Impact of Solar Energy in India and its Future Plan

Bharat Raj Singh[1*] & Manoj Mehrotra[2]

[*1]Director General (Technical), School of Management Sciences, Lucknow, India; e-mail:brsinghlko@yahoo.com
[2]Director, School of Management Sciences, Lucknow, e-mail: director@smslucknow.com

ABSTRACT

Solar Power generation is a fastest developing industry in India and its installed capacity reached to 33.730 GW up to December 2019. The main reason for this growing industry is commitment towards carbon reduction and secondly the India has the lowest capital cost per MW as compared to globally being installed solar power plants. The Indian government had an initial target of only 20GW capacities for 2022, but it was achieved four years before the schedule. The current target was raised in 2015 to 100 GW of solar capacity (including 40 GW from roof top solar) by 2022, committing an investment of Rs. US dollar 100 billion. India has established nearly42 solar parks to make land available to the promoters and rooftop solar power accounts for 2.1 GW, of which 70% is industrial or commercial production. In addition to its large-scaled grid connected with solar photovoltaic (PV) initiative, but based on local needs, India is developing off-grid solar power too.

Solar product have increasingly helped to meet rural needs: by end of 2015 just under one millions solar lanterns were sold in the country, reducing the need of kerosene. That year 118,700 solar home lighting systems were installed and 46,655 solar street lighting installations were provided under a national programme; just over 1.4 million solar cookers were distributed in India.

Keywords: *Solar power generation, carbon reduction, rooftop solar, grid-connected solar, off-grid solar.*

1. INTRODUCTION

Prime Minister Narendra Modi's government has set a target of building 100 GW of solar capacity by 2022 to help to meet one of the country's goals under the Paris climate agreement: renewable sources must account for up to 40% of power-generation capacity by 2030. From the Table-1, we can find that up to 31st Jan 2019, Installed capacity of power generation in India is around **3, 48, 650.60 MW (348 GWatts)** and still 70% generation is from coal and large hydro and 30% is from renewable energy, out of which major share is from wind power (10.1%) and solar power (7.2%), which is to be enhanced to 23% additional by 2030.

Table 1: Total Installed Capacity as on 31-01-2019

SNo.	Source	Power Installed capacity in MW	Percentage
1.	Coal	1,97,452.50	56.5%
2.	Large Hydro	45,399.22	13.0%
3.	Small Hydro	4,517.45	1.3%
4.	Biomass	9,213.80	2.6%
5.	Nuclear	6,780.00	1.9%
6.	Gas	24,937.22	7.1%
7.	Wind Power	35,138.15	10.1%
8.	Solar Power	25,212.26	7.2%
Total Installed capacity		**3, 48, 650.60**	**100%**

The comparative projected electricity generation by different sources is shown in Figure 1:

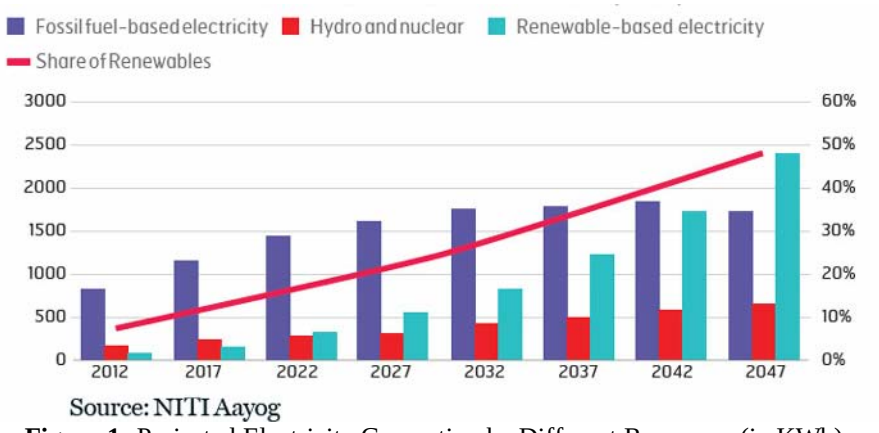

Figure 1: Projected Electricity Generation by Different Resources (in KWh)

The **Table-2** shows the potential of Renewable Energy in Indian, it shows that if we explore solar and wind in India accounting only 36 states, we can add around 900 GWatts from renewable energy and feed most of the neighboring countries through international grid despite our own requirement of power.

