Prospects of Solar Energy in India – A Review

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Abstract

The demand for electrical energy is ever increasing. The overall generation in India is 1306.614 BU during 2017-18 which is 15 % more than what was generated three years ago. Per Capita energy consumption is the indication of a nation's growth. Though the rise in power demand is seen in growth perspective, the conventional ways of power generation pollutes the environment at an alarming rate. Coal and Oil are the major fuel sources but fast depleting and rapidly polluting the environment. The share of clean and renewable energy sources needs to be increased in the total generation capacity. Targets for Installed capacity and Actual Generation need to be set and met. The government policy frameworks, research initiatives, incentives, subsidies etc. are key for the success. Reliable, clean alternative fuel sources need to be utilized. Solar and Wind energy are the major contributors in the renewable energy sector. Of these two, the potential of solar energy proves to be an excellent and economical choice, considering the geography of India. The current scenario of solar energy and the future scope are discussed in this paper.

Keywords: Renewable energy, Solar power, Green House gases, Solar Photo Voltaic cells, Solar concentrator.

1.Introduction

The development, progress towards modernisation of a country is based on the availability of electrical power. The challenge to meet the power demand is a vital one. There is a direct correlation between the per capita energy consumption and a country's development. According to Global Energy Statistical Year Book 2018, India stands third with 1156 TWh of electrical energy consumption only behind China and United States of America. During Independence in 1947, the per capita energy consumption (= Gross Electrical Energy Availability/Mid year Population) in India was 16 KWh. The same for the year 2017-18 is 1149 KWh. BP Energy Outlook forecasts that India's energy consumption would grow by 4.2 % per annum. The fastest among all major economies by 2040 with coal contributing most to meet this demand followed by renewables. India overtakes China as the largest growth market for energy by late 2020s. Though the conventional sources like coal, oil etc. contribute to energy production, the energy policy has to focus on the alternative or clean energy sources. The impact of the conventional sources on the environment is highly negative. Hence the dependency on the conventional power sources is greatly discouraged and the use of renewable or clean energy sources is highly encouraged. Geographically, India being in the tropical region with large land area and more warmer months, it is ideally located and the prospect of harnessing the solar power is excellent and is discussed in this paper.

2. Energy Sector – Global Scenario and India's Position

The investment in US Billion Dollars on renewable and clean energy sources, globally as well as regionally for the past decade is specified in Fig. 1 and Fig.2.

