Solar Power in India: Potential, Growth Rate and Installed Capacity

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Abstract: This present study aims to analyze the state wise estimated Solar Energy Potential and trend growth rate of installed solar capacity and Installation of off-grid decentralized solar photovoltaic system devices like Solar Street lights, solar home lights and solar lantern. The study is completely based on secondary data. The data were collected from Ministry of New and Renewable Energy annual reports. The data were analyzed in annual growth rate and interpreted. The finding of the study is the majority of the state's installed capacity of solar power is very low as compared to the potential level of solar power. The year wise growth rate of solar power installed cumulative capacity in India, it represents that growth rate is slightly fluctuating during the study period of 31.03.2012 to 31.12.2016. The installation of off-grid decentralized solar photovoltaic system devices of solar street lights, solar home lights and solar lantern in which Solar street lights and solar home lights are slightly fluctuating, of which solar street light's high growth rate (24.80 per cent) is accounted in 2015 and its low growth rate is recorded in (-74 per cent) in 2011. At the same time, highest growth rate (24.10 per cent) of the solar home lighting system is in 2011 and its lowest growth rate is in 2015. In terms of solar lantern's growth rate is a little decreasing in which high growth rate is (511.2 per cent) in 2011 and its short growth rate is (1.0 per cent) in 2013.

Index Terms **- Energy, Conventional sources, Environmental problems, Solar Street light.**

I. Introduction

Energy is deeply occupied in each of the social, economic and environmental extents of human development as well as an essential input to this economic growth of the country. It contributes to social development through education and public health, and help to meet the basic human needs for food and shelter[1]. Nowadays the consumption of energy in all sectors such as agriculture, manufacture and service sector has been steadily rising over the country. Apart from raising demands for energy, is also need to address growing concerns related to climate change because of utilization of maximum energy from conventional sources its due to environmental problems. Therefore urgently shift to the alternative source of renewable energy sources like solar energy, wind energy, biomass, small hydro and geothermal. Out of renewable energy sources, solar energy is the best renewable energy source, pollution free, comes with a virtually inexhaustible supply and hugely attractive form of energy in these times which is a suitable source of the world[2].

Solar energy has an experienced extraordinary growth in recent years as a result of technological improvements, cost reductions and government policies supportive of renewable energy development and utilization[3]. According to the ministry of Renewable Energy Report 2016-17, India has an estimated potential of renewable energy is 900 GW from commercially usable sources viz. Wind [102 GW (80-meter mast height)], Small Hydro 20 GW, Bio-energy 25 GW, and solar power750 GW, which assuming only 3 per cent of wasteland is made available in the country. It observed that among the renewable energy sources solar energy has a highest potential source as compared to the other sources.

II. Solar energy Scenario in India

India is gifted with an enormous potential of solar energy resource and fortunately, the majority of the states have about 300 sunny days in per year. The average solar radiation incident over the land is in the range of 4-7 kWh per day. Solar energy is generally utilized through solar photovoltaic technology and solar thermal technologies. Solar photovoltaic technology system is referred to directly convert to sunlight into electrical energy through solar panel and solar thermal technology system is utilizes heat content of solar energy into

helpful applications. More than the last thirty years in India solar energy system based several devices are developed and deployed, which is fruitfully providing energy solutions for the society, for the purpose of lighting, cooking, water heating, air heating and cooling, and electricity generation.

The solar energy is fastest growing energy source of renewable energy in India as a result of Jawaharlal Nehru National Solar Mission (NSM), which was launched on 11th January 2010. It is set the target for the deployment of 20,000 MW grids connected, 2,000 MW of off-grid solar applications including 20 million solar lights, and 20 million sq. m. solar thermal collector area by the year of 2022. It aims to create favourable conditions for developing solar manufacturing capability, support research and development capacity building activities, domestic production of critical raw materials, components and products, as an outcome to will achieve grid tariff parity by 2022 [4]. It will create an enabling policy framework to achieve this objective and make India is a global leader in solar energy.

