Current Scenario and Future Scope of Solar Energy in India

Yogesh Popat [1], Sourabh Shrivastava [2], Harshit Saxena [3]

[1]*Department of Physics, Taurian World School, Ranchi, India*
[2,3] *Grade X, Taurian World School, Ranchi, India*

Abstract **- In the last few decades, the field of Renewable Energy Sources (RESs) is the most attracting field for researchers as far as the global demand of electricity is concerned, with many innovations, technologies and applications become reality. Solar energy is one of the important categories of Renewable sources of energy which will be helpful for the sustainable development of India. Solar energy is currently fulfilling 5.1% of the total energy need of India which is second highest fulfillment by any category of renewable sources of energy. This paper depicts the current situation and future perspective of utilization of solar energy. In this paper, efforts have been made to summarize the analysis of consumption, current status, and future capability, barriers to implementation and major achievements of solar energy in different states of India.**

Keywords **- Renewable Energy Sources (RESs), solar energy, sustainable development.**

1. Introduction

Renewable energy is a term defined as the energy obtained from a type of sources which can be renewed in a short span of time. Out of all the categories of renewable sources of energy, solar energy is considered as one of the most important sources. At present, solar energy fulfills 5.1 % of the total energy need of India and 1.3 % of the total need of the world. World energy has made a prediction that if the fossil fuel - based oil, coal and gas reserves were used at the same way then they are going to be extinct in less than 10 decades [1]. The natural flow of solar energy is huge in comparison to the total energy need of India. This is valid from both the ends, technical as well as theoretical perspective, how the level of utilization of solar energy also depends upon the type developing technology and its application. The amount of solar energy intercepted by the earth is as huge as compared to the global energy demand [2]. Several countries including India have introduced a significant amount of RESs and maintained it using various technologies [3]. Amongst all the clean technologies, solar energy is an efficient and easy way to cut down the level of greenhouse gases and hence the global warming issue. The reception of solar energy in India is equal to 5000 trillion kWh per year with approximately 280 to 300 clear sunny days per year [4-5] but this giant power of solar energy is unutilized in India.

DOI: 10.18421/SAR12-05
https://dx.doi.org/10.18421/SAR12-05

Corresponding author: Yogesh Popat,
Department of Physics, Taurian World School, Ranchi, India
Email: yogeshpopat28@gmail.com

Received: 16 May 2018.
Accepted: 19 June 2018.
Published: 25 June 2018.

2. Historical background of energy in India

In late 18th century the total energy need was fulfilled by coal. Since then, the global industrialization took place by extracting energy from coal, oil, natural gas and nuclear resources such as uranium. These resources took millions of years to accumulate and depletion of these resources is taking place at the rate of 100,000 times than they are being replenished. The emission obtained from these resources and due to human activities has given rise to the greenhouse effect and hence the global warming [6]. In 1976 energy policy analyst Amory Lovins has given a term “soft energy” which describes the eco-friendly and renewable sources of energy as alternative future of energy [7]. Soft energy technologies have five defining characteristics.

(a) rely on renewable energy resources.
(b) are diverse and designed for maximum effectiveness in particular circumstances.
(c) are flexible and relatively simple to understand.
(d) are matched to end-user needs in terms of scale.

(e) are matched to end-user needs in terms of quality [8].

India was the first country to set up a ministry of non-conventional energy resources in the late 1980s. Renewable energy in India comes under the compass of Ministry of New and Renewable Energy (MNRE). Expert consultation at the Asia Energy Vision 2020, organized under the World Energy Council agreed on energy demand projection in India reflected in Table 1. [9].

Table 1. Energy demand projection in India

S.No.	Source	Unit	1991-92	2009-10	2020-21
1.	Electricity	TWh	231	725	1300
2.	Coal	Mt.	229	690	1345
3.	Petroleum	Mt.	57	165	335
4.	Natural Gas	b cum	18.6	65	130

Source: A. Kumar et al / Renewable and Sustainable Energy Reviews 14 (2010) 2434-2442

3. Methods of utilizing solar energy

Solar energy is also called 'ultimate source of energy' because it acts as an indirect source of other energies such as wind, biomass, hydro, ocean etc. Solar energy can be exploited in two ways, passive and active. Passive utilization of solar energy is using the heat or light of the sun directly without converting it in other forms [10]. The active way of utilizing solar energy is converted in other forms depending upon the applications. The Photovoltaic system (PV) and Concentrated Solar Power (CSP) are the examples of active and passive methods of utilization respectively. Solar energy is mostly exploited in three basic ways and they are as follows:

A. The Photovoltaic system (PV)

PV system is an active mode of utilization which is generally used for electricity generation. PV systems are a kind of transducer which converts light or photon to electrical energy. PV systems are also referred to as the solar cell which basically comprises of semiconducting materials (P and N-type extrinsic) made up of silicon and also made up of compounds such as GaAs or CdTe. This electricity generation is Eco-friendly in nature. Implementation of small PV modules can be done on smaller land areas hence have minimal impact on land but an implementation of larger PV modules may have a severe indirect impact on wildlife. PV modules also require periodic maintenance. Current (2017) installed PV capacity of India is around 1200 MW. Many times the distorted output is obtained from PV module due to power electronic devices such as inverters [11].

