The Role of Renewable Energy Generation in Climate Change Mitigation through Solar Power Production in India and Delhi

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Abstract

Solar energy is basically a clean, green, inexpensive and renewable energy that is produced when sunlight strikes solar cells and is subsequently converted into electrical energy. Solar energy is effectively infinite in supply and can be generated wherever sunlight is available. Solar power generation also prevents the negative impacts of fossil fuels such as the greenhouse gas emissions from coal consumption. India was a pioneer in the world to set up a Ministry of non- conventional energy resources in 1980. The amount of solar energy produced in India in 2007 was less than 1% of the total energy demand. On December 29th 2010, India's first solar park was inaugurated at Charanaka in Patan district of northern Gujarat. India is committed to a target of 40% of installed power capacity from clean energy sources by 2030. Solar energy is freely available throughout India and it's clean, green and environment friendly too. Solar energy is abundant and offers a solution to fossil fuel emissions and climate change.

Keywords: *Energy Resources, Clean Energy, Solar power, Solar Energy*

I. Global Solar Energy Scenario

Solar energy can be harnessed using either photovoltaic (PV) or concentrated solar power (CSP) systems. Photovoltaic systems are far more common and versatile. When the sun shines on the solar panel, energy from the sunlight is absorbed by the PV cells in the panel. This energy creates electrical charges that move in response to an internal electrical field in the cell, causing electricity to flow. Whereas the CSP systems use mirrors to reflect and concentrate sunlight onto receivers that collect solar energy and convert it to heat, which can then be used to produce electricity or stored for later use. Solar energy accounted for about 65% of global renewable energy capacity growth in 2022, according to a study conducted by the International Renewable Energy Agency (IRENA). IRENA's Renewable Capacity Statistics 2023 showed that a total of 192 GW of solar capacity was installed in 2022, up 22% year-on-year. Last year, renewable generation capacity increased by 295GW (+9.6%), meaning solar capacity accounted for 65.1% of the global renewable power capacity growth[1].

II. Solar Energy in India

India is a developing nation, achieving success in almost every field with flying colours. Generation of solar energy has wide scope in India. The geographical location of the country is good for generating solar energy. Solar Power, a clean renewable resource with zero emission, has got tremendous potential of energy which can be harnessed using a variety of devices. India has an average annual temperature that ranges from 25°C – 27.5 °C which means that India has huge solar potential. India is a tropical country and it receives

[1] https://www.pv-tech.org/solar-dominated-renewable-energy-capacity-growth-in-2022-irena/

solar radiation almost throughout the year, which amounts to 3,000 hours of sunshine. This is equal to more than 5,000 trillion kWh. Almost all parts of India receive 4-7 kWh of solar radiation per sq. metres. This is equivalent to 2,300–3,200 sunshine hours per year[2]The sunniest parts are situated in the south/east coast, i.e., from Kolkata To Chennai. States like Andhra Pradesh, Tamil Nadu, Bihar, Gujarat, Haryana, Madhya Pradesh, Maharashtra, Orissa, Punjab, Rajasthan, and West Bengal have great potential for trapping solar energy due to their location. Recently, India has increased its solar energy power but in comparison to the world, India still lacks behind.

III. India's Solar Power Capability

As on February 28, 2022, India has surpassed 50GW of cumulative installed solar capacity. This ranks the country fourth in solar power development. China (33%), United States (13%), Japan (12%), followed by India. India added a record 10 Gigawatt (GW) of solar energy to its cumulative installed capacity in 2021.

India's per capita power consumption is among the lowest in the world . Around 280 million people in the country do not have access to electricity. In comparison, China has a per capita consumption of 4,000kWh, with developed nations averaging around 15,000kWh per capita[3].

IV. Some Projects in India

Many large projects have been proposed in India, some of them are:

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[2] Singh, Bharat Raj , Singh Onkar,2016, Future Scope of Solar Energy in India , S-JPSET : Vol. 8, Issue 1, ISSN : 2229-7111 (Print) & ISSN : 2454-5767 , DOI : 10.18090/samriddhi.v8i1.11408

[3] https://www.livemint.com/Industry/jqvJpYRpSNyldcuUlZrqQM/Indias-per-capita-electricity-consumption-touches-1010-kWh.html

i. The Thar Desert of India, which is estimated to have the total capacity of 2245 MW, is among the largest solar parks in the world.

ii. The Jawaharlal Nehru National Solar Mission (JNNSM) launched by the Government of India had a target of generating 20,000 MW of solar power by 2022.

