Current Scenario of Solar Power and Various Schemes for Stimulation and Expansion of Solar Energy Sector in India

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1 Introduction

Power and energy are among the key factors that have a significant contribution towards the economy of a nation. Research projects that are linked to the utilities for defining, formulating, implementing and then redefining for improvement finally result in the national development along with the benefit of it reaching the consumer [1]. During the last decade of the previous millennium, most of the utilities were forces to their operations, structure and the ways the business was done. Earlier the functioning of the utilities was vertical and closely held and the demand changes it to an open system. The fast depletion of reserves of fossil resources for meeting the energy demand of high-energy intense industries and the resulting visible change, the use of these reserves caused to the environment caught the much-needed attention for decelerating the dependence on fossil fuel. The industrial activity and demand for development result in dumping carbon into the atmosphere; of the total 8 billion tonnes of carbon emissions, 81.25% comes from fossil fuels and the remaining from deforestation [2]. Renewable Energy Sources (RESs) such as pico and micro hydro, solar, wind, biomass, fuel-cell, etc. are non-polluting, clean and can easily substitute fossil fuels provided technology and economics are achieved.

The power sector in India is extremely diversified, and it also has a considerable growth rate. For both capacity addition and energy security, the power sector of India

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is amongst the fastest growing along in the world, and along with it, it's diversified. Now solar power is an integral part of India's energy expansion plan; it is not only for capacity addition but also for energy security. With the restructuring in the power sector, India looked towards solar power as an alternate source of energy. The utilities started taking much interest in this energy that is free of cost and also environment friendly for generation purpose. Since the last decade, the cost of generating power has been lessening due to technology advances resulting in the decline in the cost of equipment used in Solar Power Plants (SPP) along with efficient solar panels. The need for skilled labour exists, however, the manpower required is lesser; hence, the cost of operating a solar power plant is less in comparison to its overall cost. Moreover, with the advancement of the automation of solar power plants, there is a reduction in the cost of labour along with the cost of operation. Hence, the cost of commissioning a solar power plant is bound to come down in the near future [1].

There was a change at the global level in the regulations and laws that govern the power sector and India also has trailed this global change. In June 2003, Electricity Act 2003 came into force in India with the objective for introduction of competition for the much-needed power for all and protection of the consumer interest. The provisions of the Act were National Electricity Policy, Open access in transmission, power trading, mandatory SERC rural electrification, open access in distribution, licence-free generation and distribution, mandatory metering and in its absence stringent penalties for power theft. The Electricity Act of 2003 replaced the Electricity Act 1910, Electricity Regulatory Commission Act 1998 and Electricity Supply Act 1948. The aim of the Act and its subsequent amendments have been pushing the power sector onto a route of robust commercial growth and enabled all the States and Centre to move in synchronization and harmonization of their operations and management for national development through reliable and cheap quality of power and energy [3, 4].

As of 31 March, 2020, the grid-connected installed total capacity from all sources is 370106.46 MW, which includes power from renewable and non-renewable sources. More than half of the total installed from all sources is from fossil fuel, and coal contributing to most of it, which amounts to be 55.43%. As per data of the Central Electricity Authority (CEA) of India, the country is highly depended on coal for meeting the demand for power and energy. The breakup of total installed capacity from all the sources in India: of the 62.8% total thermal is 54.2% from coal, 6.7% from gas, 1.7% from lignite and 0.1% from diesel. Figure 1 represents the graphical bar representation of total generation including RES in BU (Billion Units) from all sources. The RES data from Ministry for New and Renewable Energy include Small Hydro Project, Solar and Wind Energy, Biomass Power, Biomass Gasifier and Urban & Industrial Waste Power.

The above date of installed capacity is not what is needed for achieving a sustainable energy target for the future, the 71% dependence on fossil fuels is to be done away with, which can be achieved by the exploitation of the potential available RES, which would be an assured reduction of the environmental and ecological impacts of power generation [5]. Greenhouse gas (GHG) emissions and air pollution are due to the extensive use of lignite and coal. Growing fluctuation in the oil prices and its

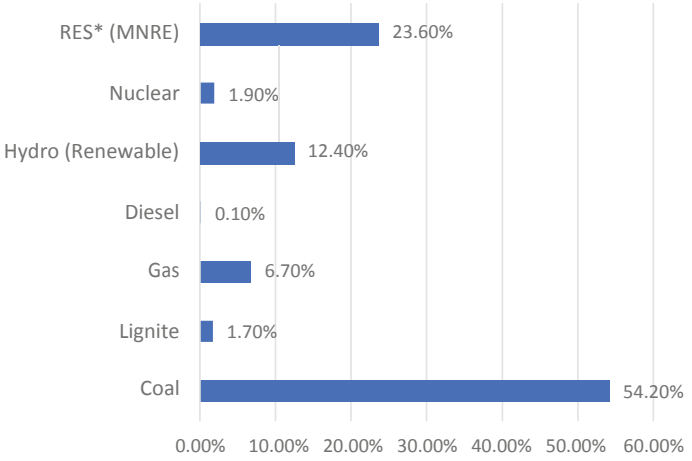

Fig. 1 Installed Capacityfrom all the sources in India [4]

import dependency, international bilateral issues among the oil-producing nations are contributing to the additional economic burden and uncertainty of diesel-based thermal units in the country. High dependency on import has resulted in greater energy insecurity and the same could continue in future. The country needs to decrease dependence on both coal and oil, and along with it focuses on RES to get a secure and stable energy system [5].