B. Solar Thermal Power Plant

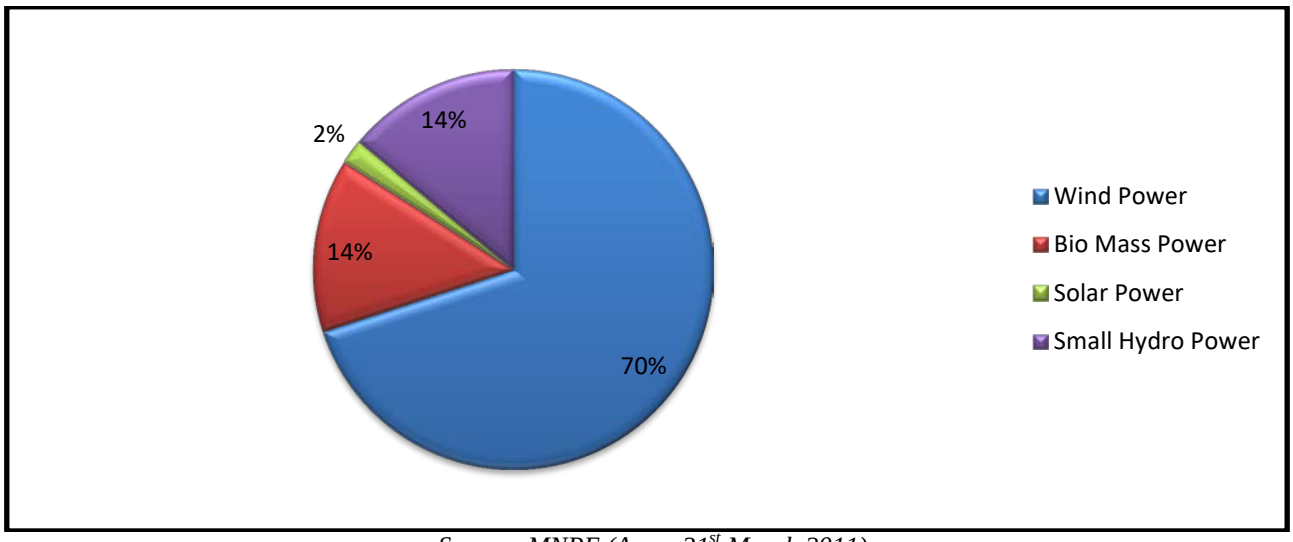
This is an active mode of exploiting solar energy which is generally used for electricity generation and heat. Solar thermal power plants are generally used with parabolic reflectors, central tower, and parabolic dishes. All these are based on classic stem power plant. These plants generally require large area for implementation. This type of power plant may supply power to small cities, hence they can act as a base of regional development. Generally, they are implemented in desert areas, therefore, they require the additional grid to polluted areas [11].

C. Solar Thermal Systems

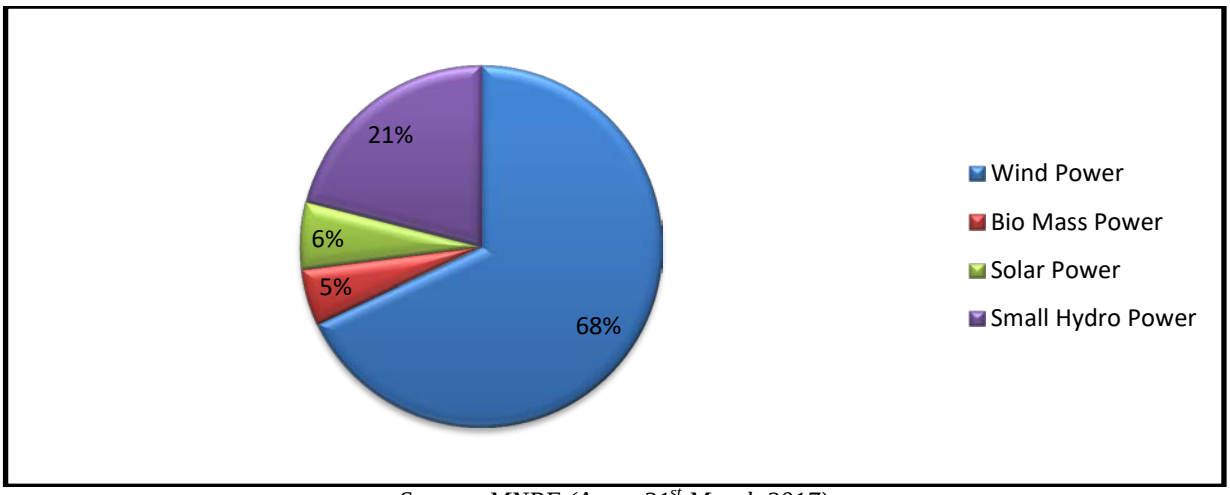
This is a passive mode of exploiting solar energy which is used to extract thermal energy which can be used for heating up of water or other eatables. Solar thermal systems are very easy to implement and operate, hence it is readily used for domestic purpose [11].

