

# Environmental & Economic Growth of Rural/Urban Electrification with Solar Energy: A Review

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**Abstract** – To solve the problems based on energy, which is being faced by India and other developing countries, Renewable energy and its technologies have enough potential. And can also provide a longstanding solution for it. Solar energy is important when we are looking at all environmental concerns and can lead renewable energy. Global energy crisis can be solved by solar energy. Solar thermal electricity (STE) will be considered as future source of electricity generation. The availability of energy, current status, strategies and policy for promotion, achievements and future potential of solar energy in India is discussed in this paper.

This paper is to review the recent development in the STE and SPV technologies. Solar power is cheaper than other energy resources like, thermal and domestic coal and has the capacity to maintain uniformity in the electricity tariffs. Observation says that the solar radiation in the worst part of India is better than the best part of Europe. The present energy and environmental problems are requires enormous attention to the utilization of solar-energy.

**Keywords:** Renewable energy, Solar Thermal & Solar photovoltaic technologies, Growth of Solar Energy in India, Global Energy Crisis.

## I. INTRODUCTION

India's mechanical and financial headway is checked by its significant vitality lack. To setup of new power plants import of exceptionally eruptive petroleum derivatives is must. In this way, it is required to use the plentiful sustainable power source assets (Biomass Energy, Solar Energy, Wind Energy and Geothermal Energy). It can likewise help India to reduce environmental change. India's vitality prerequisite is profoundly relies upon petroleum derivative. Coal and mineral oil-based power plants produces the colossal measure of the power age however it discharged ozone harming substances.

Solar Power is one of the clean renewable energy resources. The possibility of energy is very huge with solar power and it also has zero emission. With ongoing headways, sunlight based vitality frameworks are effectively accessible for modern and household employments. With the abutted preferred standpoint of least support numerous nations are changing over to sunlight based vitality. In the ongoing occasions,

engineering structures incorporate the photovoltaic cells and hardware for planning of structure plans.

India is situated between the Tropic of Cancer and the Equator. In this way, its normal yearly temperature ranges from 24°C – 27°C. India has immense sunlight based potential in the south/east coast, from Kolkata to Tamil Nadu.

The announcement in the National Action Plan on Climate Change says: "India is a tropical nation, where the accessibility of daylight with incredible force is immense every day." Therefore, sun powered vitality has extraordinary potential as future vitality source. It likewise has the benefit of giving the decentralized dissemination of vitality, to enable the general population at the root level. [7]

The Radiation climatology of India has following features: [11]

- a. The splendid daylight is accessible for around 3300 to 3700 hours in a year in the northwest and west

focal areas of the Indian sub-landmass and around 2900 hours over focal promontory aside from Assam, Kerala and Kashmir.

- b. The sunlight based vitality got over the nation all in all is about 7.6 Kwh/m<sup>2</sup>/day, amid cloud free winter months and pre storm months the most extreme around 210 Kwh/m<sup>2</sup>/month and the base 140 Kwh/m<sup>2</sup>/month amid rainstorm seasons.
- c. During winter, North India receives lowest radiation and South India receives highest and vice versa during summer.
- d. Rajasthan has least diffused sun based radiation of around 740 KWh/m<sup>2</sup> and expanding to 840 KWh/m<sup>2</sup> in Assam and to 920 KWh/m<sup>2</sup> in south of the landmass.
- e. The all out sunlight based vitality gotten by Indian Subcontinent is around 60 x 10<sup>13</sup> Mwh. In many pieces of the nation there are around 250 to 300 days of normal daylight every year.

## II. HISTORICAL GROWTH OF SOLAR ENERGY FOR INDIA

Development programs based on solar energy have been operationalized by the propelled nations following the Second World War. Nonetheless, with the improvement of atomic time in sixties, the advancement in sunlight based vitality backed off. The gigantic experience of atomic vitality and the addition of oil cost in the seventies indeed drawing consideration on sunlight based vitality. The Department of Nonconventional Energy Sources, Govt. of India, framed in 1982, reported various formative projects and exhibit ventures.

