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Original Article

Status and Potential Utilization of Solar Energy in India

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Abstract *- This paper analyses the status and potential level of renewable energy sources in India. Shifting towards conventional to renewable energy sources is a challenge for the world. India has lots of potentials, but the utilization level is very low. The study founded that solar energy is in the top position in potential (65 percent), followed by wind power (30 percent) in India in the case of renewable energy potential. But India used its about 3.98 percent of solar energy potential till yet. States named Jammu & Kashmir and Himachal Pradesh have lots of potentials but are unable to use them.*

Keywords *- Energy, Solar energy, Growth, Renewable energy.*

I. INTRODUCTION

Economics development has depended on the energy source. Energy can be defined in a number of ways. But in general, energy means the capacity to do something or to do work and produce a change in physical or non-physical terms. It is used in science to do describe the part of the market where energy itself is harnessed and sold to consumers (Ashwani Kumar et al. 2010; Ramachandra et al. 2004).In recent times, energy is the primary input in all economic activities and has become vital for improvement in the quality of human life. Infect, the whole economic system rests upon energy use in the world (PC Maithani, 2008). The energy consumption level of a nation is also seen as the level of development in recent times.

India has an agrarian economy, and the majority of the population predominantly depending on agriculture to sustain their livelihood. The majority of the Indian population uses wood, agricultural wastes, livestock dung, etc., as an energy source. On the other side, the urban population consumes a new source of energy, i.e., oil, coal, natural gas, hydroelectricity, or nuclear power. Economic development, urbanization, increasing prosperity, and increasing population create a high demand for energy consumption. Thus there is an emerging energy supply-demand imbalance. Fulfill the national demand for energy is the key challenge for the country.

The conventional sources of energy (Thermal energy, oil, and natural gas) are in nonrenewable sources of energy, which are being used for a long time in India (Karan Kapoor et al., 2014). Due to the unavailability of modern and renewable energy sources from years ago, these sources of energy are being used extensively in such a way that their known reserves have been depleted to a great extent. On the other hand, non-conventional sources of energy are underutilized in India. Non-Conventional energy or renewable sources of energy is generally defined as the sources of energy that are being produced continuously in nature. The present paper mainly focused on non-conventional energy sources in general and solar energy in particular. The study analyses the status of energy production and demands patterns of the country. Furthermore, the study analyses the potential and use of the potential of solar energy across states in India.

II. DATA AND METHODOLOGY

The present study is based on secondary data collected from a different governmental source. Consumption of conventional source of energy data collected for the period 2000-01 to 2016-17 from energy statistics, Ministry of Petroleum & Natural Gas, Govt. of India. Data on conventional and renewable energy generation were compiled for the period 2014-15 to 2017-18, the state-wise potential of renewable energy, the state-wise potential of solar energy collected for the year 2017-18 from the Ministry of Petroleum & Natural Gas, Govt. of India. Data on funds released by the center for solar energy generation were collected from Lok Sabha Starred Question No. 321, dated 09.08.2018.

Growth Analysis

The compound growth rate of consumption of conventional sources of energy has been estimated for selected periods of time. The compound growth rates are estimated with the following exponential model.

$$Y = ab^t$$

Log Y =log a +t log b

CGR= (Antilog b- 1) *100

Where,

t=Time Period in year

Y= Source of conventional energy.

a and b=Regression parameters and

CGR=Compound Growth Rate.

III. RESULTS AND DISCUSSION

In the recent decade, India is known as the country of youngsters and the faster-growing economy. This growth of the economy creates a high demand for energy. The growth rate of energy consumption of coal, lignite, crude petroleum, natural gas, and electricity is presented in table 1 for the selected period of time. It is clear from the table that the growth rate energy consumption of coal was observed 6.45 percent, 6.53 percent, and 6.49 percent for the time from 2000-01 to 2010-11, from 2010-11 to 2016-17 and 2000-01 to 2016-17 respectively.

Table 1. Growth rate of Consumption of Primary Sources of Conventional Energy in India.