4. Current scenario of solar energy in India

India, ranked 5th in global energy consumption list consumes 3.9% of world's commercial energy. The total installed capacity is about 1,44,942 MW. The amount of solar energy utilized in 2007 was less than 1% of the total energy need of India. The grid interactive solar power on December 2010 was 10MW but it rose to a level of 3.062 GW on December 2014 and 9.2 GW on March 2017. The new target set for 2017-2018 by the MNRE to utilize solar energy is 100GW. Year-end review report for 2017 of the MNRE also reflected that India is at 6th position in the world in utilizing solar energy [10]. Out of all the types of renewable sources of energy, the solar energy contribution is 2% on 31st March 2011 as shown in Figure 1. which was raised to a level of 22% on 31st March 2017 as shown in Figure 2. [12].



Source: MNRE (As on 31st March 2011)
Fig. 1. Solar Energy utilization share for India in 2011



Source: MNRE (As on 31st March 2017)
Fig. 2. Solar Energy utilization share for India in 2017

Table 2. Commissioning status of solar projects from 31.01.2017

Sl. No.	State/UT	Total Cumulative capacity till 31.03.2017 (MW)	Capacity Commissioned in till 31.10.17	Total Cumulative capacity till 31.10.2017 (MW)	% Contribution
1	Andaman and Nicobar	6.56	0.00	6.56	0.04
2	Andhra Pradesh	1867.23	271.60	2138.82	13.70
3	Arunachal Pradesh	0.27	4.12	4.39	0.02
4	Assam	11.78	0.00	11.78	0.02
5	Bihar	108.52	33.00	141.52	0.90
6	Chandigarh	17.32	0.00	17.32	0.11
7	Chhattisgarh	128.86	0.05	128.91	0.82
8	Dadar and Nagar	2.97	0.00	2.97	0.01
9	Daman and Diu	10.46	0.00	10.46	0.06
10	Delhi	40.27	16.95	57.23	0.36
11	Goa	0.71	0.00	0.71	0.004
12	Gujarat	1249.37	41.81	1291.18	8.27
13	Haryana	81.40	110.04	191.44	1.22
14	Himachal Pradesh	0.73	0.75	1.48	0.009
15	Jammu & Kashmir	1.36	0.00	1.36	0.008

16	Jharkhand	23.27	0.10	23.37	0.14
17	Karnataka	1027.84	464.54	1492.38	9.56
18	Kerala	74.20	14.00	88.20	0.56
19	Lakshadweep	0.75	0.00	0.75	0.004
20	Madhya Pradesh	857.04	282.95	1139.99	7.30
21	Maharashtra	452.37	62.64	515.01	3.30
22	Manipur	0.03	1.28	1.31	0.008
23	Meghalaya	0.01	0.05	0.06	0.0003
24	Mizoram	0.10	0.00	0.10	0.0006
25	Nagaland	0.50	0.00	0.50	0.0003
26	Odisha	79.42	0.07	79.49	0.50
27	Puducherry	0.08	0.00	0.08	0.0005
28	Punjab	793.95	82.85	876.80	5.61
29	Rajasthan	1812.93	433.55	2246.48	14.39
30	Sikkim	0.00	0.01	0.01	0.0006
31	Tamil Nadu	1691.83	20.24	1712.07	10.97
32	Telengana	1286.98	1283.45	2570.43	16.47
33	Tripura	5.09	0.00	5.09	0.03
34	Uttar Pradesh	336.73	171.01	507.74	3.25
35	Uttarakhand	233.49	13.40	246.89	1.58
36	West Bengal	26.14	7.47	33.61	0.21
37	Others	58.31	0.00	58.31	0.37
	Total	**12288.83**	**3315.92**	**15604.76**	**100**

Source: mnre.gov.in

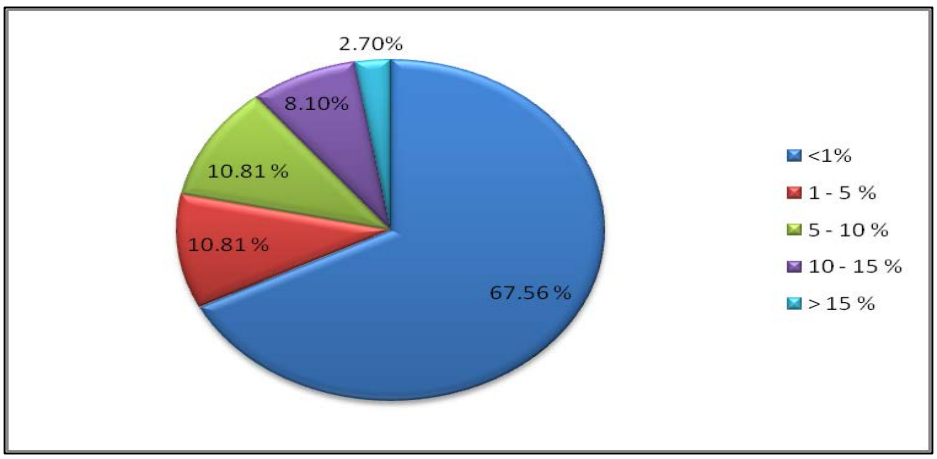
Table 2. reflects the state wise contribution in total installed solar energy projects in India as on 31.10.2017

