Electricity Generation in India (April 2015-March 2016)

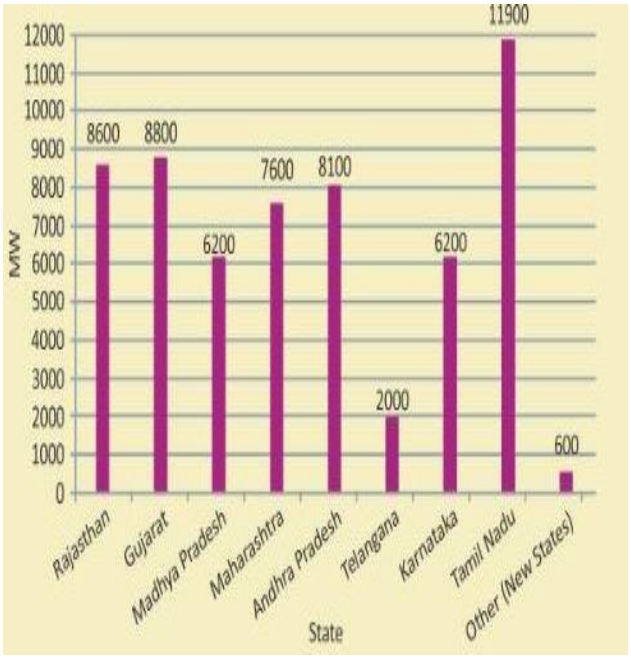

Fig 15-Tentative State-Wise Break-up of 60 GW Wind Power Under Renewable Power Target of 175 GW

VII. CONCLUSION

World is developing day by day and technology is advancing with it so, why we are still dependent on nonrenewable source of energy. Wind energy is a renewable energy which can be captured using wind turbines, so we proposed a new design of wind turbine which can be helpful to capture the gust of wind generated by running trains.

There are villages and places where transmission of electricity is not easy but train tracks are everywhere, so by installing wind turbines and piezoelectric materials along parallel to tracks can produce required electricity or power.

This generated electricity will be transmitted to nearby villages to light up the LED's which consume very less power about 3 watts.

Experimentation is being done at a very small scale in labs to checks its power generating capability and different designs of turbines were also used in this experimentation.

The cost of production of this wind turbine is very less and can be manufactured in workshops using tin sheets and men labor used is very less.

ACKNOWLEDGEMENT

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