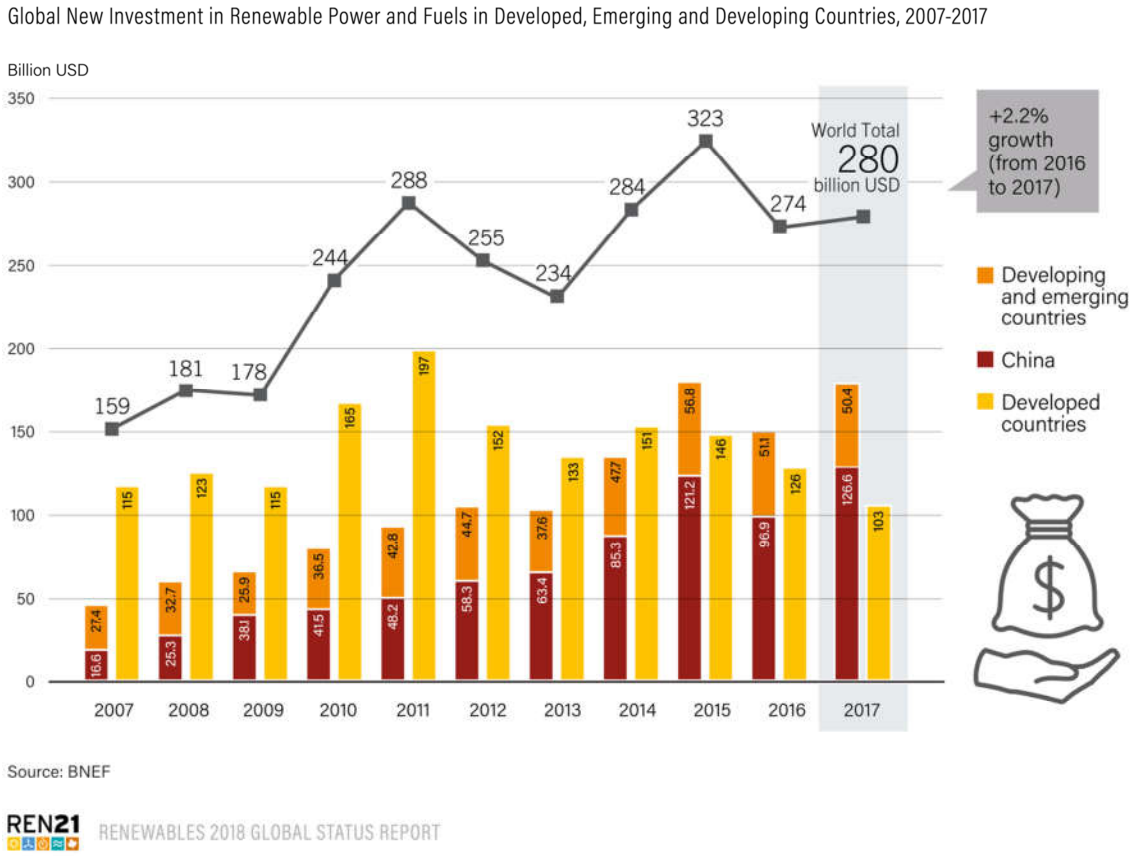


Fig. 1. Global Investment in renewable power sources

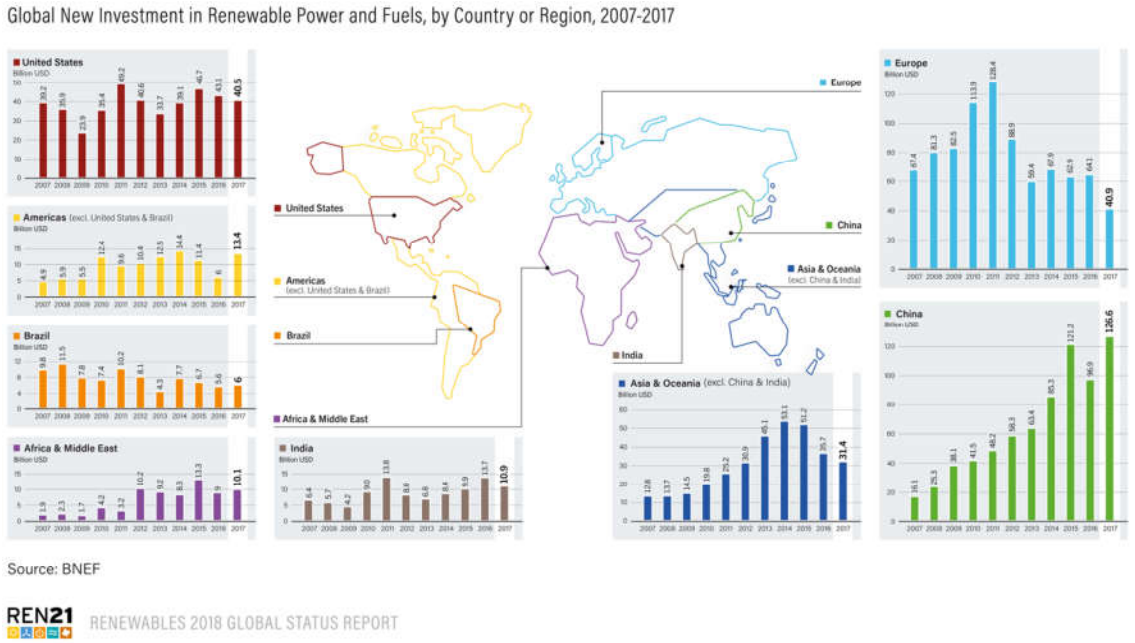
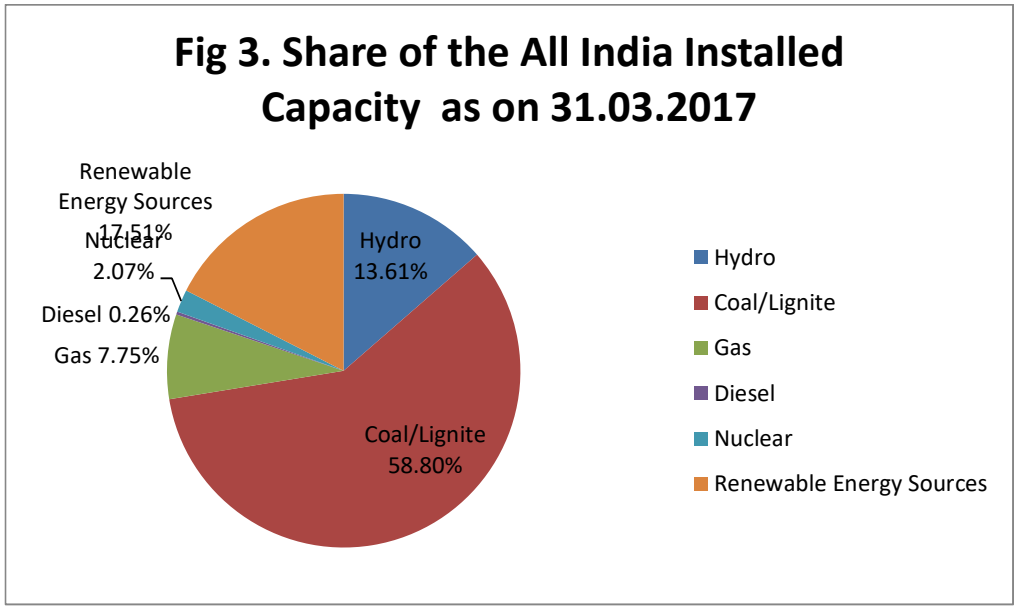


Fig. 2. Global Investment in renewable power sources by region

The share of various energy sources in the total power production in India is given in Fig. 3. The annual growth rate in power generation during the recent years is given in Table 1.