In the recent past, India has been among the fastest-growing economy, this has levied a massive burden on power sector for supplying adequate and reliable power for both industrial and urban demands. This growing economy has made India the third-largest consumer of electricity in the world [6]. As on date, the power generation is still insufficient to meet the demand, although there has been a considerable annual addition in the generation capacity. Over the past decade, there have been challenges such as fuel shortage for the operation of thermal units, infrastructure issues for the hydro projects, high price for the import of technology for the renewable sector along with the subsidy for promoting it; the consequence is that the tariff is increasing. Considering the irradiation level and the number of sunny days in India, solar energy can offer a reasonably priced solution to the issue of power deficiency and carbon footprints. The graphical representation of total generation including renewable sources in BU is as shown in Fig. 2.

Solar radiation is plentifully available along with a guarantee of no rise in the cost. Hence, moving towards renewable energy generation can provide relief from increasing tariff and energy security for consumers. The potential of solar power in Saudi Arabia has been extensively discussed in reference [7] along with the economic aspects of power and energy from the sun for that country. Solar energy technologies provide an excellent opportunity for mitigation of GHG emission, thus reducing pollution and retarding the global warming [8]. Suitable attention is required for better development and utilization of RESs in India [9]. Sharma et al. presented

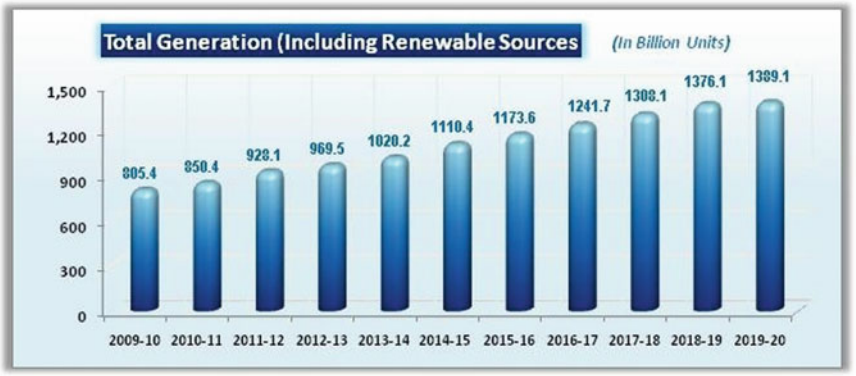

Fig. 2 Graphical representation of total generation including renewable sources in BU [4]

the analysis of technology available and then economic paybacks of solar energy in context with India until the year 2011 [10].

Today both the economic potential and technical up-gradation of solar energy are changing very fast. Hence, recent statistics is indispensable for a precise approximation of power through solar energy. This work mollifies the objective by stating the planning for the development of solar energy, setting the target, achievement of the target and assessment of government initiatives. This paper covers the inclusive study made by the authors of the existing electrical power in India with emphasis on solar energy in terms of its availability, present status, targets laid and the attainments, government initiatives, updated installed capacity along with future strategies. It is intended to provide the recent information regarding solar energy sector in India in regard with the deployment of technologies so as to harness solar energy for future development of remote areas and reduction in fossil fuel dependence.

2 The Electrical Power Installed Capacity and Demand Projection of India

Once in a few years, the Central Electricity Authority carries out Electricity Power Survey (EPS) with the objective of planning of generation capacity, infrastructure for transmission and distribution of power to load centres, by both the state/provincial and the central/federal government in India. The past vs future of electricity demand in India is shown in Fig. 3. The recently released 19th EPS projects the electrical power demand of 1743 TWh (Tera watt hour), which is 6.59% of Compound Annual Growth Rate (CAGR) from 2017. The peak load is 299GW (Giga watt), which is 6.32% CAGR by 2027 (CEA, 2017) [11].

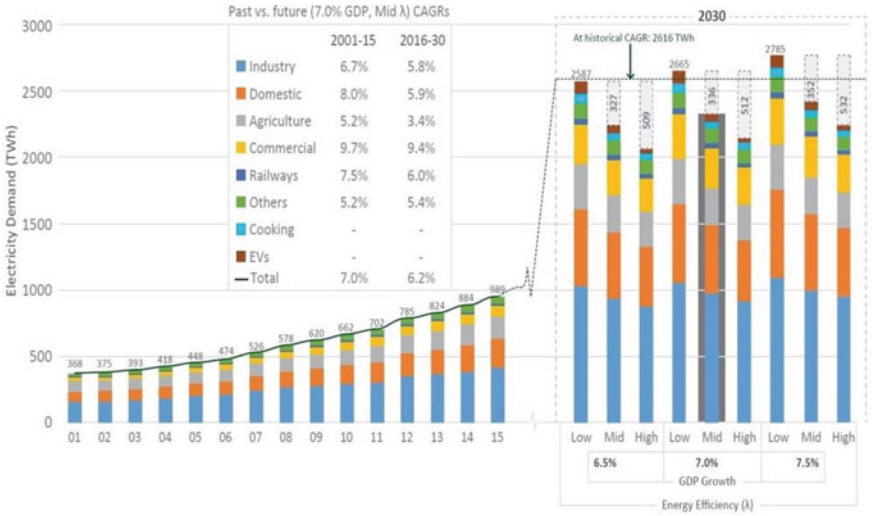

Fig. 3 Past vs Future of Electricity Demand [11]

2.1 Electricity Generation and Growth

The target of electricity generation in India for the year 2020–21 from conventional energy sources has been aimed to be 1330 Billion Unit (BU), which is an ambitious growth of 6.33% of the actual conventional generation of the previous year. For the year 2019–2020, generation from conventional sources was 1250.784 BU, which is a growth rate of about 0.12% from the preceding year. During 2019–2020, 1252.6 BU were generated as shown in Table 1 [4].