Make India a global leader in solar energy an installed solar generation capacity	
MW	YEAR
20,000 MW	2022
1,00,000 MW	2030
2,00,000 MW	2050

Table1: Solar Energy Installation projections

iii. Gujarat's pioneering solar power policy aimed at 1,000 MW of solar energy generation, and a Rs. 130 billion solar power plan was unveiled in July 2009, which produced 20 GW of solar power in 2020.

Several new policy initiatives have been taken up during the last four years including: -

i. National Solar – Wind Hybrid policy notified; Wind-Solar hybrid projects of 840 MW have been auctioned through transparent competitive bidding by Solar Energy Corporation of India (SECI), with discovered minimum tariff for hybrid project at Rs.2.67/unit;

ii. Tender invited for setting up Solar PV manufacturing capacities linked with assured off-take of 3000 MW;

iii. EoI (Expression of Interest) invited for 150 MW floating Solar power plants;

iv. The capacity of the Solar Park Scheme was enhanced from 20,000 MW to 40,000 MW;

v. Two solar parks Kurnool (1000 MW) in Andhra Pradesh and Bhadla-II (680 MW) in Rajasthan are fully operational; Solar Power projects of aggregate capacity of 5,835 MW have been commissioned inside various Solar Parks;

vi. Waiver of Inter-State Transmission charges for Solar and Wind Energy up to 2022;

vii. RPO (Renewable Purchase Obligations) trajectory for 2022 notified;

viii. Round the clock Renewable Power policy finalised;

ix. Under the Green Energy Corridor project, approx. Rs. 1,940 crore have been disbursed to the States from the Government of India share to cover projects awarded under it;

x. About 2.4 lakh Solar PV water pumps have been sanctioned and over 2.37 lakh solar pumps have been installed;

xi. 44.04 lakh Solar Urja Lamps distributed to students in the states of Assam, Bihar, Jharkhand, Odisha & Uttar Pradesh in villages which had more than 50% un-electrified households. Under this scheme 528 trainings conducted for local people and 7276 rural women have been trained to assemble solar lamps;

xii. Atal Jyoti Yojana have been installed across the country and 17.80 lakh solar home lights have been set up at homes and hamlets in villages;

xiii. Financing scheme developed jointly with Indian Renewable Energy Development Agency (IREDA) and Ministry of New and Renewable Energy (MNRE), to provide financial

support to Concentrated Solar Thermal (CST) projects by bundling the MNRE's subsidy and a soft loan from IREDA, thereby providing upfront access to 75% of CST project cost.

V. New Schemes

The Cabinet accorded its approval for the following new schemes:-

a) Prime Minister Development Package (PMDP) – 2015 for J&K : Scheme for setting up of 14 MW Solar PV Project with aggregate battery storage capacity of 42 MW, with capacity of 7 MW solar projects having the battery storage of 21 MWh each in Leh and Kargil at different locations in J&K.

b) Central Public Sector Undertakings (CPSU) Scheme Phase II (Central Producer Scheme) is for setting up the 12,000 MW Grid Connected Solar Photovoltaic (PV) Power Projects by the Government Producers with VGF support for self-use or use by the Governmental institutions/ agencies, either directly or through Distributing Companies.

c) Grid Connected Rooftop Solar Program Phase II is having two Components i.e., Component A for setting up of 4,000 MW of Grid Connected Rooftop Plants in residential area; and Component B for Incentives to DISCOMS based on achievement for installing additional grid connected rooftop capacity in all sectors over and above the base level, with the incentives of being limited to the first additional 18,000 MW of rooftop capacity added in the country.

d) Scheme for farmers- Pradhan Mantri- Kisan Urja Suraksha evam Utthan Mahabhiyaan

(PM-KUSUM) for installation of solar pumps and grid connected solar and other renewable power plants in the country has an aim to add solar and other renewable capacity of 25,750 MW by 2022. This

scheme has three components, namely, Component A for 10,000 MW Decentralised Ground Mounted Grid Connected Renewable Power Plants of individual plant size up to 2 MW; Component B for Installation of 17.50 lakh standalone Solar Powered Agriculture Pumps of individual pump capacity up to 7.5 HP; and Component C for Solarisation of 10 lakh Grid-connected Agriculture Pumps of individual pump capacity up to 7.5 HP.