The overall generation (including generation from the grid connected sources) in the past three years in India is given in Table 1.

Year	Generation (in BU)
2014-15	1110.458
2015-16	1173.603
2016-17	1241.689
2017-18	1306.614

Table 1. Overall Generation in India

The category wise performance of generation during 2017-18 is given in Table 2.

Category	%
Thermal	4.31 (increase)
Hydro	3.06 (decrease)
Nuclear	1.13 (increase)
Bhutan Import	14.94 (increase)
Renewables	24.88 (increase)

Table 2. Performance of various categories in the generation

The annual growth in power generation during the recent years is given in Table 3.

Sl. No.	Year	Growth in Conventional Generation (%)	Growth in Renewable Generation (%)	Growth in Total Generation (%)
1	2008-09	2.7	-	-
2	2009-10	6.6	-	-
3	2010-11	5.56	-	-
4	2011-12	8.11	-	-
5	2012-13	4.01	-	-
6	2013-14	6.04	-	-
7	2014-15	8.43	-	-
8	2015-16	5.64	6.47	5.69
9	2016-17	4.72	23.97	5.80
10	2017-18	3.98	24.88	5.35
11	2018-19(up to OCT 2018)	4.91	29.58	6.91

Table 3. Annual Growth in Power Generation

The issues of environmental pollution, increase in the levels of Green House Gases, Global Warming, Disasters in Mining regions, Fast depleting underground fuel stock, Spoiling the Ocean Ecosystem due to oil exploration and spillage etc. draws the attention of the global community and several policy measures are initiated by various countries to cut down the share of conventional sources in the total energy production and enhance the share of renewable sources.

The main disadvantage is CO_2 emission during coal and oil burning in conventional power plants. The BP statistical review of World Energy shows the CO_2 emission for the year 2017 in India is 2344.2 million tonnes of CO_2 . If this rate of emission grows unchecked, many of the highly populated cities will be rendered unfit to habitat.

3. Renewable Energy Sources

Several Micro or Pico dams across rivers that has natural head difference along its path, contribute to Micro or Pico hydro plants of capacity ranging from 5 KW to 100 KW. This will be sufficient for a single house or a small community especially in hilly areas. It is a clean way to garner power than putting up one massive dam, causing disturbance to human settlements. Wind energy is to convert the force of wind using large wind mills with wind turbines and generator setup. This requires a large open landscape with constant wind, for a longer time.

In Solar energy, the heat available from Sun on earth has to be converted into electric power. The most common principle is Solar Photo Voltaic along with a battery for storage. Geothermal energy taps the extremely hot temperatures available in some places, approximately 2 or 3 Km deep inside earth. Cold water is sent in through a pipe which comes out as hot steam in another pipe and drives a steam turbine which is coupled with a generator to produce electrical power.

Ocean Thermal Energy Conversion (OTEC) utilises the temperature difference in sea water (i.e.) warm water (25° C) in the upper 20 m depth zone and cold water (5° C) at 1000 m deep in sea, to run a heat engine to generate electricity. Wave energy is the idea of using the energy from the un-resting waves. In wave motion, there is a water column that is oscillating up and down. This is used to compress air, which in turn runs a turbine to generate electricity. Tidal Barrages are built to harness energy from the tides during high and low tide periods. This again depends on the geography of the location to strategise the position of the small dams in the sea, but it is a very clean way of power generation.