Table 3. State wise contribution in solar energy projects in India as on 31.10.2017

% of the installed capacity from the total installed capacity of solar energy projects in India	**Name of states**
< 1%	Andaman and Nicobar, Arunachal Pradesh, Assam, Bihar, Chandigarh, Chhattisgarh, Dadar & Nagar, Daman & Diu, Delhi, Goa, Himachal Pradesh, Jammu & Kashmir, Jharkhand, Kerala, Lakshadweep, Manipur, Meghalaya, Mizoram, Nagaland, Odisha, Puducherry, Sikkim, Tripura, West Bengal, Others
1 – 5%	Harayana, Karnataka, Uttar Pradesh, Uttarakhand
5 – 10 %	Gujarat, Madhya Pradesh, Maharashtra, Punjab
10 – 15 %	Tamil Nadu, Rajasthan, Andhra Pradesh
>15 %	Telangana

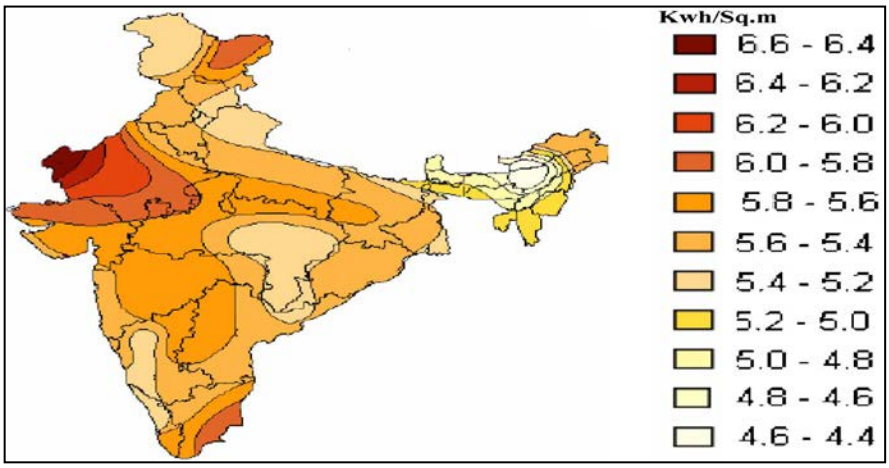
Source: mnre.gov.in

Table 3. shows the names of the states with installed capacity less than 1%, 1-5 %, 10-15 %, and greater than 15 % of the total installed capacity of solar energy in India i.e., 12.288 GW and in Figure 3. it is noted that in 67.56 % of the states of India, the installed capacity of solar energy projects are lesser than 1% of the total installed capacity of solar energy projects. In 10.81 %, 10.81 %, 8.10 % states the same is respectively 1-5%, 5-10% %, 10-15% % of the total installed capacity of solar projects. Only in the remaining 2.70 % states, the installed capacity of solar energy projects is above 15% of the total installed capacity of solar energy projects. India is also known as a sunny belt of the world. There is a huge scope for exploiting solar energy technology to fulfill the energy needs of more than 1.324 billion population of India. As already discussed in section 1, most parts of India get 280 to 300 clear sunny days which make the country an appropriate place to implement solar energy technology. The daily average solar energy incident over India varies from 4 to7 kWh/m^2 with the sunshine ranging from 2300 to 3200 per year. This much solar energy is sufficient enough to generate 500,000 TWh electricity per year, assuming 15% conversion efficiency of the SPV modules [13]. Figure 4. shows the map of India which reflects the solar radiation level in different parts of the country. It is observed form the map that the highest global radiation is received in Rajasthan, Gujarat, and parts of Ladakh region. A fair amount of radiation is received by Andhra Pradesh, Madhya Pradesh and Maharashtra [14].