The Government of India starts recognizing the importance of solar power in 2006 by making a Rural Electrification Program, which provides guidelines and rules for the implementation of off-grid solar applications. However, the installed capacity through this policy in 2012 is only 33.8MW. [8]

Solar energy (solar photovoltaic and solar thermal) could satisfy the global electrical energy demand by 2060. Within 2035, the world's renewable energy sources could also grow by at least 60 percent and could even double. According to International Energy Agency (IEA), renewable energy could supply up to four times more energy than today by 2060 It could be the world's biggest essential vitality source by 2060. The industrialized countries are mentioning India to take the authority in the improvement of sun oriented vitality in the Third World to satisfy the vitality need.

Sun oriented Energy Center (SEC), a particularly committed unit built up in 1982 by the Ministry of New and Renewable Energy.

On eleventh January, 2010 Jawaharlal Nehru National Solar Mission (JNNSM) was propelled. Following are the objectives set by the mission:

- Installation of 20,000 MW of network associated sun based power, 2000 MW of off-framework sun oriented applications including 20 million sun powered lights by 2022.
- 20 million sq. Sun based warm gatherer zones.
- Provide and create favorable conditions for developing solar manufacturing capability.
- To achieve this objective create an enabling policy and aggressive R&D and make India a global solar energy leader. [11]

## III. SOLAR ENERGY STATUS AND CURRENT SCENERIO IN INDIA

Sun oriented vitality is the vitality gotten from the sun through the type of radiation. India is having 250-300 radiant days in a year. The normal sun oriented radiation force got on India is 200 MW/km square (megawatt per kilometer square). Sun oriented is essential, albeit right now underutilized, vitality assets in India with the capability of an improved and persistent power supply (particularly in remote region) and increment the security and soundness of India's vitality supply. Sun based vitality power fluctuates topographically with western Rajasthan accepting the most astounding yearly radiation vitality and the north-eastern districts getting the least. India has enormous dimension of sunlight based radiation, getting the sun oriented vitality likeness in excess of 5000 trillion kWh/year. Contingent upon the area over the globe, the day by day frequency of sun beams ranges from 4 to 7kWh/m<sup>2</sup>, with the long periods of daylight running from 2300 to 3200 every year [1]

Solar radiation levels and impact on different areas of the country are given in fig. 1. It can be analyzed that although the highest annual global radiation is received in Rajasthan, Northern Gujarat and parts of Ladakh region, the other parts of Andhra Pradesh, Maharashtra, and Madhya Pradesh are also receive fairly good amount of radiation as compared to other parts of the world like: Japan, Europe and the US where development and deployment of solar technologies is maximum.

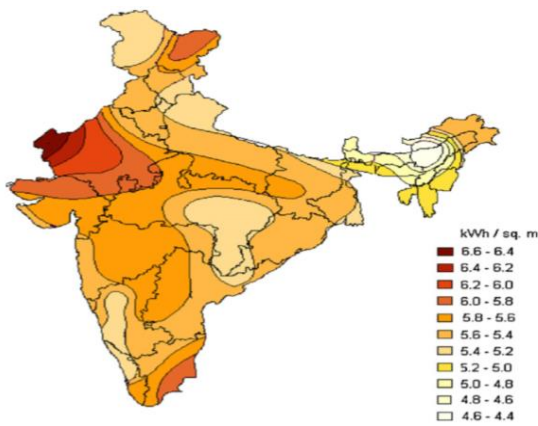


Fig. 1 Solar Radiation on India [3]

#### IV. INSTALLED CAPACITY AND SOLAR ENERGY DEMAND IN INDIA

In Indian energy mix an unmatched role is played by the Solar Power. Network associated sun based limit of 19.58 GW has been introduced till February 28, 2018 and government is extremely near accomplish the objective set at first as 20GW in 2017-18 itself.

The administration had reconsidered the objective of network associated sunlight based vitality limits from 20GW to 100GW by 2022. The legislature has chosen to sell 30 GW sun oriented vitality limits each in 2018-19 and 2019-20 to accomplish 100 GW lattice associated limits by 2022. [13]

Moreover, the administration would likewise sell off 10 GW limits each in the two financial years to accomplish 60 GW of wind control age limits by 2022. Wind control age limit of India is 32.8 GW according to Central Electricity Authority information. Till February, 2018 the absolute sustainable power source limits were 62.8 GW. Despite the fact that in the following ten years, the market driven by rising force request and costs for petroleum derivatives is set up to develop fundamentally.