Particulars	Growth Rate (% per annum)		
	2000-01 to 2010-11	2010-11 to 2016-17	2000-01 to 2016-17
Coal (In ' 000 Tonnes)	6.45	6.53	6.49
Lignite (In ' 000 Tonnes)	3.97	1.59	4.25
Crude Petroleum (In ' 000 Tonnes)	6.47	3.42	6.00
Natural Gas (In Million Cubic Metres)	5.79	-2.42	4.79
Electricity* Hydro & Nuclear (In GWh)	7.84	7.07	8.75

Source: Author's estimation
*Note: * Includes thermal, hydro & nuclear electricity in utilities.*

Very high growth to the energy consumption of electricity was an observer (8.75 percent) during the time 2000-01 to 2016-17 which indicating the high demands for energy in this time duration. In the case of natural gas only was the time between 2010-11 to 2016-17, when the growth rate of energy demand was reached at negative growth (means declining demand), other all-time had founded be positive. The results of energy demand are highly alarming that the future development of the economy depending on the energy consumption and the conventional resource of the energy generation deteriorated at a faster rate. If in recent times, we have not converted towards a renewable source of energy, then those days are not too far when we consume all our conventional energy sources.

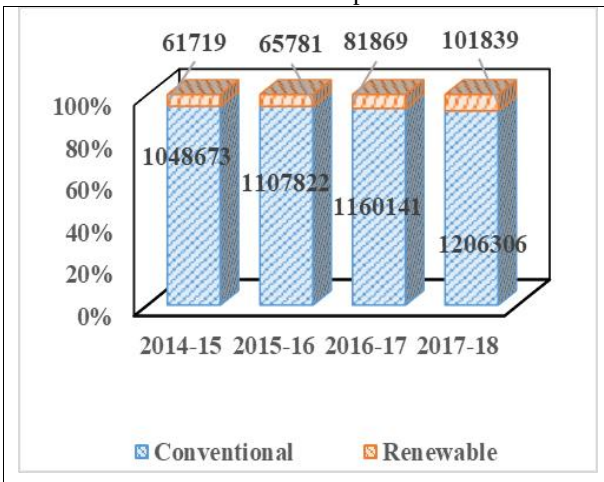

Fig. 1(A) Energy Generation by source

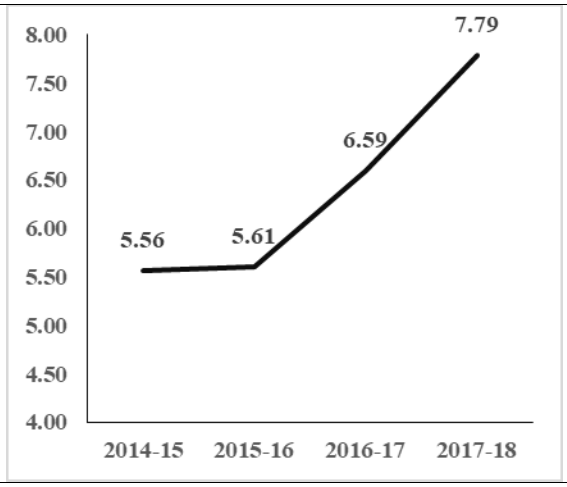

Fig. 1(B) Renewal energy share in total energy

Source wise, energy generation is shown in figure 1 (A) and the share of renewable energy in total energy in table 1(B). It is clear from the table that the major part of the energy is generated by conventional sources (coal, lignite, natural gas, and Crude Petroleum) in India. Around 1308142 MU power generation with the conational and non-convention source in India during 2017-18. The share of renewable energy in total energy has been increased over time (Figure 1-B). Renewable source of energy has been contributed to the energy sector about 5.56 percent in 2014-15 which increased up to 7.79 percent in 2017-18. But it is very clear from the figure that the share of renewable sources of energy is very low. Furthermore, the results provided clear-cut evidence that if India wants to sustain economic growth in the future, then it should be essential to promote the non-convention source of energy. It is a core policy matter for the nation to convert dependency from conventional to non-conventional sources of energy generation for the future economic development of India.