Source: mnre.gov.in

Fig. 3. Percentage of states with different % contribution in solar energy projects in India as on 31.10.2017

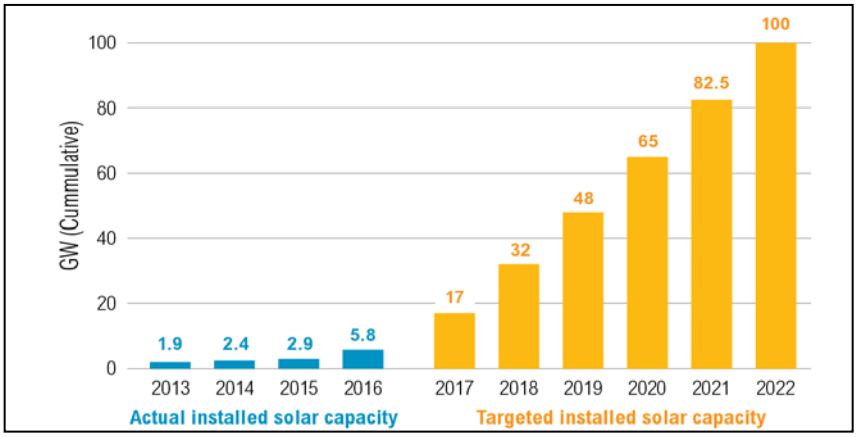


Source: [14]

Fig. 4. Solar radiation map of India

5. Future projection of solar energy exploitation in India

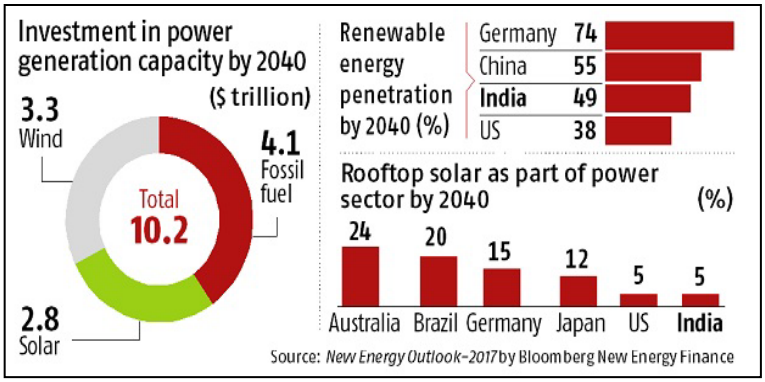
Indian government has set a target of 175GW renewable power installed capacity by 2022 and out of this 175 GW, solar energy projects have a share of 100GW. A target of 14550 MW grid renewable power has been set for 2017-2018 and in this 14550 MW, solar energy projects are expected to fulfill 10000MW. The Government of India has set a target of 175 GW renewable power installed capacity by the end of 2022. Figure 5. shows the year on year target of India to reach 2022 solar goal which is 100 GW.



Source: Bloomberg New Energy Finance (BNFF); The Economic Times

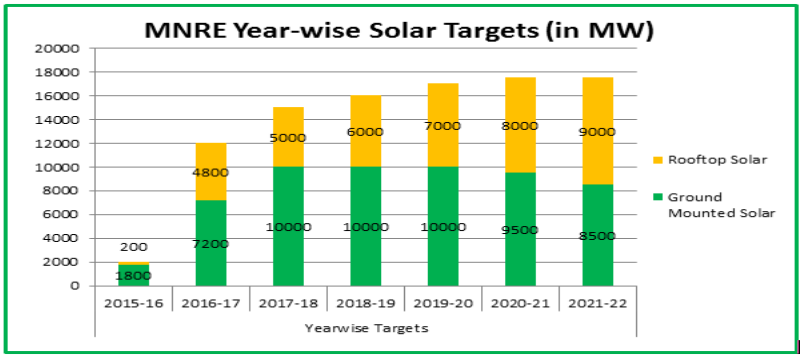
Fig. 5. Year on Year Target of India to reach 2022 solar goal

The Bloomberg new energy finance report also reflects that India presents $4 trillion opportunities in the energy market and accounts for 15% of all the investments in power generation to 2040 [15]. Figure 6. depicts the renewable energy investment in power generation and penetration of renewable sources of energy and rooftop solar energy project ranking different countries by 2040 [15]. Figure 7. depicts the year wise target of different financial years from 2015-16 to 2021-22 for rooftop solar and ground-mounted solar energy projects separately.



Source: BNEF

Fig. 6. Investment and penetration of solar energy at an International level



Source: mnre.gov.in

Fig. 7. A year-wise target of solar energy projects of the MNRE

6. Highlights of the solar energy sector in India

A. Recent achievements of the MNRE India

(a) Solar tariff is at its lowest level 2.44 per unit, achieved through transparent bidding and facilitation

(b) Ambitious bidding trajectory for the 100GW capacity of solar energy.

(c) India attains the global 6th position in solar power installed capacity.

(d) By November 2017, a total of 62 GW renewable power installed, of which 11.79 GW installed since January 2017.

(e) From January 2017 to November 2017, 11788 MW of grid-connected power generation capacity from RESs has been added and solar power projects hold a share of 5502.38 MW (46.67%)

(f) 1.42 lakh Solar Pump has been installed in the Country as on 30.11.2017 including 1.31 lakh during last three and half year.