4. Solar energy

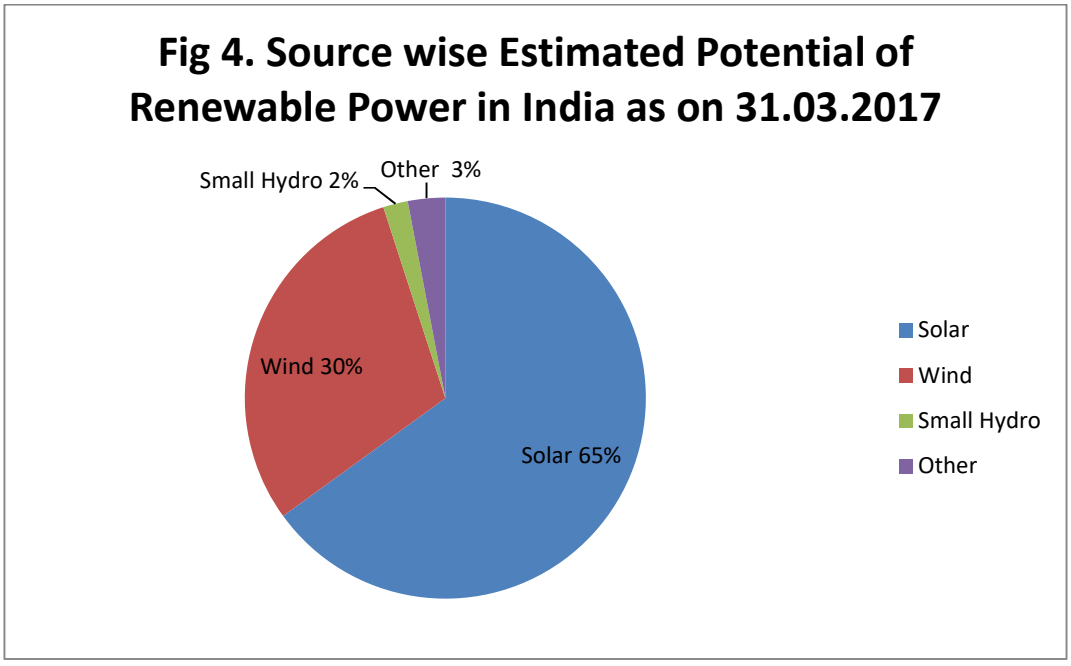
Solar energy is the cleanest form of energy, available in abundance at no cost. In India, which is a tropical country, being closer to Sun, compared to many other countries, the quality of solar energy and the duration of availability is excellent.