Table 2. Potential of renewable energy across states in India (As of 31.03.2017)

(Potential in MW and Share in %)

State	Estimated Potential	Rank	State Share in National Potential
Rajasthan	162326	1	16.2
Gujarat	121791	2	12.2
Jammu and Kashmir	112800	3	11.3
Karnataka	86906	4	8.7
Madhya Pradesh	74429	5	7.4
Tamil Nadu	54089	6	5.4
Maharashtra	50701	7	5.1
Andhra Pradesh	49590	8	5.0
Himachal Pradesh	37444	9	3.7
Odisha	29614	10	3.0
Uttar Pradesh	27061	11	2.7
Telangana	24858	12	2.5
Chhattisgarh	19715	13	2.0
Uttarakhand	18781	14	1.9
Jharkhand	18525	15	1.9
Assam	14249	16	1.4
Bihar	12646	17	1.3
Arunachal Pradesh	10724	18	1.1
Manipur	10747	19	1.1
Other	**64139**	**NA**	**6.4**
India	**1001132**	**NA**	**100**

Source: Energy statistics, ministry of petroleum & natural gas, Government of India.

The level of the potential of renewable energy sources across the state has presented in table 1. It is clear from the table that Rajasthan is the most potential state for renewable energy generation, which has the potential of renewable energy about 16.2 percent of the total national potential. Gujarat and Jammu & Kashmir are the states which take the second and third position in the potential of renewable energy, i.e., 121791 MW and 112800 MW (12.2 percent and 11.3 percent of the total national potential) as on 31.03.2017 estimation of govt. Ministry. Madhya Pradesh is the state which got the top fifth position in the case of total renewable energy potential (74429 MW which is 7.4 percent of the national potential). It is important to mention that the energy potential of solar is 142310 MW, wind 18870 MW, and all other sources are very few in Rajasthan. In the case of Gujarat, the high potential is Wind (84431 MW) followed by Solar 35770 MW. At the same time, in the case of Jammu & Kashmir, the top potential is energy (111050 MW), followed by hydro 1707 MW. The Madhya Pradesh state has the top potential of renewable energy of solar 61660 MW, followed by wind 10484 MW, and followed by biomass 1386 MW. The top 20 states/ UT of the nation have around 93.6 percent of the national potential for renewable energy.

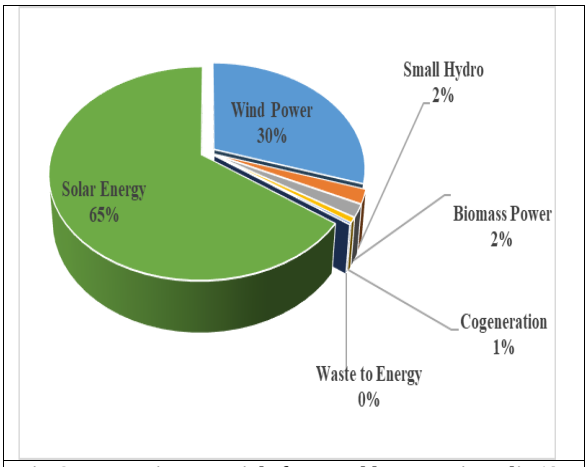

Fig. 2 source wise potential of renewable energy in India (As of 31.03.2017)

Figure 2 shows the distribution of the energy potential of India across different sources as of 31.03.2017. Solar energy potential is the top position which contributes about 65 percent of total potential, followed by wind power about 30 percent. Other sources of renewable energy are a negligible contribution. So from this picture, it is clear that policymakers need to concentrate on solar and wind power for future development. India is one of the leading countries having good Direct Normal Irradiance (DNI), which depends on the geographic location of the country (earth-sun movement, the tiltofEarthrotationalaxisandatmosphericattenuationdue tosuspendedparticles). It is important that properly harness this potential has blessed and also a challenge for India. Blesses in terms of high potential and challenge in terms of technological lag than developed nations. The development of this potential utilization is fully on the government sector because the private sector is not happy to invest in this area due to very high investment and high risk.