(g) Solar projects of the capacity 23656 MW have been tendered and LoI for 19,340 MW issued [12].

Table 4. Physical progress in the solar energy sector in the year 2017-18 (January- November 2017)

Solar Sector Category	Achievement (Jan-November 2017) (MW)	Cumulative Achievement as on 30.11.2017 (MW)
Grid Interactive Solar Power	7599.31	16611.73
Off Grid SPV system	146.02	551.56
Total	7745.33	17163.29

Source: mnre.gov.in

B. Major Initiatives of the MNRE India

(a) Solar energy tariff is at historically the lowest level 2.44/kWh. The recent chronology is of the recent solar tariff is tabulated in Table 5.

Table 5 Reduction in solar tariff in India

S.No.	Period	Capacity (MW)	Lowest Tariff (Rs/kWh)	Scheme	State
1	Feb-2017	750	3.30	State	Madhya Pradesh (REWA Park)
2	May-2017	250	2.62	VGF	Rajasthan (Bhadla IV Solar park)
3	May-2017	500	2.44	VGF	Rajasthan (Bhadla III Solar park)
4	Aug-2017	500	2.65	State	Gujarat (Non-Solar Park)

Source: MNRE

(b) "Development of Solar parks and Ultra mega solar power projects" has been enhanced from 20,000 MW to 40,000 MW.
(c) Approved 35 solar parks in 21 states of India having capacity of 20,514 MW.
(d) 23656 MW has been tendered out, of which LOI is issued for 19340 MW.
(e) 3 new solar parks have been approved in this year at Rajasthan (1000 MW), Gujarat (500 MW) and Mizoram (23 MW) after an issue of guidelines for enhancement of capacity from 20,000 MW to 40,000 MW under solar park scheme.
(f) Kurnool solar park of Andhra Pradesh has emerged as World's largest solar park with a capacity of 1000MW.

C. Advantages of Solar Energy

(a) First and foremost advantage of using solar energy is its eco-friendly nature. It does not release CO_2 and other harmful gases which are responsible for global warming [16].
(b) The solar energy sector will act as a base of sustainable development for India. Solar energy is available in abundance which will last for several years whereas other non-renewable sources will have a finite life [16].
(c) Solar energy will generate space for employment and will help make Indian economy strong. The MNRE is rigorously working on the advancement of the solar energy sector in India. Many of the schemes and achievements of the MNRE are presented in section 6 of this paper. The sector of solar energy in India is expected to produce seven lakh jobs in the country in the next 10 years. This could help improve the rural economy in India [17].
(d) Grid independence is one added advantage of solar energy technology. Solar energy installations can be done anywhere. It can also be used easily for a domestic purpose [18].
(e) Solar energy has variable uses. It can be used for many purposes such as heating, cooking or electricity generation and many of the educational and corporate organizations are implementing solar panels. It can also be used in satellites, car panels, calculators etc. [18]. All the benefits of solar energy are summarized in table 6.

Table 6. Merits of using solar energy

Eco-Friendly	Renewable	Economic growth	Suitable for remote areas	Employment	Unlimited	Reduced dependence
No emission of harmful greenhouse gases.	Solar energy is available from the sun which is renewable in nature.	Once implemented can be used free of cost	Once implemented can be used free of cost	Capable to provide 7 lacs jobs within 8-10 years	Solar energy is coming from the sun in a huge amount	Will reduce the dependency on traditional fossil fuels

7. Current energy policies in India

A. Electricity Act 2003

The objective of the Electricity act 2003 is to provide a framework for the growth of the electricity sector in India. Under section 3(1) and 3(2), it has been stated that the Central Government shall prepare and publish the Electricity Policy and tariff policy in coordination with other authorities for the development of the power. Section 4 states that the Central Government in consultation with state governments prepares and propagates a national policy, permitting stand-alone systems for rural areas. Section 61, 61(h) and 61(i) state that the appropriate commission shall subject to the provision of this act, specify the terms and conditions for tariff determination. Section 86(1), state commissions shall discharge the following functions, namely, promote cogeneration and generation of electrical energy from RESs by providing suitable measures for grid connectivity and sale of electricity, purchase of electricity, a percentage of total electricity consumption in the area of the distribution license.

B. National Electricity Policy, 2005

The policy is responsible to project preferential tariff for electricity produced by renewable sources of energy. It also aimed to provide electricity in all areas having no grid connectivity by 2012. It also aimed to increase minimum per capita availability to 1000kWh per year by 2012.

C. Tariff Policy, 2006

Pursuant to the provision of section 86(1)(e) of the Act, shall fix a minimum percentage of purchase of energy by states from renewable sources of energy and providing special tariff for solar energy. It will take time till non-conventional sources of energy compete with the conventional sources in terms of cost and efficiency.

D. Integrated Energy Policy, 2006

It aimed to suggest and project a path to fulfill the total energy needs of the country in an integrated manner up to 2031-2032. It mainly focuses on electricity generation from renewable sources of energy.