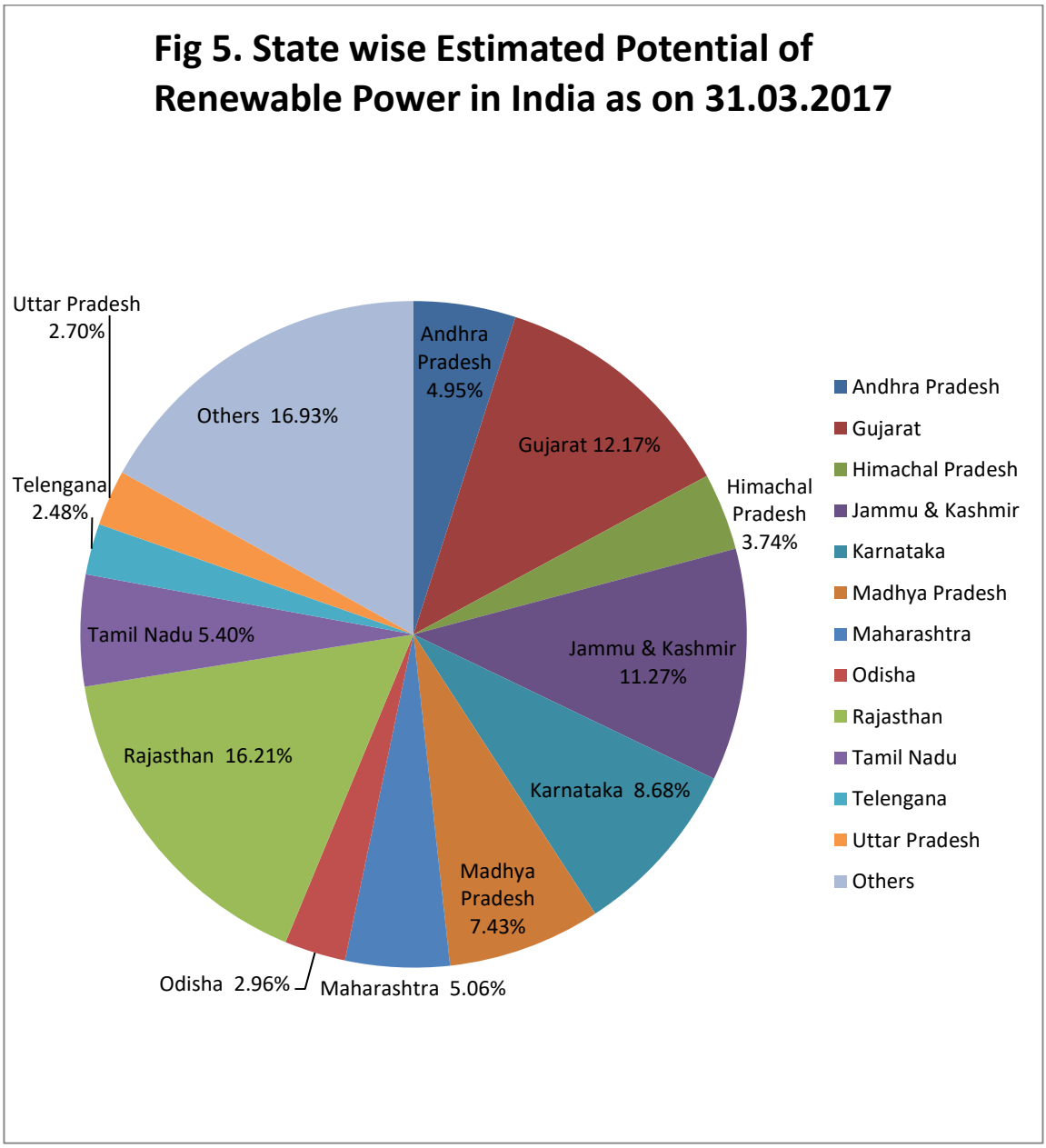
4.1 Capturing Solar energy

The Solar energy can be captured as heat or as electricity directly. When capturing as heat, the heat from the Sun is used to produce hot water/steam using Flat plate collector/Solar concentrator discs, which will be used to produce electricity. It can be captured directly as electricity using Solar Photo Voltaic cells and Solar panel. These are semiconductor materials with proper doping, capable of creating charge carriers, when solar radiation falls on them.

4.2 Current scenario of Solar Potential in India

The source wise estimated potential of renewable electric power is shown in Fig. 4 whereas Fig. 5 shows the state wise estimated potential of renewable power in India.





The countrywide estimated potential of renewable power is given in Table 4. A closer examination of the table indicate that renewable sources begin to take more share of the total power generation thereby relieving the burden on the conventional sources. This will have a positive impact on the environment as there is a curb on the drawbacks of conventional generation.

The Solar power is leading the table with 649342 MW followed by the Wind power of 302251 MW. The solar energy leads the immediate competitor with double the capacity. Extracting power from the solar potential is being implemented invariably in all the States. The key lies in the sky and in successfully harnessing the potential of solar energy.

The Solar power capacity is steadily increasing in all the states of India. The reason for this can be attributed to the government initiatives through various policies, subsidies, projects and schemes. Through the last four years, India has doubled its renewable energy capacity.

Table 4. Source wise and State wise Estimated Potential of Renewable Power in India as on 31.03.2017

(in MW)

States/UTs	Wind Power	Small Hydro Power	Biomass Power	Cogeneration-Bagasse	Waste to Energy	Solar Energy	Total	
							Estimated Reserves	Distribution (%)
Andhra Pradesh	4429	409	738	250	123	3840	49590	4.95
Arunachal Pradesh	-	2065	9	-	-	8650	10724	1.07
Assam	-	202	279	-	8	13760	14249	1.42
Bihar	-	527	646	200	73	11200	12646	1.26
Chhattisgarh	77	1098	246	10	24	18270	19715	1.97
Goa	1	5	26	-	-	88	120	0.01
Gujarat	84431	202	1226	50	112	35770	121791	12.17
Haryana	-	107	1375	100	24	4560	6167	0.62
Himachal Pradesh	-	3460	142	-	2	33840	37444	3.74
Jammu & Kashmir	-	1707	43	-	-	111050	112800	11.27
Jharkhand	-	228	107	-	10	18180	18525	1.85
Karnataka	55857	3726	1222	1400	-	24700	86906	8.68
Kerala	1700	647	864	-	36	6110	9358	0.93
Madhya Pradesh	10484	820	1386	-	78	61660	74429	7.43
Maharashtra	45394	786	1970	2200	287	64	50701	5.06
Manipur	-	100	15	-	2	10630	10747	1.07
Meghalaya	-	230	11	-	2	5860	6103	0.61
Mizoram	-	169	1	-	2	9090	9262	0.93
Nagaland	-	182	10	-	-	7290	7482	0.75
Odisha	3093	286	433	-	22	25780	29614	2.96
Punjab	-	578	3178	160	45	2810	6771	0.68
Rajasthan	18770	52	1122	10	62	142310	162326	16.21
Sikkim	-	267	2	-	-	4940	5209	0.52
Tamil Nadu	33800	604	1164	700	151	17670	54089	5.40
Telangana	4244	102	-	100	2	20410	24858	2.48
Tripura	-	47	3	-	176	2080	2306	0.23
Uttar Pradesh	-	461	1765	2000	5	22830	27061	2.70
Uttarakhand	-	1664	88	80	148	16800	18781	1.88
West Bengal	2	392	529	-	-	6260	7183	0.72
Andaman & Nicobar	8	7	-	-	6	-	21	0.00
Chandigarh	-	-	-	-	-	-	0	0.00
Dadar & Nagar Haveli	-	-	-	-	-	-	-	0.00
Daman & Diu	-	-	-	-	131	-	131	0.01
Delhi	-	-	-	-	-	2050	2050	0.20
Lakshadweep	8	-	-	-	3	-	11	0.00
Puducherry	153	-	-	-	1022	-	1175	0.12
Others *	-	-	-	-	-	790	790	0.08
All India Total	302251	21134	18601	7260	2554	649342	1001132	100.00
Distribution (%)	30.19	2	1.86	0.73	0.26	64086	100.00	