Now the National solar mission target is from 20 GW to 1000 GW by the year of 2021-22 for Grid Connected Solar Power Projects. In this revised target, in which 100 GW of solar power is planned to be achieved in 7 years period and broadly consist of 40 GW Grid connected Rooftop projects and 60 GW large and medium size land-based solar power projects with effect from 17 June 2017. Thus, several solar energy systems and devices are commercially available with affordable cost in the market[5]

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III. Statement of the Problem

Energy is an essential input an economic growth and human development of the country. In India, 69.5 per cent of the electricity generation is mainly depended on the conventional source of Coal, it leads to increasing greenhouse gas emissions and environmental damages whereas there is an exhaustible source. The demands of energy are day by day are increasing, of which 33 per cent of the energy demand is generally depended on other countries by means of importing. Electricity shortage is a major role in hampering the growth of the economy as well as human development. In India, millions of peoples are still living without reliable, sufficiently and affordable sources of the country. Despite increasing the installed capacity of electricity by more than 113 times in 65 years, India is still not in a position to meet its peak electricity demand with energy requirement. The peak power deficit during the financial year 2001-02 was 12.2 per cent, nearly 9252 MW, even so, at the end of Financial Year 2014-15, peak power deficit decreased to the only 2.4 per cent. It resulted that the demand and supply gap slightly decreasing the country. The 85 per cent of rural households in India are mainly depending on solid fuel for their cooking needs and 55 per cent of all rural households have access to electricity. The low access of household leads to the large-scale use of kerosene which impacts on environmental problems and climate change.

IV. Methodology

The study is completely based on secondary data. The data were collected from various reports particularly on Ministry of New and Renewable Energy annual reports, Journals, newspaper, government reports, and websites. The data were analyzed in annual growth rate and interpreted.

V. Objectives of the Study

The objectives of the study are as follows,

1. To analyze the state wise estimated Solar Energy Potential and installed solar capacity in India as on 31.12.2016.
2. To examine the trend growth rate of Installed Capacity of Grid Interactive Solar Power in India during the study period as on 31st March 2010 to 31st March 2016 in India.
3. To analyze the year wise Installation of off-grid decentralized solar photovoltaic system devices like Solar Street lights, solar home lights and solar lantern in India (As on 31st March).

VI.Review of Literature

Deshmukh, et.al, [6] study reveals that solar energy has an enormous potential for renewable energy source, availability and flexibility in range and applications is one of the priciest options in India. The Jawaharlal Nehru National Solar Mission is a determined target of 22 GW of solar power capacity by 2022. It is another aim of departure from the past, as India has started to mainstream climate considerations in energy planning, and has allocated a large public subsidy for the promotion of solar energy. But the mission of objectives is unclear and actions are not aligned with India's development needs.

Harish and Raghavan[7], study depicts that the Jawaharlal Nehru National Solar Mission is depending upon the certain critical features such as subsidy structure, the role of standardized systems and institutional models of delivery. The actual costs of small systems are in terms of on a per watt considerably higher than level costs, assumed for the subsidy which is inside the reach of the rural poor receive lower subsidies as compared to larger systems.

Arora[8], study shows that 75 million of the households are not accessible to the electricity they are using the kerosene for the purpose of lighting which is unsafe from a health point of view. While annual expenditure on kerosene for lighting is approximately USD 2 billion, USD 1.8 billion in rural areas, as well as 16 per cent of villages, are un-electrified, approximately 95,000 villages so that these villages are socially and economically backward. The 9 million diesel pump sets are deployed by farmers for irrigation purposes, of which 4.5 million diesel pump sets are located in solar resource regions and have the land for installation Solar PV system. The average capacity of the pump is 3.73 KW, and total potential of these pumps comes to 16,785 MW. The 400,000 telecommunication towers are installed in India, of which 84,000 telecom towers powered by diesel generating sets are located and it is suitable solar resource regions, as well as the average capacity of diesel generating a set is 4KW but total potential comes from the solar PV in 336 MW.