Table 3. Potential and utilized of solar energy across states in India (As of 31.03.2017)

State	Estimated Potential Solar Energy (MW)	Rank	Potential Use (MW)	% Potential Used
Rajasthan	142310	1	3469	2.44
Jammu and Kashmir	111050	2	0	0.00
Madhya Pradesh	61660	3	1912	3.10
Gujarat	35770	4	2048	5.73

Himachal Pradesh	33840	5	0	0.00
Odisha	25780	6	205	0.79
Karnataka	24700	7	2392	9.68
Uttar Pradesh	22830	8	637	2.79
Telangana	20410	9	4014	19.67
Chhattisgarh	18270	10	137	0.75
Jharkhand	18180	11	19	0.11
Tamil Nadu	17670	12	2906	16.45
Uttarakhand	16800	13	291	1.73
Assam	13760	14	8	0.06
Bihar	11200	15	145	1.30
Manipur	10630	16	0	0.00
Mizoram	9090	17	0	0.00
Arunachal Pradesh	8650	18	0	0.00
Nagaland	7290	19	0	0.00
West Bengal	6260	20	20	0.33
Other	**33192**	**NA**	**7687**	**23.16**
India	**649342**	**NA**	**25871**	**3.98**

Source: author's estimation based on Ministry of Petroleum & Natural Gas, Govt. of India data.

After the following discussion, it is well established that solar energy potential is in the top position in total renewable energy potential in India. State wise potential of solar energy and utilization of the potential of solar energy is present in table 2. Rajasthan state had the top in total renewable as we as in solar energy, but the state unable to use its potential, as on 31.03.2017 the state used about 2.44 percent (3469 MW out of total 142310 MW energy potential) of its potential. Jammu & Kashmir is the second topper in terms of renewable energy potential (at the second position in total renewable as well as at the same position in solar energy potential). But the state is unable to use its potential of solar energy potential. In the same case in Himachal Pradesh, the state gets the 5th rank of solar energy potential, but utilization is zero percent to date.

Telangana is the state which has the 9th position in the potential of solar energy, but the state had at the top position to utilize its potential (19.67 percent of total potential utilized). As Telangana, the state Tamil Nadu, also having at the 12th position but using its 16.45 percent of potential and got the second rank of potential utilization. Madhya Pradesh and Gujarat are the states which hav[e third] and 4th positions of solar energy potential. Madhya Pradesh used its 3.10 percent of solar energy potential, and Gujarat used its 5.73 percent potential.

It is certain to mention that the solar energy potential in all hilly states like Arunachal Pradesh, Manipur, Mizoram, Jammu & Kashmir, Nagaland, and Assam are fully unutilized (except Assam utilized 0.06 percent). Reducing this variation is also a challenge for the government and policymakers.

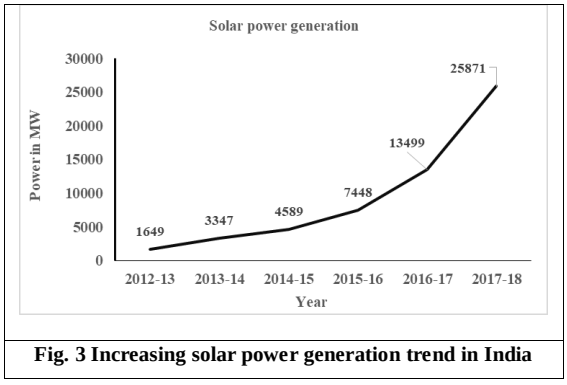

Fig. 3 Increasing solar power generation trend in India

The increasing trend of solar power generation in India is presented in figure 3. As we have seen in this figure, India generates 1649 MW of solar energy during 2012-13, which was increased around one fold in the next year, i.e., 3347 MW during 2013-14. The graph shows the increasing trend of solar energy generation in India. Solar energy generation increase with a growth rate of 92 percent from 2016-17 to 2017-18 and reached a level of 25871 MW.