*Industrial Waste

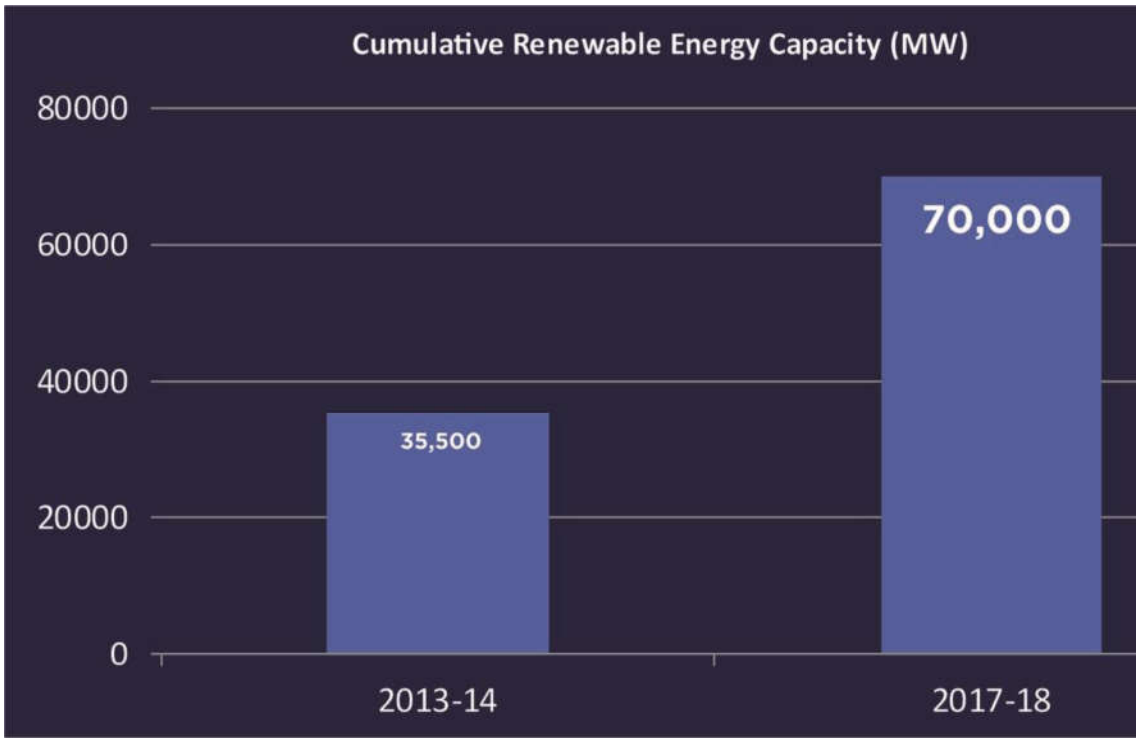


Fig. 6. Cumulative Renewable Energy Capacity (MW)

India ‘s global standing is 6th in terms of solar power installed. Solar capacity growth is tremendous by over 8 times from 2630 MW to 22000 MW surpassing the target.