The target for electrical power generation from conventional sources for the year 2020–2021 comprises of 1138.533 BU from thermal; 140.357 BU from hydro; 43.880 from nuclear and 7.230 BU import from Bhutan; this totals to 1330BU [4].

2.2 Future Projection of Power Requirement in India

By the end of the next decade, it is expected that the power demand will increase by 128%. The estimation of the power demand by the industrial sector in 2014–2025 is 550GW, and in the year 2029–2030, it will be 760 GW; which would be an increase of 38.18% [12]. Looking at these projections, for sustainable development, the solution to the increase in electrical power demand lies in the optimal utilization of the available solar days [13].

Table 1 Annual conventional power generation and its growth in India [4]

Year	Contribution of conventional sources towards power generation (billion units)	Percentage growth of generation
2009–2010	771.6	6.6
2010–2011	811.1	5.56
2011–2012	876.9	8.11
2012–2013	912.0	4.01
2013–2014	967.2	6.04
2014–2015	1048.7	8.43
2015–2016	1107.8	5.64
2016–2017	1160.1	4.72
2017–2018	1206.3	3.98
2018–2019	1249.3	3.57
2019–2020	1252.6	0.26
2020–2021	91.913	22.85

3 Renewable Energy Generation Capacity in India

India ranks amongst first few of the countries that produce substantial amount of power from renewable sources [14]. As per statistics available on 31 March, 2020, about 35.86% of India's installed generation capacity is from new and renewable sources; generating approximately 21.22% of total utility electricity in the country [15]. The National Electricity Plan for the year 2018 National Electricity Plan sets out ambitions to achieve 275 GW of renewable by the next 10 years, which would increase contribution from the renewable sources to an estimated 24% in electricity generation and 44% of installed capacity [16]. India has certain prominent locations from where geothermal energy can be harnessed up for meeting the local demand. With geothermal energy, another option after efforts on solar, wind, biomass has shown promising results, now the Ministry of New and Renewable Energy (MNRE) is targeting 1 GW of geothermal capacity by 2022.

The target of stand-alone renewable energy is comparatively easy to achieve; however, there are many technical challenges for connecting power from renewable sources to the grid. In the next 2 years (by March 2022), the government has a target to achieve 175 GW of grid-connected renewable electricity. The breakup of which is 57.14%, from solar, 34.28% from wind, 5.71% from biomass and 2.87% from small hydropower. As of 30 April, 2020, India has 45699.22 MW of installed large hydro capacity. Excluding this contribution from the large hydropower, the installed grid-interactive renewable power capacity as of 30 June, 2020 is depicted in Fig. 4. Assessing the statistics, it can be concluded that new and fast-developing renewable energy sources, managed by the MNRE, are gaining much-needed momentum.

India's renewable installed power capacity target for 2020 is 175 GWalready, 50.09% of it has been achieved. The total installed grid interactive renewable power

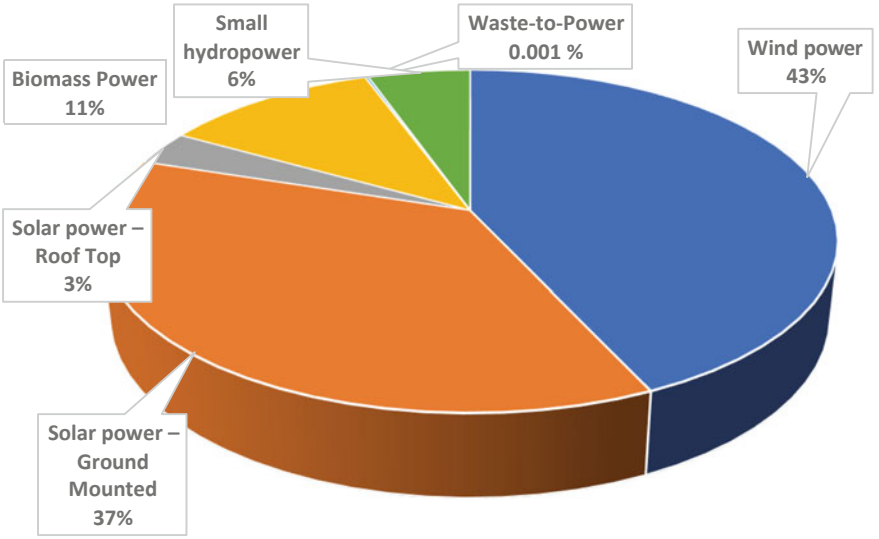

Fig. 4 Installed grid-interactive renewable power capacity [15, 15]

capacity (excluding large hydropower) is 87669.16 MW as of 30 June 2020. For meeting the ambitious target of installed capacity, as on 30 June 2020, as far as the solar power is concerned, nearly half of the target has been achieved, which is around 35122.30 MW. The target attainment is being achieved on daily basis from both roof and ground- mounted panels. Even the installation of power from wind is more than halfway towards achieving the target, the total installed grid interactive wind power is almost 37829.55 MW. The eminent among achieving the target is small hydropower that is above 90%. The contribution of both Biomass bagasse and non-bagasse cogeneration has already reached 95% of the target. The pace of achieving the target is considerable despite the lockdown due to the pandemic 2020.