Table 2: Potential of Renewable Energy in India

SNo	Small Hydro	Bio-Energy			Solar Energy	Wind Energy	Total
36+ states		Bio-mass	Bio-Gas	Waste Energy			
1	19,749	17,536	5,000	2,554	748,990	102772	**896,602**

New installations this calendar year 2019, will reach nearly 14 gigawatts (GW), which are about 50% more than the capacity added last year2018, according to a report by the Gurugram-based renewable energy consultancy firm Bridge to India, released on Jan. 09, 2019. The new capacity addition will take India's installed solar capacity to about 38 GW by the end of the year 2019. Overall, the country is added nearly 16 GW of clean energy capacity in 2019, driven by large-scale solar projects, which is *3rd fastest and record level addition of solar power in the world.*

2. ROOF TOP SOLAR POWER INSTALLATIONS

Though large scale installations account for 87% of solar power generation, today the adoption rate of solar rooftop panels is accelerating. Today, the renewable power has been adopting at a rapid rate worldwide. India is also becoming as a leader of renewable energy generator in the global arena. To make the sustainable development of India, the central government has already set a target to achieve 175 GW of installed capacity of renewable energy by the end of 2022. Out of this, the target set for solar installations is 100 GW and remaining 75 GW is of Wind, Mini-hydro, Tidal, Ocean, Bio Gas, Nuclear etc.

Till Dec 2019, against the above target, we have already been achieved approx. 33.73 GW and 40 GW is under different stages of implementation. This inclination towards solar generation has allowed India to overpower the US and become now the 2nd largest country in terms of solar power generation in the world. Now, the country is moving ahead towards the achievement of the laid targets for the year 2022.

It is also observed that the large scale of installations accounts for 87% of solar power generation, today and the adoption rate of solar rooftop panel is accelerating with higher pace. The installed capacity of solar rooftop augmented from 117 MW to 1250 MW from the period between 2013 to 2016. Considering this immense growth, the Ministry of New and Renewable Energy (MNRE) through its National Solar Mission of India has set a target of 40 GW power through rooftop solar by 2022. The target may seem ambitious, but it is still achievable [**1-9**].

India installed 2,308 MW of solar capacity in the 4th Quarter of 2019

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India installed 2,308 megawatt (MW) of solar capacity and 817 MW wind projects in the fourth quarter (Q4) of 2019, according to a recent report by research firm JMK Research and Analytics:

- It added that the quarter saw a significant increase in installed capacity across wind and solar, clocking an overall 40 per cent growth over the previous quarter.
- "India commissioned 34 gigawatts (GW) of solar capacity and 38 GW of wind capacity as of 31 December 2019. The current pipeline of solar and wind projects stands at 32 GW, which is likely to be commissioned in the next two to three years," the firm said in its renewable sector update released on Thursday.
- It added that the utility-scale solar segment saw an addition of 7.5 GW and 2.7 GW in wind in 2019.
- According to the research firm, about 15 GW of new capacity addition is expected in 2020 including 4 GW of wind installations and 11 GW of utility-scale solar installations.

Regarding quarterly estimates, it said, "In the next two quarters -- Q4 2019 and Q1 2020 -- addition of about 6 GW of new solar capacity and 2 GW of new wind capacity is expected."
In this quarter, the government issued 41 tenders with the aggregate capacity of 4.5 GW across the solar and wind sector. And in the rooftop solar segment, 23 new tenders under the capex and RESCO models were announced, the report added [**10-17**].

India's renewable capacity installations reached 86 GW as of 31 December, 2019. Wind energy became the biggest contributor with 44 per cent share in the total renewable energy mix followed by solar with 39 per cent share.

- About 2.4 GW of new wind capacity was added in 2019, which was a 10 per cent increase over 2018.
- Gujarat led the installations with commissioning of 1.4 GW of new wind projects followed by Tamil Nadu with 650 MW and Maharashtra with 212 MW.

3. SOLAR POWER CAPACITY IN INDIA

New installations this calendar year will reach nearly 14 gigawatts (GW) as shown in **Fig. 2,** which are about 50% more than the capacity added last year, according to a report by the Gurugram-based renewable energy consultancy firm Bridge to India, released on Jan. 09. The new capacity addition will take India's installed solar capacity to about 38 GW by the end of the year. Overall, the country is estimated to add nearly 16 GW of clean energy capacity in 2019, driven by large-scale solar projects [**18-26**].