In India's Cumulative Installed Power Capacity, Renewable Energy comprises 20.3% of India's total installed capacity, with solar accounting for 6.6%. Among renewables, solar account 32.4% of the installed capacity.

*Data from CEA, MNRE, Mercom India Solar Project Tracker (Installed Capacity as on 31 March, 2018)*

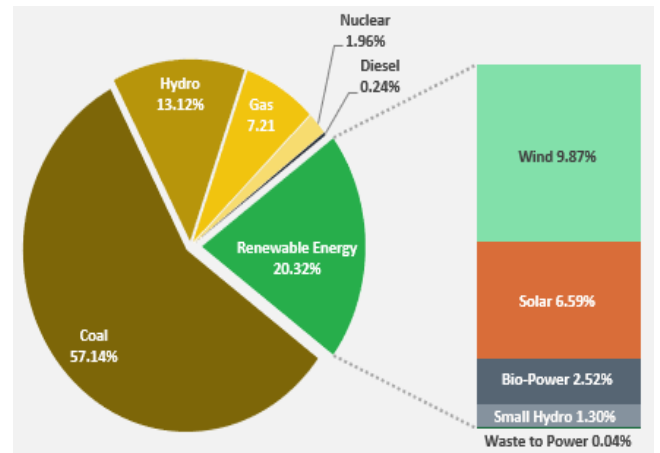


Fig. 2 India-Cumulative Installed Power Capacity

[Source: Mercom India Research]

For extensive and long haul vitality supply technique of India, consolation for the spread of sunlight based power age (both CSP and PV) and go for framework equality (right now at around RS.5/kWh) by 2022 and equality with coal control age (as of now at around RS.4/kWh) by 2030 are the key components [6]. India's long-term power requirements can easily fulfill by Solar Power. But it has to be cost-competitive.

Indian solar installations in calendar year 2017 grew exponentially with the addition of 9,629 MW in new large-scale and rooftop solar capacity. The installation total was more than double the 4,313 MW installed in 2016 and made 2017 the best year for solar installations in India to date. The robust growth boosted the country's total installed capacity to 19.6 GW as of December 2017. However, despite the encouraging installation numbers, many completed projects were unable to get commissioned before the end of the year due to evacuation and grid connection delays.

Expansive scale sunlight based establishments represented the majority of all out establishments in 2017, capturing around 90 percent of the aggregate with 8,634 MW introduced, while the rest of the 10 percent originated from housetop sun powered increases totaling 995 MW.

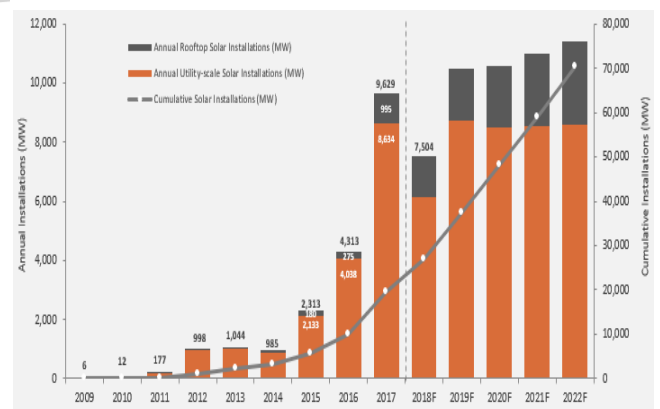


Fig. 3 India Solar Demand Forecast

[Source: PV Magazine; 2018]

Rooftop installations grew by 56 percent year-over-year with cumulative installations totaling nearly 1.6 GW as of December 31, 2017.