3.1 Renewable Energy Potential, Target and Regulatory Support

Regulatory provisions play a vital role in encouraging the investment in solar energy. The GOI has a renewable energy target of 175 GW, this will result in accelerated investments in the area. As per the market survey of the Deutsche bank conducted earlier, it was expected that by the year 2019–2020, the annual capital investment in the solar energy sector will surpass that of coal, which is due commitment by global investors worth US$35 billion [18]. This report also estimated that starting from the financial years 2016–2017, the dependence on fossil fuel (primarily coal) can be cut down by 8% by having 5 GW of solar capacity addition per year for 5

years. The results include savings through reduced coal imports along with a significant reduction in GHG emissions [19]. To promote renewable energy penetration, state electricity regulatory commissions are required to aggressively emphasize the installation and use of RES within their jurisdiction. The State Government can promote renewable energy by providing preferential tariffs for installing renewable generators, and the Central Government can provide additional support by allowing open access to the power grid for renewable energy consumers and generators. As part of its 12th 5-year plan, the government aimed to add 30 GW of new renewable energy capacity by 2017 [23]. In 2008, a target was set of achieving 15% solar energy penetration in India by 2020.

As per the requirement of the National Action Plan on Climate Change (NAPCC) under the Electricity Act, so as to strengthen the existing Renewable Purchase Obligations (RPOs), the RPOs set state-wise purchase targets for both the electrical distribution companies and the consumers, for sourcing renewable electricity from third-party generators through the grid [19]. The Electricity Generation (GWh) through RES against Total Utility Power Installed since 2014–2015 is given in Table 2.

The renewable energy targets of 175 GW, which consist of 100 GW generation by solar, and 40% of which will be from rooftop solar [22]. This is a quantum leap from the solar target of 20 GW by 2022 set under the Jawaharlal Nehru National Solar Mission (JNNSM). The new targets include 60 GW of wind power, 10 GW of biomass and 5 GW of small hydro. To achieve these targets, India needs to invest about US$200 billion [24] in the renewable sector. The targets contribute towards the commitment by India submitted to the United Nations Framework Convention on Climate Change (UNFCCC) in December 2015. The commitment was made ahead of the Global Conference of the Parties (COP21) climate talks in Paris.

Table 2 Renewable Electricity Generation among Total Utility Power Installed Year-wise renewable energy generation (GWh) [20]

Source	2014–2015	2015–2016	2016–2017	2017–18	2018–2019	2019–2020
Large Hydro	129,244	121,377	122,313	126,134	135,040	155,970
Small Hydro	8,060	8,355	7,673	5,056	8,703	9,366
Solar	4,600	7,450	12,086	25,871	39,268	50,103
Wind	28,214	28,604	46,011	52,666	62,036	64,639
Bio mass	14,944	16,681	14,159	15,252	16,325	13,843
Other	414	269	213	358	425	366
Total	191,025	187,158	204,182	227,973	261,797	294,288 [21]
Total utility power	1,105,446	1,168,359	1,236,392	1,302,904	1,371,517	1,385,114
Percentage renewable power	17.28%	16.02%	16.52%	17.50%	19.1%	21.25%

3.2 Scheme to Promote Solar Energy

The National Action Plan for Climate Change (NAPCC) in June 2008 initiated the development of solar technologies in India. To take it further, in November 2009, National Solar Mission was initiated. Jawaharlal Nehru National Solar Mission" (JNNSM) aimed to reach parity with the grid power tariff by 2022. This targets the development and deployment of solar energy technologies in the country [16, 16].

4 Current Scenario of Solar Power in India

In recent years, as the need for more and more power for development is increasing, the role of solar energy sources has also been increasing with minimum ecological impact.

4.1 Grid-Interactive Solar Power

Solar energy is free, does not produce any waste during the process of power generation, it is secure and simple to maintain. Figure 5 details the installed capacity of Grid Interactive Solar Photovoltaic (SPV) power for all the states, which is 35122.30 MW in India as of 31 June 2020. Karnataka ranks first as the solar state; it had a 5,000MW installed capacity by the end of the financial year 2017–2018. This includes Pavagarh solar Park of installed capacity of 2050 MW, which was the world second largest photovoltaic solar park. The second-largest solar power state of India is Rajasthan; total photovoltaic capacity by the end of 2020, it will be of capacity 5222.86 MW. Bhadla photovoltaic solar park is the world's largest solar park as of March 2020, located in Bhadla, Phalodi tehsil, Jodhpur district, Rajasthan. The solar park has a total capacity of 2245 MW by the end of March 2020. Tamil Nadu has the third highest operating solar power capacity in India, and as on June 2020, the total operating capacity is 3918.10 MW.