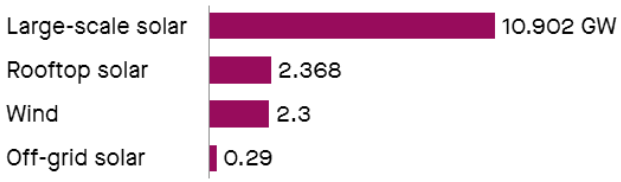

Figure 2: Renewable Energy Capacity Additions in 2019

The central and state governments have been auctioning tenders to build large-scale solar projects, whose main customers will be state-owned power distribution companies. These projects take up to two years to get commissioned, which is when the new capacity is considered added, said Bridge to India analyst, (**see Fig.3**).

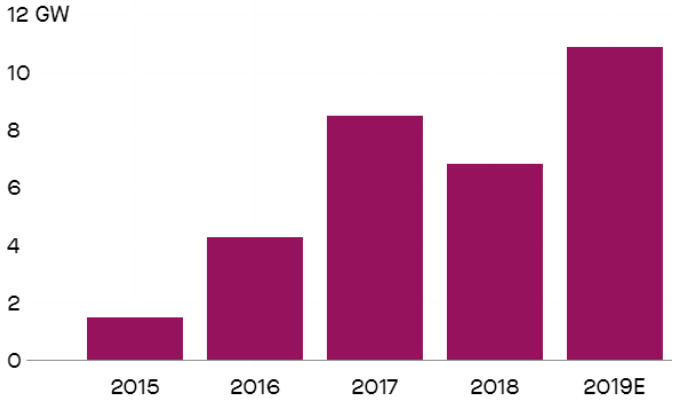

Figure 3: Large Scale Solar Capacity Additions

In 2018, addition of new capacity fell primarily due to low tender activity in the past couple of years, Saran said, adding that the projected rise in additions this year is a result of heavy tendering activity in late 2017 and early 2018. After dipping in the second half of 2018, government tenders picked up again in December, when India's ministry of new and renewable energy announced plans to issue tenders for 60 GW by March 2020 [**27**].

Apart from such large-scale projects, installation of rooftop solar panels also continues to rise. Indian households have not yet warmed to rooftop solar panels due to their high cost of purchase. But commercial and industrial buildings, which are supplied grid electricity at significantly higher rates than residential users, find it economical to switch over to solar panels, (see **Fig. 4**).

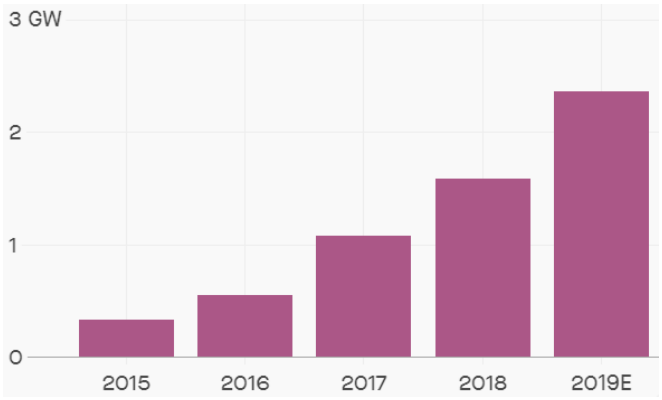

Figure 4: Roof Top Solar Capacity Additions

As land becomes tougher to acquire, developers are now eyeing water bodies. "The latest tenders for floating solar have gone well and there has been a lot of excitement from developers," Saran said, adding that new auctions for floating solar projects of up to 5 GW are expected from the government in 2019. Winning bids for the government's tenders this year will range from Rs3 and Rs2.5 per unit of electricity, the report said. Bids had fallen to Rs2.43 in 2017, (see **Fig. 5**).

Power generated from coal generally sells at over Rs3 per unit in the country.

Figure.5: Range of Winning Bids at Solar Auctions

4. BENEFITS OF INSTALLING SOLAR ROOFTOP PANELS IN BUILDINGS

There are several reasons that further accentuate the benefits of installing solar rooftop panels in buildings like: Space has no restriction, cost saving in electric generation, no government investment etc.

4.1 Cost savings

The biggest advantage of installing rooftop solar panels is that they offer cost savings. The tariff rates for rooftop solar in comparison to industrial and commercial tariff rates are cheaper by 17% and 27% respectively. Rooftop solar installations are also attaining grid parity in many residential sectors of India. For building owners, rooftop solar installations can even help in cutting down electricity bills. Rooftop panels supply electricity to buildings, so they need to buy less electricity from the grid thereby saving on energy costs.

4.2 Secured investment

Electricity prices keep on fluctuating from time to time. So, it is difficult to calculate the expenditure on electricity for a certain period of time. However, when it comes to electricity generated by solar rooftops, the price of power generated can be calculated easily. In fact, one can even calculate the cost of electricity generation for another 10 years. In this way, it is a secure investment.