Current Projects (includes both installed and under installation projects).

The state wise Solar Power Generation (installed and in process) capacity is shown in the Table-I. Leading efforts have been made in Gujarat where about 720 MW Solar Power generation capacity has been installed and Maharashtra is next where about 133 MW Solar Power generation capacity addition was in progress.

- Solar Cycling Track is constructed in Hyderabad having the length of 23 km which contains 16000 solar panels. It is India's first and World's second Solar Cycling Track.
- Dhanas Lake in Chandigarh is home to North India's largest floating solar power project.
- Sanchi (Madhya Pradesh) is set to be India's First 'Solar City", as it sits near the Tropic of Cancer makes it ideal for harnessing solar power, and will reduce over 14000 tonnes of Carbon Emissions annually.

STATES/ UTs	**Solar Power Generation (in MU)**
Andaman & Nicobar Islands	19.49
Andhra Pradesh	6601.74
Arunachal Pradesh	21.93
Assam	174.20
Bihar	139.53

Chandigarh	9.75
Chhattisgarh	482.98
Dadra & Nagar Haveli and Daman & Diu	24.46
Delhi	201.69
Goa	11.84
Gujarat	8215.84
Haryana	460.67
Himachal Pradesh	50.69
Jammu & Kashmir	0.00
Jharkhand	16.76
Karnataka	11363.08
Kerala	697.67
Ladakh	0.00
Lakshadweep	0.09
Madhya Pradesh	3155.93
Maharashtra	3441.24
Manipur	6.93
Meghalaya	0.00
Mizoram	2.68
Nagaland	0.00
Odisha	571.62
Puducherry	10.20
Punjab	2165.74
Rajasthan	28104.14
Sikkim	0.00
Tamil Nadu	7505.74
Telangana	5428.40
Tripura	5.49
Uttar Pradesh	2945.98

Uttarakhand	276.50
West Bengal	101.50
India	**82214.50**

Table 2: State-wise Renewable Energy Generation from Solar Power in India (2022-2023) Source: Ministry of Power, Govt. of India. 2023

VI. Challenges and Constraints

LAND SCARCITY

Per capita land availability is a scarce resource in India. The amount of land required for utility-scale solar power plants - 1 km² for every 20–60 megawatts (MW).

SLOW PROGRESS

India is now 7th in PV capacity worldwide, and 9th in Solar Thermal Systems with nations like Japan, China, and the US currently ranked far ahead.

GOVERNMENT SUPPORT

Phase I- 100 MW Rooftop (2010-13): The government has announced an allocation of Rs.10 billion towards the Jawaharlal Nehru National Solar Mission (JNNURM). It is an increase of Rs. 3.8 billion from the previous budget. 1,000 MW of grid connectivity.

Phase II - 1000 MW Rooftop (2014–2017): Cumulative target for grid-connected solar PV (including rooftop): 4,000 – 10,000 MW (for both grid connected and off grid)

Phase III -2000 MW Rooftop (2017–2022)): Cumulative target for grid-connected solar PV (including rooftop): 100 000 MW. In the present budget of 2024, The 2024-25 Interim Budget provided for a budgetary allocation of Rs 10,000 crore to solar power grid projects in FY-2025 BE from Rs 4,757 crore allocated in FY-2024 with Revised Estimates which is a huge 110 percent increase.