Telangana ranks fourth with the solar power installed capacity of 3689.36MW. Installed photovoltaic solar capacity in Andhra Pradesh is 3618.77 MW, at the fifth position. Andhra Pradesh has three photovoltaic solar stations, these are: Anantha-puramusolar park, Kurnool solar park and Kadapa solar park, having an approved solar capacity of 1500 MW, 1000 MW and 1000 MW, respectively. Gujrat is in sixth position in developing solar power, and by the end of June 2020 its total photovoltaic capacity reaching 3053.69 MW. Madhya Pradesh is at seventh position with its total photovoltaic capacity reaching 2311.80 MW. Madhya Pradesh has two solar power stations; the approved solar power capacity for Neemuch-Mandsor solar park and Rewa Solar Park is 750MW. Maharashtra, Uttar Pradesh and Punjab are next in order they have a total installed solar power capacity of 1869.97 MW, 1174.10 MW and

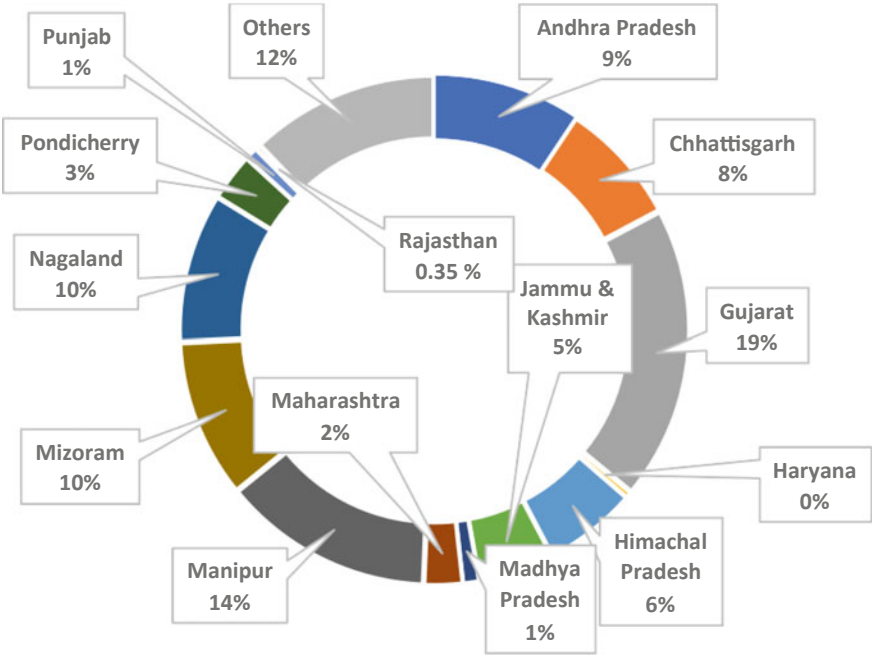

Fig. 5 State wise installed capacity of Grid-Interactive Photovoltaic Solar Power [27]

947.10 MW, respectively. These top 10 solar power states contribute 90% of the total installed capacity of Grid-Interactive photovoltaic solar power in the country. Other 10% installed capacity of Grid-Interactive photovoltaic solar power comes from the remaining left states in the country.

4.2 Off-Grid Installed Solar Power

Solar energy in its various forms has been successfully harnessed by India, by the end of June 2020, 17.21 lakhs Home Lighting System (HLS), 7.31 lakhs Street Lighting System (SLS) and 75.49 lakhs Solar Lantern (SL) have been installed and are operational. There are 256156 solar photovoltaic (SPV) pump systems and Solar Power Plants (SPP) reached 215767-Kilowatt peak (kWp). Figure 6 gives the Decentralised/Off-Grid solar energy devices/systems in India.

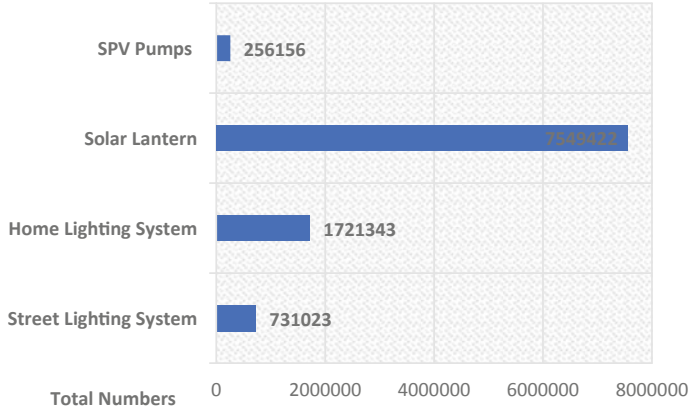

Fig. 6 Cumulative systems installed up to 30 June 2020 [26]

5 Ranking of India's Solar Capacity

There has been an exponential rise in the last decade in the renewal energy installation across the globe. Figure 7 shows the cumulative solar power installation capacity of countries across the globe.

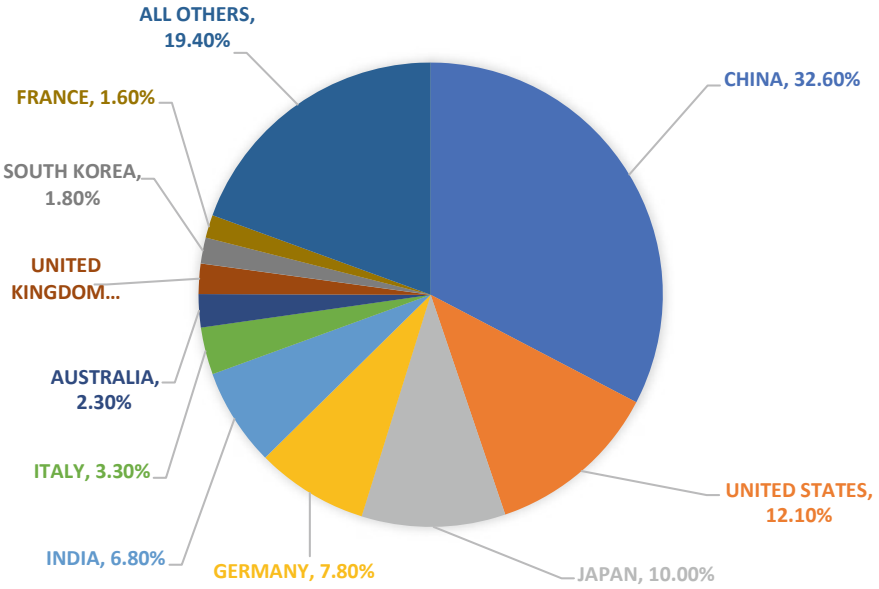

Fig. 7 Country-wise solar power installed capacity [29]