However, this sector has facing a lot of challenges. Forecast shows the total installations to decline by about 22 percent year-over-year to 7.5 GW in 2018. The lower forecast reflects a smaller pipeline of projects scheduled for commissioning in 2018. Auction activity was not very robust in 2017 and though there was a surge in activity at the end of the year, most of the projects that were tendered are not likely to be commissioned until 2019, a factor that is reflected in our five-year forecast. [11]

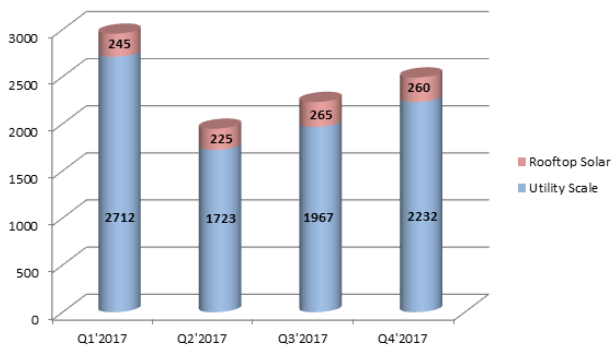


Fig. 4 Solar Installation in 2017 by Quarter (MW)

## V. CHALLENGES AND GROWTH OF SOLAR ENERGY IN INDIA

A colossal segment of our rustic territory is as yet starving of power for farming purposes and house machines. Sun oriented vitality can assume critical job to take care of this issue. The popular British business analyst Thomas Robert Malthus in 1789 unmistakably demonstrated that earth would confront a difficult issue sooner rather than later except if ventures to be taken to control the populace.

An extensive scale sun oriented power plant for the most part requires around one kilometer<sup>2</sup> for age of each 20-60 MW. The capital expense of sun oriented power framework is higher than that of traditional arrangement of intensity age. India's restricted financing of sunlight based activities is a noteworthy limitation for its improvement in India. [3]

For country's economic growth, solar energy is very important. In 2010, National Solar Mission was launched. Introductory advancement and development has been sensational. Under 12 MW in 2009, sun oriented power age developed to 190 MW in 2011 in India. It became fivefold to 1,000 MW in March 2013, yet India has far to go to achieve its objective of expanded sun oriented power age to 20GW by 2020.

There are certain schemes for solar power growth in India are as follows:

- National Solar Mission
- Jawaharlal Nehru National Solar Mission (JNNSM)

The JNNSM is empowering the creation of both PV and CSP innovation with equivalent weightage. This mission has conveyed 20 GW of sun powered power by 2022. The ongoing arrangement rules by government incorporate improvement of sun powered power, watch on power deficiencies, partner concessions and so on. Their arrangement has picked up force in 21st century giving noteworthy enthusiasm to the improvement of sunlight based vitality.

Low prices of photovoltaic (PV) modules results in low final cost of generation of solar power. India has the world's lowest solar costs. The normal costs of 15 to 17 pennies for every kilowatt hour (kWh) in India. The costs for modules are going down in the following four years. The expense of sun oriented power is 16 percent lower than the costly framework associated regular vitality providers in 2022. Lattice equality will prompt two noteworthy changes in the sunlight based market. To start with, matrix associated limit will increment with an a lot quicker rate than previously, and second, to advance off-network age, guidelines and approach will be updated.

Solar power capacity can boost by the combination of growth of electricity demand, cost of fossil fuel and challenges of availability of suitable place, and the environmental regulations to more than 50 GW by 2022. After 2018, the market will experience an exceptional change. Ease of sun based power inside and out with mind-boggling expense of matrix power will persuade the appropriation organizations, private firms utilizing open access, and firms setting up their own hostage limit. This is the beginning of the development period of sunlight based power in India. The network associated sun powered limit will rise quickly to around 35 GW by 2020.

The cost of generating solar power depends, inter alia, upon intensity of radiation, size of the solar plant, cost of financing, etc. The tariff for solar power is now being determined largely through tendering process. For installation of rooftop solar PV projects, the Ministry of New and Renewable Energy (MNRE) has worked out benchmark cost as follows: (as on July, 2018). [12]

TABLE 1: COST OF GENERATION OF SOLAR ENERGY

Capacity	Amount per kW
Upto 10 kWp	Rs. 60,000/- per kW
10 kWp – 100 kWp	Rs. 55,000/- per kW
100 – 500 kWp	Rs. 53,000/- per kW

## VI. ACHIEVEMENTS IN SOLAR SECTOR

India's solar industry is very busy in the year 2017. 5.5 GW of PV had installed in India till November. India's ambitious renewable energy goals are helping to become a

world leader in the solar power industry. Although, the renewable energy activity in India increase rapidly, as solar is dominating with almost 48% share of total installed capacity. [3]

27.07 GW capacity of renewable energy has been added in India during last 3.5 years, which includes 7.26% of solar, 67.18% of wind, 12.54% of small hydro and 4.28% of biomass.