VII. India in the World context:

Using a three-phase approach given above, Jawaharlal Nehru National Solar mission's objective is to establish India as a global leader in solar energy, by creating the policy conditions for solar technology diffusion across the country as quickly as possible. India has been playing a leadership role in encouraging the establishment of a solar based economy across the globe. India, in partnership with France, promoted the establishment of International Solar Alliance (ISA) in 2015. In 2018, ISA was transformed into a treaty based organisation headquartered in India. India achieved 4th global position in wind and renewable power and 5th global position in solar power deployment respectively. India has already achieved its target of 40% installed electric capacity from non-fossil fuels on Nov 2021 itself. (as per International Renewable Energy Agency - Renewable capacity statistics 2023)

Solar Energy Policies in Delhi

In 2016, Delhi announced its last solar policy "Delhi Solar Energy Policy, 2016". The target of Delhi was to achieve approximately 1000 MW solar energy by 2020 from the solar rooftop but it has only achieved 230 MV which was less than 25% of the target set, according to government data. It should be made compulsory for all government buildings to install solar panels on roof space with more than 500 square metres.

In 2022, a new draft "Delhi Solar Policy, 2022" was introduced by the Delhi Government under the Department of Power with some exemplary mission. The policy of 2016 has not achieved its target of 1000 MV. The new draft targeted to have 750 MV from solar rooftop and 5250 MV from utility scale solar projects from outside Delhi totalling 6000 MV by 2025-26. Delhi Government plans to increase the share of solar energy in Delhi's annual electricity demand from the current 9% to 25% by the end of 2025. This means more solar

energy in the mix compared to traditional thermal energy.

Community Solar Rooftops in Residential Sector
They are introducing a new idea where people who don't have big enough rooftops or live in apartments can work together to install solar panels in one place. They can then share the benefits based on how much they invest. This sharing of benefits will be made possible through group net-metering or virtual metering. In simple terms, the Delhi government wants to use more solar power, both from rooftops and larger solar projects, and they want more people to be involved in using and benefiting from solar energy, even if they don't have suitable rooftops themselves. They aim to make solar energy a bigger part of Delhi's electricity supply.

The government's policy aims to help people in Delhi who want to use solar energy on their rooftops. They will assist domestic consumers by providing the Renewable Energy Service Company (RESCO) Model. Under this model, a solar company will pay for the setup of the solar system on the consumer's rooftop, and in return, the consumer will pay a fixed fee for using it. The policy also suggests a "hybrid" version of this model, which combines agreements between consumers and electricity distribution companies (discoms) with agreements between discoms and solar developers.

The Delhi government's policy also offers incentives to commercial and industrial consumers who want to generate solar power, up to a capacity of 500 megawatts for their initial installation. This is in addition to the support provided to domestic consumers. They are also providing a service where prospective consumers can get their rooftops assessed for free to see if they are suitable for solar panels. Additionally, they will create a report or scorecard called a "solar score" that tells consumers how much solar energy their rooftops could potentially generate.

Energy Transition in Delhi

LUT University, Finland researched on energy transition in Delhi. The research discovered that if the city follows effective policies, it could get the majority of its electricity from solar energy by the year of 2050. This solar power would mainly be derived from prosumers. Additionally Delhi would import renewable energy from nearby states which have a lot of renewable energy resources available like Rajasthan and Himachal Pradesh.

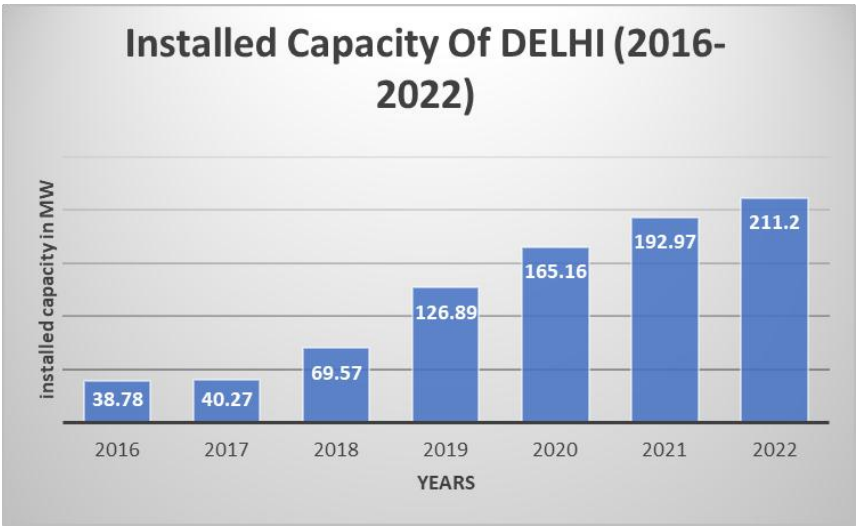

Figure 1: Installed Capacity of Delhi (2016- 2022)