Worlds' global solar installed capacity is 673000MW, where India ranks fifth. India's total Solar Photovoltaic Capacity contributes approximately 6.8% to global renewable solar energy installed capacity. China contributes 32.6% of the global renewable energy installed capacity; its contribution is with 204700 MW. The United States, Japan, Germany, Italy, Australia, United Kingdom, South Korea, France and all other countries stand at second, third, fourth, sixth, seventh, eighth, ninth, tenth and so on, respectively, positions for solar power installed capacity in the world with 75900 MW, 63000 MW, 49200 MW, 20800 MW, 14600 MW, 13300 MW, 11200 MW, 9900 MW and 121600 MW, respectively.

India has been making consistent and sincere efforts to meet the ambitious 2022 targets. The installed capacity of solar power is close to half of its target; it stands at 35122.30 MW as of 30 June 2020. The target is expected to be attained by the ongoing installation and expansion programmes.

Most of the Indian states have significant solar insolation throughout the whole year, which include Karnataka, Andhra Pradesh, Gujarat, Tamil Nadu, Rajasthan, Maharashtra, Madhya Pradesh, Punjab, Telangana, Uttar Pradesh, etc. Figure 8 shows the installed solar projects state wise. Both the central and state governments are

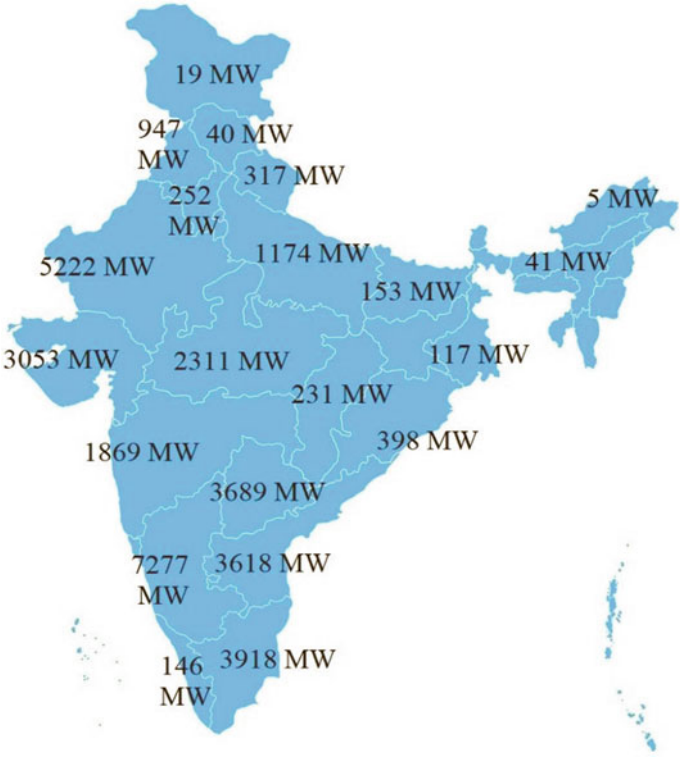

Fig. 8 State-wise status of Solar power installed capacity in India [27]

working towards installing more and more solar projects and providing subsidy where necessary.

5.1 Solar Power Progress of India in 2020–2021

As per records of MNRE, scheme-wise solar progress is given in Table 3. Grid interactive or Grid-connected and off-grid are the two types of solar power productions.

Grid interactive solar power is further categorised as Solar Power–ground mounted and Solar Power–roof top. The capacity of the ground mounted and rooftop type is 32305.15 MW and 2817.15 MW, respectively. Off-grid SPV systems contribute 980.84 MW.

6 Initiatives by Government of India for and Promotion of Renewable Energy

To cater for all the aspects of new and renewable energy, the Ministry of Power of Government of India(GOI) created a new department in the year 1982, naming it as the Department of Non-Conventional Energy Sources (DNES). Looking into the requirement for more efforts in the direction of renewable energy, in 1992, this department was upgraded into a separate Ministry and was called the Ministry of Non-Conventional Energy Sources (MNES). In October 2006, it was renamed as Ministry of New and Renewable Energy (MNRE).

Table 3 Scheme wise solar physical progress in 2020–2021 [17]

Type of solar power scheme	Target	Achievement in FY- 2020–21	
		During April-June 2020	Cumulative as on 30.6.2020)
I. Grid interactive solar power (Capacities in MWp)			
Ground Mounted	9000.00	192.66	32,305.15
Roof Top	2000.00	301.85	2817.15
II. Off-grid/captive solar power (Capacities in MWEQ)			
SPV Systems	500.00	2.45	980.84
TOTAL	11,500	496.96	36,105.14

6.1 Institutions Under the Ministry of New and Renewable Energy

The MNRE set up five institutions of excellence to promote renewable energy, three of these institutions are autonomous bodies and two public sector undertakings. The Autonomous institutes are National Institute of Solar Energy (NISE) at Gurugram in Haryana, National Institute of Wind Energy (NIWE) at Chennai in Tamil Nadu and National Institute of Bio Energy (NIBE) in Kapurthala in Punjab. The two public sector undertakings (PSU) are Indian Renewable Energy Development Agency (IREDA) and Solar Energy Corporation of India (SECI) in Delhi. The autonomous institutes undertake activities related to research and development, standardization, certification, testing, skill development, resource assessment and awareness in their respective energy source and associated technologies. The Ministry established a non-banking financial institution under the administrative control named IREDA, the objective of this PSU is to provide term loans for renewable energy and energy efficiency projects for all the renewable energy sources. SECI comes under the Companies Act—Sect. 3, it is the executing branch of the Ministry for implementation of solar and wind energy projects [26].