VII. Results and Discussion

Table7.1 shows that among the states/UTs in India, Rajasthan is received the highest potential as compared to other states it is accounted in 142GW as followed by Jammu & Kashmir (111GW), Maharashtra (64 GW) and Madhya Pradesh (62 GW) which states are the highest potential source for generating solar power. It measured by the availability of land sources and temperature levels etc. Whereas UTs & others and Goa (1GW) are received very lowest potential, besides Delhi (2GW), Tripura (2GW), Punjab (3GW) states are obtaining low potential level as compared with other states in India.

The total installed capacity of solar power is 9012.69 MW, of which Tamilnadu is a highest installed capacity of solar power is accounted in 1590.97 MW as followed by Rajasthan (1317.64 MW), Gujarat (12.9MW), Andhra Pradesh (979.65MW) and Telangana (973.41MW, which are nearly 66.9 Per cent of the installed capacity of solar power is coming from in their states. Whereas Arunachal Pradesh, Goa, Himachal Pradesh, Jammu & Kashmir, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim states are zero per cent installed capacity of solar power in India. Assam (0.1 per cent), Jharkhand, Kerala (0.2 per cent), West Bengal (0.3 per cent), Delhi (0.4 per cent), Uttarakhand (0.5 per cent) and Haryana (0.6 per cent) are very lowest installed capacity of solar power as compared to other states in India. It observed that majority of the states are installed capacity of solar power is very low as compared to potential level.

Table 7.1: State wise estimated Solar Energy Potential and installed solar capacity in India as on 31.12.2016.

State wise estimated Solar Energy Potential and installed solar capacity in India					
Sl.No.	**State/UT**	**Solar power potential (GW)**	**%**	**Installed Capacity (MW) as on 31.12.2016**	**%**
1	Andhra Pradesh	38	5.1	979.65	10.9
2	Arunachal Pradesh	9	1.2	0.27	0.0
3	Assam	14	1.9	11.18	0.1
4	Bihar	11	1.5	95.91	1.1

5	Chhattisgarh	18	2.4	135.19	1.5
6	Goa	1	0.1	0.05	0.0
7	Gujarat	36	4.8	1158.5	12.9
8	Haryana	5	0.7	53.27	0.6
9	Himachal Pradesh	34	4.5	0.33	0.0
10	Jammu & Kashmir	111	14.8	1.00	0.0
11	Jharkhand	18	2.4	17.51	0.2
12	Karnataka	25	3.3	327.53	3.6
13	Kerala	6	0.8	15.86	0.2
14	Madhya Pradesh	62	8.3	840.35	9.3
15	Maharashtra	64	8.5	430.46	4.8
16	Manipur	11	1.5	0.01	0.0
17	Meghalaya	6	0.8	0.01	0.0
18	Mizoram	9	1.2	0.10	0.0
19	Nagaland	7	0.9	0.50	0.0
20	Odisha	26	3.5	77.64	0.9
21	Punjab	3	0.4	545.43	6.1
22	Rajasthan	142	18.9	1317.64	14.6
23	Sikkim	5	0.7	0.01	0.0
24	Tamil Nadu	18	2.4	1590.97	17.7
25	Telangana	20	2.7	973.41	10.8
26	Tripura	2	0.3	5.02	0.1
27	Uttar Pradesh	23	3.1	239.26	2.7
28	Uttarakhand	17	2.3	45.10	0.5
29	West Bengal	6	0.8	23.07	0.3
30	Delhi	2	0.3	38.78	0.4
31	UTs& Others	1	0.1	88.68	1.0
Total		750	100.0	9012.96	100.0

Source: (Ministry of New and Renewable Energy, Government of India, Annual report, 2016-17), p.58 [9].