4.3 Higher energy availability

Though the deficiency of power in India is decreasing rapidly, still there are many people both in the rural and urban areas, who have improper and unreliable access to electricity. These people are forced to rely on alternatives like diesel generators. These alternatives pose harmful effects on the health and they are volatile in terms of their operating costs. In such a scenario, solar energy serves as an affordable source of electricity. Since rooftop solar panels harness the power of the sun to generate electricity, they are eco-friendly. Furthermore, their cost of operation is also stable.

4.4 User get support from the government

In order to encourage people to adopt solar energy, the government offers tax credits to those who install rooftop solar panels whether it be for residential or commercial purposes. As per the Ministry of New and Renewable Energy, the government pays 30% of the installation cost as a subsidy to the installer.

4.5 Reduces carbon footprints

Solar panels harness sunlight to generate electricity. So, they pose fewer pollution risks to the environment in comparison to conventional sources of energy. Unlike a generator, they run without producing any noise and give out lesser emissions of harmful gases. Furthermore, it is a good source of energy that combats climate change. Thus, rooftop solar is ideal as it reduces carbon footprints.

4.6 Green source of energy

This is an era where more and more people are adopting eco-friendly items. The consumers, especially industrial and commercial consumers, are willing to make capital investments to contribute towards the preservation of the environment. Environment-friendly customers are even willing to pay higher than grid power.

4.7 Low maintenance cost

The chief factor that accentuates the importance of rooftop solar panels is that they require very less maintenance. They come with a service life of over 20 years if maintained properly.

4.8 Suitable for Indian climate

Rooftop solar panels utilize sunlight to convert it into electricity. India is situated at an ideal geographical location and receives ample tropical sunlight. There are almost 300 sunny days with clear skies each year in India. Thus, rooftop solar panels are ideal to be used here.

4.9 Multiple applications of solar power

Along with the generation of electricity, solar power can meet several other purposes. It can be used to heat water and supply hot water or air to a building. It can also be used to run electric generators.

4.10 It doesn't require additional space for installation

One of the biggest advantages of rooftop solar panels is that they can be installed on any type of roof. So, people don't need to vacate a land or invest in buying additional land to set up rooftop solar panels. Furthermore, the panels offer protection to the roof of the building in which they are installed.

5. FUTURE PLAN IN SOLAR POWER GENERATION

In the past few years, the large-scale deployment of solar power has faced a range of challenges. Ambitious price targets set a high bar, with rapid technological advances needed to meet these expectations. However, the industry has excelled, with installations of solar panels set to reach a record high this year. According to recent research from Bloomberg NEF, wind and solar energy are now the least expensive forms of power in two-thirds of the world, and advancements in technology are pushing it towards an even brighter future. The DNV GL energy transition outlook provides an outlook of 33 percent of all electricity being generated from solar by 2050, with all renewables totaling 80 percent of electricity generation.

5.1 Solar storage pushes positive signs

The major drawback of solar energy is that it can only function for part of the day. A 2012 study by Lawrence Berkeley National Laboratory predicted that the more solar panels deployed, the lower the value of the energy would be, as all the energy would be delivered at once and other sources of power would still be required at night. A follow-up study in 2016 from Nature Energy forecast costs would need to fall substantially for solar to remain competitive. The study concluded that this downward trend in the value of energy produced would make solar less competitive, unless storage capacity increased substantially. However, these studies could not anticipate the massive reduction in the costs of photovoltaic (PV) and storage technologies and how efficient these plants would become.

5.2 Bright future due to Tech advances drive

With strong growth, particularly in many smaller markets, the solar future is bright. The industry is set to grow 17.5 percent this year alone, with decreased costs making it a more attractive proposition. Bifacial PV modules and the expanding application of single-axis trackers are helping to fuel this growth. Bifacial modules provide additional energy as they can absorb and convert light into electricity from both sides of the module, capturing energy that reflects from the ground. Recent projects have been announced that take advantage of bifacial modules to increase the output beyond that of traditional mono-facial systems. DNV GL are working with customers across Egypt, Brazil, Mexico and the US, all of whom are deploying bifacial modules, to drive down costs and increase the value of these PV assets. Combining these systems with single axis-trackers designed for bifacial applications can also increase the total energy output. However, bifacial systems require additional simulations and measurements to estimate and optimize the output. The industry is making progress toward reducing the uncertainty with a growing collection of performance data from the field, which is helping us validate models and demonstrate the added value of these assets.