E. National Rural Electrification Policies, 2006

It aimed to provide access to electricity to all households by the year 2009 with proper quality and reliability and at reasonable rates. It also aimed to provide an off-grid solution to fulfill electricity demands in rural areas. The Gram Panchayat shall certify and confirm the electrified status of the village as on 31st March each year.

F. Jawaharlal Nehru National Solar Mission (JNNSM) 2010

JNNSM aimed to project a target for electricity demand and fulfillment of it for the coming years. This mission gave a specific target of 20,000 MW of grid-connected and off-grid solar power capacity by 2022 with 2000 MW as a share of off-grid capacity.

G. Renewable energy certificates, 2011

It was introduced in 2011 to enhance the capacity of renewable energy by leveling the inter-state divergences of renewable energy generation and the requirement of the obligated entities to meet their Renewable Energy Portfolios (RPOs) with different price rates for solar and non-solar.

H. International Solar Alliance (ISA)

ISA is an initiative of the Indian Prime Minister Shri Narendra Modi to collaborate the efforts of 120 countries around the globe to promote the utilization of solar energy and thereby reduce the dependence on fossil fuels. Shri Modi took this initiative in November 2015 at the Wembley Stadium. ISA projected the wider deployment of solar energy technologies which will reduce the production and development costs and will help in reducing the level of global warming.

I. National Action Plan on Climate Change (NAPCC), 2008

In 2008, Government of India laid the foundation of the NAPCC. It aimed for sustainable growth to address climate changes. Its first mission was an intensification of development and deployment of solar energy technologies. It also advised that the RPOs are to be set at 5% of total grid-purchased, and increased by 1% each year for 10 years.

J. Corporate Social Responsibility (CSR)

It is founded to encourage the participation of private sector and to contribute to national as well as global growth. It aimed to meet social goals such as pollution-free generation. The CSR funds are channelized by top 500 companies as 2% of their profits towards the off-grid solution.

8. Barriers and challenges in the advancement of the solar energy sector in India

A. Technical Barriers

There is a limited supply of system components such as batteries, inverters and other conditioning components. The low power efficiency of the PV systems is of major concern. The efficiency of thin film system ranges from 4–12% and for crystalline PVs, it is 22%. Also, the cadmium used in CdTe is of toxic nature and the tellurium is very rarely available mineral. The increased demand for the PV also surpassed the silicon supply [5].

B. Institutional Barriers

There is a significant communication gap between various governmental agencies, authorities, stakeholders, and ministries which results in a barrier to implementation of the solar and renewable energy sector. Different states of India such as Haryana, Rajasthan, Punjab and Uttrakhand adopted single window project approval and clearance system for implementation of the RESs. However, this system is highly time-consuming and its effectiveness is highly questionable. This type of system reduces the faith of the investors in the investment for deployment of the RESs [19].

C. Research and Development (R&D) Barriers

In the deployment of solar energy technologies, the lesser efficiency of the PV systems is the result of improper R&D work. The main reason behind the lack of R&D work is due to shortage of finance, R&D institutions and lack of coordinated goal driven effort among the national and international organizations. In India, the replicating of technologies is taking place rather than advanced R&D work [19].

D. Local Infrastructure

The Llack of infrastructure is another barrier. Additional infrastructure is required especially for implementation of solar energy technologies in rural areas. Solar power plants are established in remote areas due to which there is a need for additional transmission lines to transport electricity in different locations [20].

E. High Payback Periods

Due to high initial cost and poor efficiency of the PV modules, the payback time of solar installations is quite high. Although in recent years the costs of solar technologies have come down they are still higher than the costs of conventional technologies [21].

F. Financial Barriers

The GOI has announced a budget for rooftop PV and solar power plants that do not qualify under the JNNSM and sell to state utilities [21]. RE project must have low fuel costs and less operational and maintenance costs but it tends to be higher than conventional technologies [22].

G. Lack of trained people and training institutes

India has very low percentage of trained workforces in the field of solar energy technologies and very low number of solar training institutes which is of major concern. Although the government is providing subsidies to organizations and individuals to promote solar energy installations, these will not be effective for long if customers can only use bad products installed by untrained technicians [23].

H. Lack of Awareness

Solar technology is very recently developed technology due to which peoples are less aware of it and also there is lack of promotion activities from government agencies. Many consumers have a view that the solar capacity is unreliable due to its availability during daytime but they are unaware that these technologies are a highly reliable hybrid form of PV or thermal system [24]. A brief summary of barriers to the implementation of solar energy technologies is tabulated in Table 7.