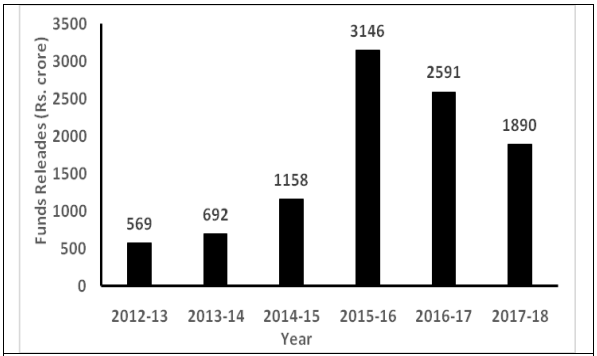

Fig. 4 Funds released from the center for solar energy generation

Figure 4 presented the fund allocation for solar energy generation from the central government. The center allocates Rs. 569 crore for solar energy during 2012-13, which further marginal increased in next year. Fund allocation to solar energy at the top during 2015-16. In this year, the growth of fund allocation was jumped almost three times from the previous year, 2014-15.

It is also notable the after 2015-16, the fund allocation was reduced year by year and reached Rs. 1890 crore in 2017-18. This indicated that the government does not prioritize this area as required.

National Solar power mission

Jawaharlal Nehru National Solar Mission (JNNSM) was launched in 2009 with the target for Grid Connected Solar Projects of 20,000 MW by the year 2022. The Mission had completed adopting a three-phase approach. The first four years (2009-10 to 2013-14) had been marked as Phase-I. During this phase aim of this project was to add 1,000 MW of grid solar power by 2013. The remaining 4 years of the Twelfth Plan (2013–17) had been marked as Phase-II with an additional another 3,000 MW by 2017. At that time, the thirteenth Plan (2017–22) will be Phase-III of the project (now no thirtieth plan, new government abolished the planning era).

Table 3. Targets of power generation in different years under solar power generation Projects.

Year	Rooftop type solar power project(MW)	Ground Mounted type solar power project (MW)	Total (MW)
2015-16	200	1800	2000
2016-17	4800	7200	12000
2017-18	5000	10000	15000
2018-19	6000	10000	16000
2019-20	7000	10000	17000
2020-21	8000	9500	17500
2021-22	9000	8500	17500
Total	**40000**	**57000**	**97000**

Source: Jawaharlal Nehru National Solar Mission, Press Information Bureau. Ministry of New and Renewable Energy, Government

The target for 2017 may be higher based on the availability of international funds and technology transfer. But in June 2015, The Union Cabinet of India gave approval for stepping up of India's solar power capacity goal under the Jawaharlal Nehru National Solar Mission (JNNSM) by five times, reaching 100 GW by 2022. The target will comprise of 40GW rooftop and 57 GW through large and medium scale grid-connected solar power plants. By this step of the government, India will become one of the greatest countries in the world in solar energy power generation. That new solar target of 100 GW is expected to abate over 170 million tonnes of CO2 over its life cycle. The total investment will be around Rs.6,00,000 cr. (at the rate of Rs.6Cr. per MW at present rate) for 100 GW power generation. Table 4 shows the targets of power generation in different years.

IV. CONCLUSION

The paper discussed the current status of solar energy in India. The Ministry of non- convection energy resources, the government of India, is trying to increases the power capacity and achieve the target of 100 GW by 2022. After the forgone discussion, it is well established that conventional source is the main source of energy in India. The country is having lots of potentials, but the utilization level is at a lower level.

India used about 3.98 percent of its solar energy potential, which is very lower. It is certain to mention that the solar energy potential in all hilly states like Arunachal Pradesh, Manipur, Mizoram, Jammu & Kashmir, Nagaland, and Assam are fully unutilized (except Assam utilized 0.06 percent). Reducing this variation is also a challenge for the government and policymakers.

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