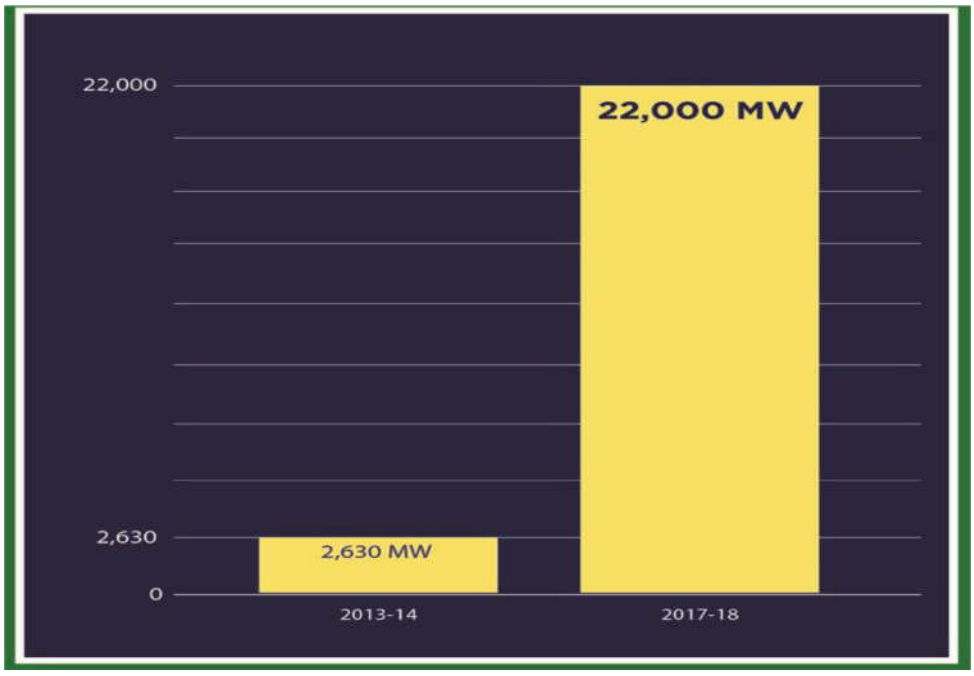


Fig. 7. Growth of Solar power in four years

The per unit cost of Solar power is brought down from Rs 6.17 to Rs 2.44.

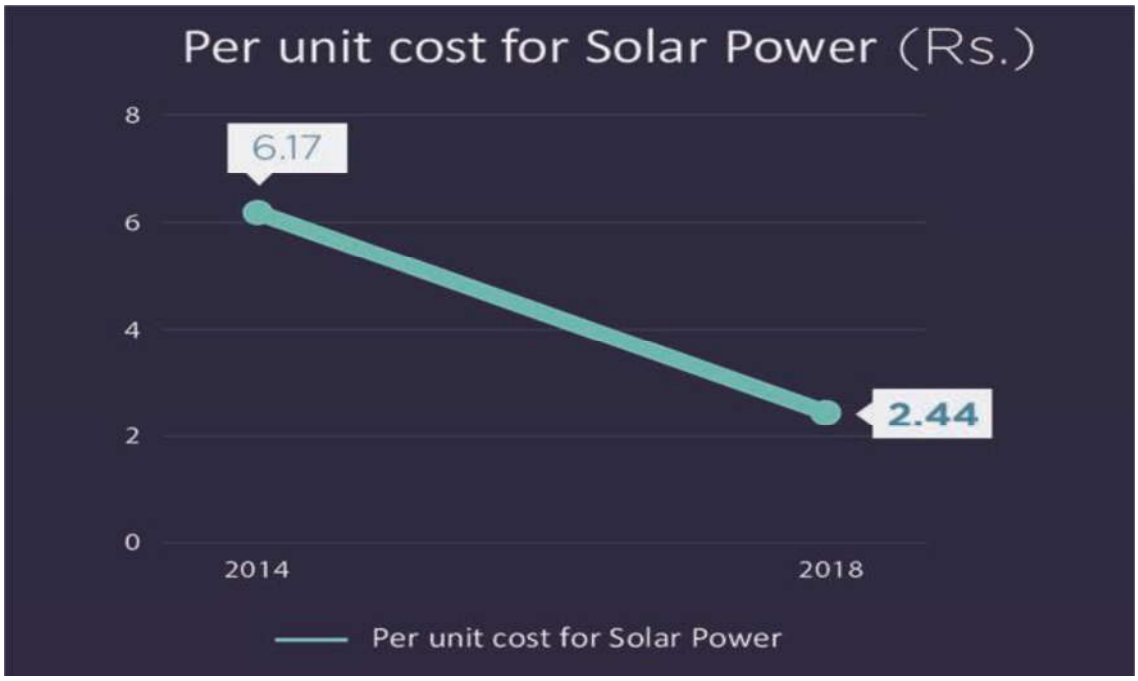


Fig. 8. Reduction in per unit cost of Solar Power

It has 41 solar parks in 21 states with an aggregate capacity of over 26144 MW. Kurnool Solar Park is set up with a capacity of 1000 MW. Pavagada Solar Park is under installation with a capacity of 2000 MW. The target of solar power is enhanced from 20000 MW to 40000 MW. The usage of solar power in homes, as lamps, for street lights and as solar pumps are shown Fig. 7 and Fig. 8.