5.3 Sun setting giving over whelming responses on fossil fuels

Based on the 80 percent decrease in the cost of solar over the last decade, fossil fuels are becoming increasingly less competitive, particularly during peak solar production. As such, less flexible generators are being ramped down at these times, reducing revenues and profitability for existing plants, which may end up being retired earlier than anticipated. However, as the sun begins to set, generation from solar decreases, which creates a need to quickly ramp up generation from non-renewable sources to meet afternoon and evening demand. In dynamic energy markets with high penetration of renewables, electricity prices can vary during the day and can increase dramatically during peak times with fast ramp

rates needed to compensate for solar going offline. At these times, flexible generators are required to quickly deliver power. This has resulted in flexible generators, such as gas peaked plants, being compensated at higher rates thus making dispatchable resources more cost effective. However, energy storage technologies are coming of age and enabling dispatchable solar plus storage resources to address challenges associated with variable renewables.

Moreover, the cost of energy storage has decreased vastly over the last few years. This has enabled the development of more advanced solar plus storage systems. The Los Angeles Department of Water and Power recently approved a power purchase agreement for a 400 MW solar and 300 MW / 1,200 MWh battery energy storage systems north of Los Angeles, California. Additionally, NV Energy in Nevada, recently signed deals for 1.2 gigawatts of PV plus nearly 600 megawatts of storage to come on-line by 2023, just outside of Las Vegas. Continuous decreases in technology costs, combined with the development of solar plus storage plants, creates a new paradigm for setting market prices or for power purchase agreements (PPAs) that account for the time of power dispatch from these combined assets. As solar and storage costs continue to decrease and more hybrid plants are deployed, the value of flexible, non-renewable power generation will continue to erode; thereby allowing hybrid assets to extend production and address afternoon and evening loads and decrease the need for fast ramping assets in the first place. Through flexible solar energy generation assets that can be dispatched throughout the day, solar plus storage systems are set to begin redefining dynamic energy markets and reduce the historical disadvantage of solar generation.

5.4 A healthy glow in Energy & Climate

The value of renewables goes beyond just energy or climate and is being valued across adjacent industries. A recent study by MIT predicted that investments in renewable energy generation would result in a return on that investment of 34 percent in reduced healthcare costs alone due to reduced air pollution. The study focused on ten US states whose electricity generation profiles are currently made up of an average of 42 percent coal, higher than the current 30 percent US average. The study showed that these states could reduce healthcare costs by $4.7 billion if they hit their target of 13 percent renewable energy by 2030. Remarkably, this increases to more than $20 billion if the percentage of renewable energy was doubled to what is becoming a modest 26 percent of this region's overall electricity generation. The study estimates a $9 billion investment in renewable capacity would be needed to reach this goal. A recent study by the National Renewable Energy Laboratory found that solar energy reduces respiratory and cardio health issues, among other health benefits. It even has been shown to reduce the number of lost work days related to health issues.

5.5 Transition to clean energy

The climate emergency is upon us and we need to act now. Renewables are often touted as a major part of the solution for climate change, which are not only readily available today, but the costs are increasingly competitive and are forecast to decrease well into the future. These economic benefits to healthcare come about from the transition to renewable generation, which are in addition to the known economic benefits to the energy industry and the climate. The energy industry finds itself at the intersection of remarkable economic opportunities, at a time where the economy, climate, and public health are all urgently searching for solutions to systemic problems within each. Renewables are poised to deliver, through technologies that are willing and able. The solar industry is pushing forward, but markets and regulations need to keep up to enable the transition to clean energy future.

6. CONCLUSION

Prime Minister Narendra Modi's government has set a target of building 100 GW of solar capacity by 2022 to help meet one of the country's goals under the Paris climate agreement: renewable sources must account for up to 40% of power-generation capacity by 2030.

From the above study it is seen that comparatively solar capacity versus wind energy is fastest additions in India:

- It added that the quarter saw a significant increase in installed capacity across wind and solar, clocking an overall 40 per cent growth over the previous quarter.
- "India commissioned 34 gigawatts (GW) of solar capacity and 38 GW of wind capacity as of 31 December 2019. The current pipeline of solar and wind projects stands at 32 GW, which is likely to be commissioned in the next two to three years," the firm said in its renewable sector update released on Thursday.
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The benefits of solar power are more as green energy generations. Currently solar power in India becomes *3rd fastest and record level addition of solar power in the world*.

It also indicates that if we explore solar and wind in India accounting only 36 states, we can add around 900 GWatts from renewable energy and feed most of the neighboring countries through international grid despite our own requirement of power.

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