Source - Ministry of New And Renewable energy

According to official data, a new target of generating 500 MV of solar energy has been set by the power department of Delhi which is more than double of current generation. It said that it produced at least 25% of the total electricity through solar plants. In 2016 the solar contribution was less than 0.3% , it has grown significantly, making up 7% of energy. Looking ahead it is expected that solar power will continue to rise and reach 11% of energy production in

the next two years. Similarly renewable energy has increased from less than 0.3% in 2016 to 15% in 2022. It is projected that this trend will continue and renewable power is expected to reach 22% of energy production in the next two years.

The New Solar policy

Delhi Solar Policy 2024 aims to put solar panels on government buildings and encourages individual homeowners, housing societies, industrial and commercial property owners, etc., to do the same. The goal is to have more than half of Delhi's energy come from solar power by 2030. The Power Department is also working on a plan for the future, called the Master Plan of Delhi 2041, which focuses on using renewable energy more and talks about how to use solar power in Delhi. This plan will try to get at least 80% of the new power from renewable sources by putting solar panels on farms, government buildings, houses, highways.

Delhi Metro Rail Corporation

Delhi Metro Rail Corporation(DMRC) is building 27 elevated metro stations under phase IV . It has future plans to install solar plants. In phase IV DMRC aims to have 10 MW of solar power generated across these metro stations, which is estimated to generate about 1 crore units of solar energy per year. Currently Delhi Metro receives 35% of its energy from renewable sources and they plan to increase this to 50% by 2031. Out of 35%, about 30% comes from solar energy generated offsite from the Rewa Solar plant in Madhya Pradesh, 4% from rooftop solar plant and 1% from waste-to-energy plant in Ghazipur.

The Largest Rooftop Solar Installation under RRTA of Delhi- Meerut Region

Regional Rapid Transit System (RRTS) DELHI - MEERUT corridor of Sarai Kale khan mega terminal will have a wide roof area, which is

more than 1500 square metres. They planned to install solar panels on this roof, and this will be the largest solar rooftop installation. It is expected that 10 MW of renewable energy could be generated from the whole project. The length of the corridor will be 82 kilometres including 16 stations and out of 16 solar will be installed at nine stations[4]. Included Sarai kale khan and Ashok Nagar in Delhi. The target has been set to generate at least 10 MW of renewable energy from the solar panel, with an aim to satisfy the need up to 40% of the total energy requirement by corridor through the renewable energy. RRTS System focuses on sustainable energy solutions including solar power, decreasing environmental impact and cost of energy.

VIII. Conclusion

Renewable Energy has started playing an increasingly important role for enhancement of grid power, providing energy access, reducing consumption of fossil fuels and helping India pursue its low carbon development path. India is a developing nation with tropical climate and 3000 hours of sunshine per year, which has surpassed the cumulative installed solar capacity, ranking fifth in global solar power development. The country has implemented large solar projects including Thar deserts best projects and Gujarat's pioneering policy. The solar rooftop systems capacity in India has been commissioned at various states and UT's. The renewable energy generation from solar power stations has the highest generation in Andaman & Nicobar Islands, Andhra Pradesh, and Gujarat. Delhi has limited land area that is why it is focusing on rooftop PV solar panels installation which receives almost 300 sunny days. It is favourable for solar panel installation. Delhi is actively working on increasing

[4]https://m.timesofindia.com/city/delhi/with-30k-sqm-of-roof-space-rrts-to-make-hay-while-the-sun-shines/amp_articleshow/93463564.cms

solar energy capacity by formulating policies and installing rooftop solar panels to overcome the limitation of ground based solar projects. There is potential for solar power in India for the future. There is a need for more efficient and sustainable energy generation systems.

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