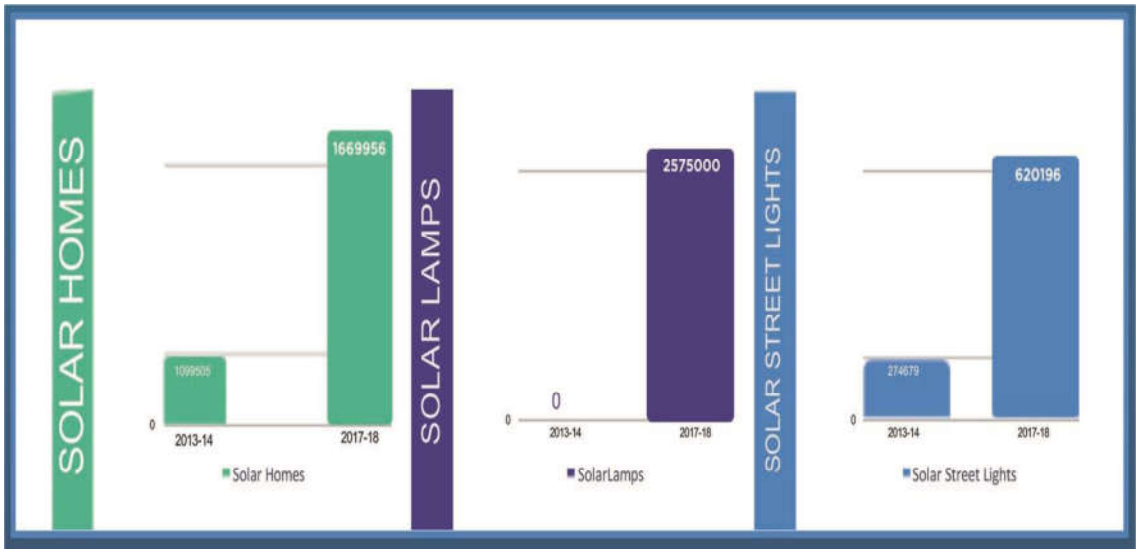


Fig. 9. Solar power for homes, lamps and street lights

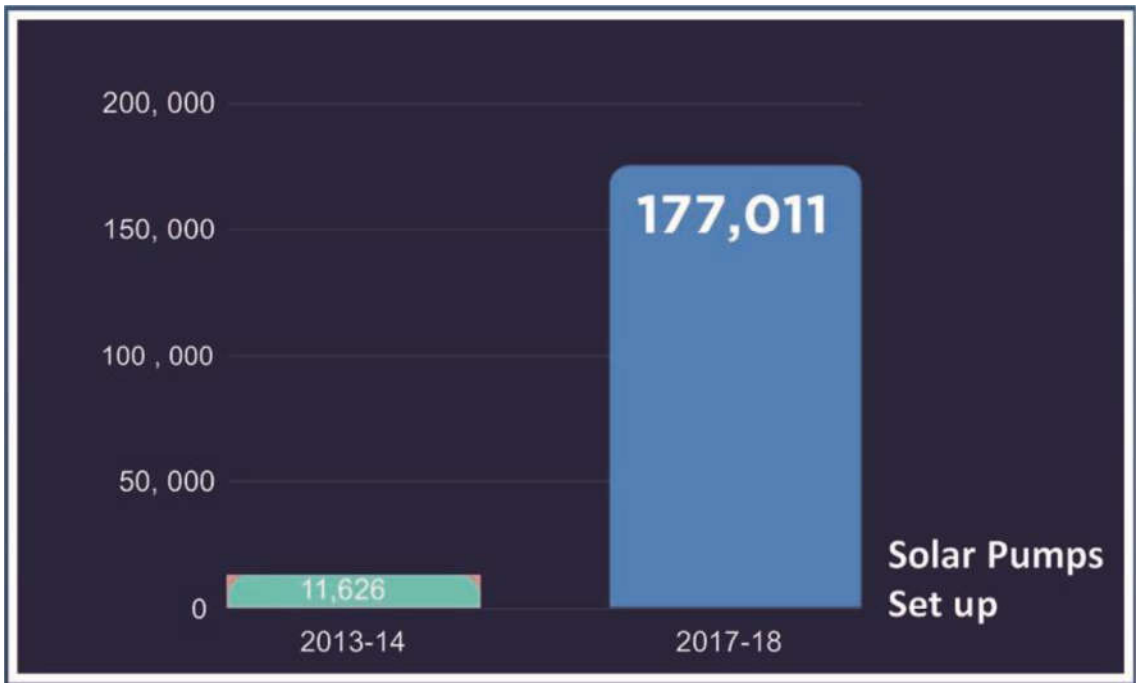


Fig. 10. Solar pumps

On December 2017, International Solar Alliance (ISA) is formed with headquarters in India, with a vision to bring the world together for harnessing solar energy for universal energy access at affordable rates.

5. Conclusion

The demand for electric power is emergent and will continue to grow. Avenues for reliable, renewable and cleaner energy are to be probed and implemented. The challenge remains in large scale implementation of renewable energy sources, by creating awareness among the population with a resolve to protect the planet from the effects of atmospheric pollution due to conventional sources. For a country like India, Solar power is the best choice, considering the tropical placement, wide spread and multi terrain landscape. If every household has a solar power source to meet some part of its power requirement, dependency on the utilities is reduced. Investment on the Transmission and Distribution through OH lines or UG cables can be spared. Especially when natural calamities like cyclone or earthquake occur, the restoration of transmission lines and poles to transmit power to the remote villages and hamlets takes longer periods. Public unrest and hardship becomes unavoidable. When every household has a small solar power source to meet its basic needs, people carry on with their work avoiding much of the difficulties.

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