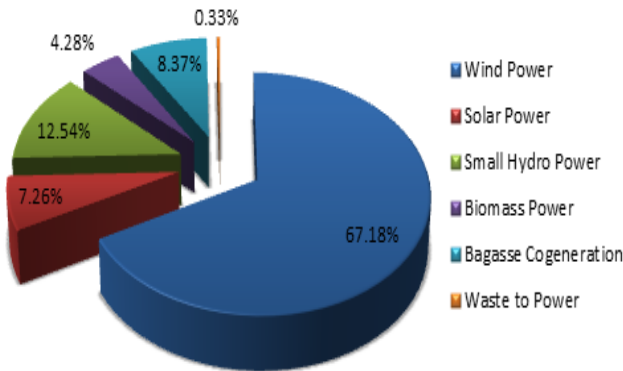


Fig. 5 Renewable Energy by Installed capacity in India

The solar sector in India grows exponentially, with installation of PV going over 17 GW, which includes 863.92 MW from solar roof top projects [4]. The ambitious target to achieve 40% cumulative electric power through renewable energy by 2030, and installation of 175 GW of renewable energy by 2022 (solar and wind) has set by the government.

**Increasing Demand of Solar Energy:** With the increasing economy, India’s energy demand is also increasing. The renewable energy is around 18.37% out of the total capacity of installed power generation. In 2017, India has its biggest ever PV power capacity growth of 5526 MW, out of which 1.7 GW was contributed by the solar rooftops.

A total of 20 GW have been approved in 21 states by around 35 solar parks. Target has also been increased to 40 GW, from 20 GW which is set under the country’s development of Solar Parks and Ultra-Mega Solar Power projects scheme. Andhra Pradesh’s Kurnool solar park is the world’s largest solar park, with the capacity of 1 GW at a single location. [8]

Under India’s Solar Off-Grid and Decentralized applications program, 1.89 MW (63 solar micro grids) has been installed [3]. Up to 30% financial support on the costs of micro/mini-grids systems for installation in rural areas is given by Ministry of New and Renewable Energy (MNRE). 863.92 MW of PV rooftop is installed out of 1.76 GW of capacity which has been approved [9].

Many private institutions also provide their huge campus for installation of Solar Plant under government schemes. This benefited institution and also the nearby

area. In Rajasthan many private universities take the advantage of this. For example, a solar plant of 220KW capacity is installed in Suresh Gyan Vihar University, Jaipur. Also the capacity is increasing by 100 KW in near future. That helps the University for Power Load and the surplus power is distributed to the nearby areas.



Fig. 6 120KW Solar Power Plant in SGVU, Jaipur

Altogether in 2017, new milestones were achieved by India and set a base for the further development of its renewable energy sector. If the momentum goes on, it will surely achieve its goals and helps the Indian Power Sector.

## VII. CONCLUSION

Electricity shortage in India needs an immense addition in capacity to meet the demand of its promptly growing economy. Solar Energy’s marginal cost of generation is low and it is indigenous and distributed. Energy security can increase by transforming supply, reducing its dependence on import, and alleviating fuel price volatility.

The institutional structure and co-activity in New and Renewable vitality between U.S.A. and India supports and builds the correspondence between two nations at working dimension. Activities have been taken in decreasing the sun oriented expenses in mix with expanding cost in lattice power will persuade the conveyance organizations and private firms to utilize open access and setting up their very own hostage ability to start its development stage and make sunlight based power cost-effective option in contrast to customary power source.

Growth and development of solar power is expected to contribute in lowering the emissions per unit of GDP by 20-25 percent by 2020. By its advantages & applications, this will also help to improve industrial & economic growth of India. Also it helps the security of energy supply, economic growth, environment protection and open new job & business opportunities. Thus there is a need to substantiate the efforts for balancing non-conventional sources with other sources for a quality & reliable power supply.

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