6.2 Schemes Under GOI to Boost RE Sector

For sustained industrial growth in specific and national development in general, the power and energy sector are the key sectors for any country. GOI has also recognised the power sector for sustained industrial growth. The initiatives taken by GOI for the improvement of renewable energy contribution to the power sector have been mentioned below:

A. **National Thermal Power Corporation Limited (NTPC)**

Through NTPC, VidyutVyapar Nigam Limited (NVVN) under Phase-I implemented a total of 1GW solar power, this power comes under projects that are grid interactive. These large solar power plants are connected to grid at 33 kV and above voltages. These comprise 500 MW capacity Solar Photovoltaic (SPV) and Solar Thermal (ST) technologies. The National Solar Mission (NSM) is amongst the GOI initiatives under National Action Plan on Climate Change, which has three stages. The first stage is Migration Scheme, the second is NSM Phase-I, Batch-I and the third is NSM Phase-I, Batch-II.

So as to give a quick start to the NSM, and also to have a swift and smooth implementation of the then on-going projects of solar power that were in the implementation stage in different States, in Feb 2010, the government made an initiative to allow the migration of those ongoing projects into NSM. From the then ongoing projects, 16 projects of 54 MW SPV and 30 MW ST capacity were mitigated for long-term procurement of power by NVVN. The Central

Electricity Regulatory Commission (CERC) notified tariff for 2010–11 for the mitigation scheme, which was decided to be 17.91₹ per unit for SPV and 15.31₹ per unit for ST.

B. **National Solar Mission**

The status of NSM Phase-I, Batch-I & Batch-II, provisions, allotment, tariff and commissioning is:

(1) Reverse bidding method is used for the allotment of projects, bids were invited in two batches, namely, NSM Batch-I and nSMBatch-II. Bids for the same were invited in two batches. In August 2010, bids were invited for SPV (150 MW) and ST (470 MW) projects under Batch-I, and in August 2011, bids were invited for SPV (350 MW) projects.

(2) The project capacities for Batch-I were for both SPV and ST, with capacity up to 5 MW and 100 MW, respectively. Allotment was made to 28 SPV projects having a total capacity of 140MW and 7 ST projects with a total capacity of 470MW. The aggregate of combined SPC and ST projects was 610MW. The bids of the power tariff for SPV were at an average of 12.12 ₹ per unit, in the range of 0.95₹ per unit to 2.76 ₹ per unit, For ST projects, bids of the power tariff were at an average of 11.48₹ per unit in the range of 10.49₹ per unit to 12.24₹ per unit. As for the commissioning status of NSM Phase-I, Batch-I, it stands at three ST projects of aggregate 200 MW capacity and 28 SPV projects of aggregate 140 MW capacity.

(3) The project capacities for Batch-II were 5MW to 20MW for SPV. Allotment was made to 27 SPV projects having a total capacity of 340MW. The bid tariff was at an average of 8.77₹ per unit, in the range of 7.49₹ per unit to 9.44₹ per unit. As for the commissioning of the projects, the status of NSM Phase-I, Batch-II is 330MW capacity.

(4) Under the NSM Phase-I, two additional projects were allocated. One of the SPV projects was of 10MW capacity set up by the Solar Corporation of India (SECI). The other SPV project was of 5MW capacity set up by Delhi Mumbai Industrial Corridor Development Corporation Limited.

(5) Under the unbundling scheme of NSM Phase-I, SPV projects of 533MW and SP projects of 200MW have been commissioned.

(6) NVVN purchases power at the decided tariffs from the commissioned plants and sells it to the State Utilities and the distribution companies (DISCOMs). This works under a mechanism of bundling power from unallocated quota of power coal-based stations of NTPC on equal capacity basis. There are 17 thermal plants that are a part of this bundling. The bundling was done so as to effectively reduce the average per unit cost of solar power that the State Utilities and DISCOMs are bound to purchase. A revolving fund of Rs.486 crore has been established as a Payment Security Mechanism ensure timely payments to developers in the event of delays or defaults in payments by State Utilities and DISCOMs in the payments to be made to NVVN.

III. **NTPC State-Specific Bundling Scheme**

In the year 2015, a scheme, namely, State-Specific Bundling Scheme was introduced. This scheme permitted solar power projects to bundle with coal-based power projects. The ratio of solar power to coal-based thermal power for dandling is 2:1. The sole objective to bundle solar and coal projects was to bring down the tariff. The target capacity to be bundled was 3000MW under the scheme. In the year 2018–19, 2750 MW, and in 2019–20, 200 MW has been commissioned. The Kadapa Ultra Mega Solar Park in Andhra Pradesh was commissioned in 2020. The remaining 50MW is ready and will be commissioned in 2020–2021.