Table 7.2 Trend growth rate of solar power Installed cumulative capacity (MW) in India

Year wise installation	**Solar power (in MW)**	**Annual growth rate**
31.03.2012	513	-
2012-2013	1446	181.87
2013-2014	2647	83.05
2014-2015	3743.97	41.44
2015-2016	6762.85	80.63
2016-2017*	9012.85	33.27

Source: (Ministry of New and Renewable Energy, Government of India, Annual report, 2016-17). p.59. *Data upto 31.12.2016.

Table 7.2 reveals that the year wise growth rate of solar power installed cumulative capacity in India. It depicts that installed capacity of solar power growth rate is fluctuating during the study period of 31.03.2012 to 31.12.2017. In its highest growth rate of solar power was accounted in 2012-2013 by reason of launched the

Jawaharlal Nehru National Solar Mission and its lowest growth rate was recorded in 2016-17, but it is only counted nine months.

Table 7.3: Installation of off-grid decentralized solar photovoltaic system devices in India (As on 31st March2016)

Year wise installation	Solar street lights(Nos.)	AGR	Solar home lights(Nos.)	AGR	Solar lantern (Nos.)	AGR
31.03.2010	797344	-	603307	-	119634	-
31.03.2011	204523	-74	748676	24.10	731202	511.2
31.03.2012	226506	10.75	892974	19.27	930813	27.3
31.03.2013	255879	12.97	993595	11.27	939862	1.0
31.03.2014	274679	7.35	1099505	10.66	959862	2.1
31.03.2015	342788	24.80	1194342	8.63	985012	2.6
31.03.2016	396184	15.58	1285841	7.66	1001268	1.7

Source: Ministry of New and Renewable Energy; Energy statistics 2013, Central statistics office [11].

Table 7.3 examined that the trend growth rate of installation of off-grid decentralized solar photovoltaic system devices such as solar street lights, solar home lights and solar lantern. The growth rate of solar street lights and solar home lights are slightly fluctuating during the study period. Of which solar street light's high growth rate (24.80 per cent) is accounted in 2015 and its low growth rate is recorded in (-74 per cent) in 2011 as compared to the study period. At the same time, highest growth rate (24.10 per cent) of the solar home lighting system is in 2011 and its lowest growth rate is in 2015. In terms of solar lantern's growth rate is a little decreasing in which high growth rate is (511.2 per cent) in 2011 and its short growth rate is (1.0 per cent) in 2013.

Conclusion

The study concluded that majority of the state's installed capacity of solar power is very low as compared to the potential level of solar power. The year wise growth rate of solar power installed cumulative capacity in India, it represents that growth rate is slightly fluctuating during the study period of 31.03.2012 to 31.12.2016. From its highest growth rate was accounted in 2012-2013 by reason of launched the Jawaharlal Nehru National Solar Mission and its lowest growth rate was recorded in 2016-17, but it is only counted in nine months if this counted one-year growth rate is may be high or low. Other findings of the growth rate of installation of off-grid decentralized solar photovoltaic system devices of solar street lights, solar home lights, and solar lantern. Solar street lights and solar home lights are slightly fluctuating, of which solar street light's high growth rate (24.80 per cent) is accounted in 2015 and its low growth rate is recorded in (-74 per cent) in 2011. At the same time, highest growth rate (24.10 per cent) of the solar home lighting system is in 2011 and its lowest growth rate is in 2015. In terms of solar lantern's growth rate is a little decreasing in which high growth rate is (511.2 per cent) in 2011 and its short growth rate is (1.0 per cent) in 2013.

The study suggests that to utilize the potential of solar power and to reducing the conventional based power sources as well as the majority of the states potential level is high but installed capacity level of solar power is very low, the growth rate of installed capacity of solar power and off-grid solar photovoltaic devices are slightly fluctuating. Therefore central and state governments are to focus on fulfilling the gap.

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