Table 7.A brief summary of barriers to the implementation of solar energy technologies

S.No.	Barriers to implement solar power installations	Description of barriers	Researcher's
1	Technical barriers	Low efficiency of the PV module	[5]
2	Institutional barriers	The communication gap between different agencies	[19]
3	R & D	Low speed of R&D work	[19]
4	Local infrastructure	Additional infrastructure required	[20]
5	High payback periods	Payback period is longer due to poor efficiency of the PV modules	[21]

6	Financial barriers	Financing mechanism is time taking	[22]
7	Lack of trained people and training institutes	Less trained people and training institutes	[23]
8	Lack of awareness	Lack of promotion of activities from government side	[24]

9. Conclusion

The global energy crisis is an important issue at international level. The whole world is looking towards energy security and environmental protection by reducing the dependency on traditional fossil fuels and solar energy technologies are proving itself as a best alternative source. Accordingly, the focus is on solar energy technologies that are likely to account for 5% in the electricity mix by 2032. India has set a tremendous goal in the field of solar energy installation for coming years which is easily achievable. India has the capability to fulfill at least 35-40% of the total energy need by solar technologies. India recently has become a world leader in using solar energy technologies but still there is large scope in the improvement of the strategies for solar installation which requires great support not only from government but also from the youth of the country.

References

[1] Kumar, A., Kumar, K., Kaushik, N., Sharma, S., & Mishra, S. (2010). Renewable energy in India: current status and future potentials. *Renewable and Sustainable Energy Reviews*, *14*(8), 2434-2442.

[2] Thomas B Johansson, Kes McCormick, Lena Neij, Wim Turkenburg .(2004). *"The Potential of Renewable Energy"*, Thematic Background Paper, International Conference for Renewable Energy, Bonn. PP 1-36.

[3] Okazaki, T., Shirai, Y., & Nakamura, T. (2015). Concept study of wind power utilizing direct thermal energy conversion and thermal energy storage. *Renewable energy*, *83*, 332-338.

[4] Urja Akshay.(2008). Newsletter from New and Renewable Source of energy Government of India.

[5] Sadhu, M., Chakraborty, S., Das, N., & Sadhu, P. K. (2015). Role of solar power in sustainable development of India. *Indonesian Journal of Electrical Engineering and Computer Science*, *14*(1), 34-41.

[6] Kamal, S. (2013). *The Renewable Revolution: How we can fight climate change, prevent energy wars, revitalize the economy and transition to a sustainable future*. Routledge.

[7] Amory Lovins, Soft Energy Paths, p. 54,1977

[8] Armaroli, N., & Balzani, V. (2007). The future of energy supply: challenges and opportunities. *Angewandte Chemie International Edition*, *46*(1-2), 52-66.

[9] Planning Commission, Government of India-September 1995 and September 1996 Projections to 2020-2021.

[10] Center, F. S. E. (2000). Florida photovoltaic buildings program: status report, observations, and lessons learned. *Cocoa, FL: Florida Solar Energy Center*.

[11] Vezmar, S., Spajić, A., Topić, D., Šljivac, D., & Jozsa, L. (2014). Positive and Negative Impacts of Renewable Energy Sources. *International journal of electrical and computer engineering systems*, *5*(2), 47-55.

[12] Press Information Bureau, Year End Review, Government of India, Ministry of New and Renewable Energy, 27 December 2017.

[13] Sharma, A. (2011). A comprehensive study of solar power in India and World. *Renewable and Sustainable Energy Reviews*, *15*(4), 1767-1776.

[14] Garud, S., & Purohit, I. (2009). Making solar thermal power generation in India a reality–Overview of technologies, opportunities and challenges. *The Energy and Resources Institute (TERI), Darbari Seth Block, IHC Complex, Lodhi Road, New Delhi, 110003*.

[15] The Bloomberg New Energy Finance Report (BNEF) 2017.

[16] Alrikabi, N. K. M. A. (2014). Renewable energy types. *Journal of Clean Energy Technologies*, *2*(1), 61-64.

[17] Rebecca Bundhun.(2017). *"Renewable energy: India's next employment boom"*, The national business.

[18] Mains 2016: All about India's Solar Policy, Forum IAS, 30 November 2016.

[19] Khare, V., Nema, S., & Baredar, P. (2013). Status of solar wind renewable energy in India. *Renewable and Sustainable Energy Reviews*, *27*, 1-10.

[20] Kulkarni, A. (2010). Report on barriers for solar power development in India. *South Asia Energy Unit, Sustainable Development Department, The World Bank*.

[21] Ansari, M. F., Kharb, R. K., Luthra, S., Shimmi, S. L., & Chatterji, S. (2013). Analysis of barriers to implement solar power installations in India using interpretive structural modeling technique. *Renewable and Sustainable Energy Reviews*, *27*, 163-174.

[22] Patlitzianas, K. D. (2011). Solar energy in Egypt: Significant business opportunities. *Renewable energy*, *36*(9), 2305-2311.

[23] Philibert, C. (2006). Barriers to technology diffusion: the case of solar thermal technologies. *International Energy Agency, Organisations for Economic and Development*.

[24] Rachit S, Vinod KG.(2016). *"Current status, Policies and Challenges in India"*, Research and Reviews Journal of Engineering and Technology, ISSN: 2319-9873, Volume 5, no. 2, pp 18-22.