IV. **Development of Solar Parks and Ultra Mega Solar Power Projects**

(i) In December 2012, the Scheme for Development of Solar Parks and Ultra Mega Solar Power Projects was rolled out. This scheme has an aggregate capacity of 20,000 MW. Later the capacity of the Solar Park Scheme was doubled and it stood at 40,000 MW in March 2017. The target of this enhancement was to be met with by setting up 50 solar parks by the year 2021–22.

(ii) In general, the capacity of a solar park is 500 MW or above. The projects are implemented only in non-agricultural land. To set up a solar park for each MW capacity roughly 4 to 5 acres of land is required. However, smaller parks with a capacity up to 20 MW are also considered in States/UTs, where there is insufficient land is available. The total central grants approved under the Scheme for Development of Solar Parks and Ultra Mega Solar Power Projects is Rs.8100 crore.

(iii) There is the provision of financial assistance for the solar parks by the SECI. The financial support provided by GOI through the Ministry for the detailed project report of a solar park project is Rs.25 lakh. There is an additional provision of Rs. 20 lakh, of which 60% is earmarked for the development of the internal infrastructure and the remaining 40% is for the development of external power evacuation infrastructure of solar park, otherwise 30% of the project cost, including grid connectivity cost, is provided. The lower amount of the two is given on achieving the milestones prescribed in the scheme.

(iv) Solar Park Scheme has a target to develop at least 50 solar parks. These parks should have an aggregate installed capacity of 40,000 MW of solar power and these must be developed by 2021–22. Up till December 2019, based on the proposals received, an aggregate capacity 22,879 MW has been approved, these are 39 solar parks distributed across 17 States. They are parks that are at different stages of development in different states. As per the status of land for the development of solar parks, 82,600 acres out of 1,31,000 lakh acres of land identified have been acquired. Solar projects of an aggregate capacity of 7767 MW have been commissioned and the details are given in Table 4.

Table 4 Solar Projects commissioned inside Solar Parks till 31 December 2019 [26]

Sr No	Solar Park	Capacity Approved (MW)	Capacity Commissioned (MW)
1	Pavagada SP, KA	2000	2000
2	Kurnool SP, AP	1000	1000
3	Bhadla-III SP, Raj	1000	900
4	Ananthapuamu SP, AP	1500	887
5	Rewa Solar Park, MP	750	735
6	Bhadla-II SP, Raj	680	680
7	Bhadla-IV SP, Raj	500	500
8	Ananthapuamu-II SP, AP	500	400
9	Neemuch-MandsorSP,MP	750	250
10	Kadapa SP, AP	1000	200
11	UP Solar Park, UP	440	165
12	Kasargod SP, Kerala	200	50
	Total	**10,320**	**7767**

E. Scheme for SPV projects under Ministry of Defence

Under Phase-II/III of NSM**,** with the Viability Gap Funding (VGF), there is a provision of setting up Grid-Connected Solar PV Power Projects by defence establishments. The establishments under Ministry of Defence and Para Military Forces come under this scheme. The proposed renewable energy capacity of 300MW under Ministry of Defence was approved by GOI in January, 2015. Approval for 241 MW has been given to different Defence Organisations, out of which, 53.11% is already commissioned and balance capacities are under implementation stage. Table 5 gives the details of the defence schemes.

Table 5 Present Status of Defence Scheme (as of 31 December 2019) [26]

Sl No	Ministry	Org	Capacity Approved (MW)	Capacity Commissioned (MW)
1	Department of Defence Production (116.5 MW)	OFB, Kolkata	7	7
2		BEL	75.5	62.5
3		BDL	10	10
4		HAL, Nashik	15	15
5		Of, Kanpur	5	5
6		MIDHANI	4	4
7	Department of Defence	DOS/MES	125.45	25
		Total	241.95	128.5

Table 6 Year wise targets under National Solar Mission [26]

Year	Tendering target (MW)
2019–20	30,000
2020–21	30,000

F. Focus Area under Phase-II of NSM

Grid interfaced projects come under Phase-II of the NSM. The aim is for accomplishing significantly higher scales of the target of 100 GW by 2022, the details of which are in Table 6. GOI has finalized tendering trajectory so as to achieve the target. Selection of capacity for Phase-II, grid interfaced projects is being done via different schemes such as Viability Gap Funding (VGF), Generation-Based Incentive (GBI) and bundling. GOI has considered all probable choices for enactment; hence, there is provision that the allocation of target capacity may be changed depending upon the resource availability.

G. Solar Energy Potential and Achievements

Based upon solar radiation and availability of land, in the country, the potential of solar power has been assessed to be around 750 GWp. In December, 2019, 33,730 MW was the total solar power capacity installed. Tenders of around 22,839 MW were in pipeline for which letter of intent(LOI) has been issued but not commissioned, and for around 28,578 MW, tender issued but LOI yet to be issued.

7 Conclusion

The current scenario up till March 2020, of the solar power sector of India has been assessed. The much distributed, clean and free of cost solar energy has a very low cost of generation and has a potential of reducing the import of fossil fuel for power generation and reducing import dependence. India aims to achieve solar capacity 100000 MW by 2022. The successful achievements of the ambitious targets are through various projects and solar parks for which many new institutes and organisations have been established. This target is being achieved through various initiatives and schemes of both the state and central government. The renewable energy would be contributing about 35% of the energy demand. After making continuous strides towards sustainable development through solar energy, wind energy and small hydropower, now India has identified geothermal energy and the next option for electrical power from renewable energy sources.

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