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INDIA'S RISING SOLAR SECTOR

Solar energy is a key component for achieving the ambitious target set by Hon'ble Prime Minister for the renewable energy sector. It is expected that at least 25-30 GW of solar PV modules and equivalent capacity of the balance of materials, inverters etc will be required for the next 10 years. As we expand our solar energy capabilities, we welcome global and domestic investors to become part of our RE journey. By aligning with India's clean energy goals, they can contribute to India's energy transition.

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Amitesh Kumar Sinha
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PREFACE

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Building upon India's strong commitment towards clean sources of energy, Hon'ble Prime Minister of India, Narendra Modi, reiterated India's strides in the renewable energy sector on the occasion of the World Sustainable Development Summit 2021- "Renewable energy is picking speed in India. We are well on track to setting up 450 GW of generating renewable energy by 2030. India's private sector and several individuals are contributing to this (target)."

India's renewable energy sector provides a massive opportunity for growth. Currently, India has the fourth largest installed capacity of renewable energy in the world. But India has not stopped here and our expansion plans to install 450 GW capacity by 2030 is one of the largest globally. Solar energy capacity expansion is definitely key to achieve this plan.

In 2015, during COP21, India led the way by declaring ambitious government commitments for a New India powered by clean sources of energy, which includes 33-35 percent reduction in the emissions intensity below 2005 levels and an increase in the share of non-fossil fuels in the total installed capacity to 40 percent, by the year 2030. In fact, India has already achieved a drop of 24 percent of emissions intensity and is well on its way to achieve its targets.

Not only is the country focusing on building a New India but is also leading the coordinated efforts to build a New World powered by clean energy. International Solar Alliance (ISA) was launched by our Prime Minister and former French President François Hollande in 2015, and is the 1st intergovernmental organization to be headquartered in India.

India's geographic location is also advantageous in realizing the country's potential. India experiences high solar incidence in most parts of the country, thus, solar energy becomes one of the important pieces of the puzzle. Solar energy has a central place in the country's National Action Plan on Climate Change with National Solar Mission as one of the key Missions.

Recently, India also climbed up to the 3rd spot on the EY's 'Renewable Energy Attractiveness Index' due to its impressive performance on the solar photovoltaic front. The sector is one of key importance for India. Therefore, it presents numerous opportunities backed by strategic government support.

The Ministry of New and Renewable Energy (MNRE) is undertaking continuous efforts to encourage investments across the value chain by supporting companies through the entire investment process, quick grievance redressal, constant industry feedback and lucrative incentives. In order to incentivise manufacturing within the solar sector and localise supply chains, the government has also introduced schemes such as the Production Linked Incentive (PLI) Scheme for high efficiency Solar PV modules.

This report focuses on providing an overview of the solar sector and its growth potential for the country. It presents a range of exciting incentives, support mechanisms and opportunities presented by India. The report further showcases the vast potential and investment opportunities in the Indian solar sector.

I thank all those who have helped in bringing this report to the fore and hope that readers find it to be insightful. We invite you to come explore and invest in India's sunshine sector!

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INDIA'S RENEWABLE ENERGY SECTOR: AN INTRODUCTION

As a nation developing at an unprecedented pace, India's energy needs have been rising rapidly and consistently. In the decade ending in 2017, the country's Total Final Consumption (TFC) grew by over 50 per cent across all sectors.[1] As of 2019, at 1,285 Terra Watt Hour (TWh),[2] India is the third-largest power consumer in the world, after China and the United States of America.[3]

At the same time, India recognises the threat that conventional fossil fuels pose to the health of our climate and has committed itself to the ideals of clean energy, and sustainable and inclusive development. In the energy revolution towards renewables, India has emerged as a global leader paving the way forward in non-conventional energy production. Not only does it have ambitious goals under the Paris Climate Agreement of 2015,[4] but India has also made strides in meeting the various Sustainable Development Goals (SDG) 7 targets set by the United Nations (UN).[5] Introduced in 2015, the SDG 7 aims to 'ensure access to affordable, reliable, sustainable and modern energy for all.' In keeping with this, India has undertaken one of the largest programmes to provide universal access to energy and clean cooking gas. It is also fostering the generation and deployment of renewable energy and increasing its consumption share in the economy, while doubling the rate of energy efficiency improvements.

By 2030, India's energy demands are expected to reach 2,785 TWh.[6] Under the 'Atmanirbhar Bharat' Abhiyan, India will strive towards meeting these demands domestically. Given India's carbon emission reduction targets under various climate agreements, renewable energy will play an important role in meeting this energy requirement.

This report focuses on India's solar sector and the opportunities it presents. While underscoring the advancements in India's renewable energy sector as a whole, the report also details the strength of the solar segment and its growing presence in India. Solar energy holds tremendous potential in India and has made considerable technological advancements too. As highlighted in this report, global and domestic investors can benefit from the promises of the sector while their investments can further the development and consumer adoption of solar energy in India.

[1] https://niti.gov.in/sites/default/files/2020-01/IEA-India%202020-In-depth-EnergyPolicy_0.pdf
[2] https://data.bloomberglp.com/professional/sites/24/2020-06-26-Indias-Clean-Power-Revolution_Final.pdf
[3] https://www.business-standard.com/article/news-cm/india-presently-3rd-largest-energy-consumer-in-world-118111300715_1.html
[4] https://climateactiontracker.org/countries/india/pledges-and-targets/
[5] https://sdgs.un.org/goals/goal7
[6] https://www.brookings.edu/wp-content/uploads/2018/10/The-future-of-Indian-electricity-demand.pdf

INDIA'S RENEWABLE ENERGY TARGETS

The twin targets of increasing the generation and supply of energy to meet developmental needs and salvaging the global climate has put emphasis on the domestic renewable energy sector. By the end of 2019, India had already more than doubled its renewable energy deployment and by 2030, it is expected to account for 55 per cent of the nation's total installed power capacity.[7]

India's RE Sector at a Glance

Year	Installed RE Capacity (in GW)	% Share of RE in Total Installed Capacity	Generation from Renewable Sources (in BU*)	Total Generation from All Sources (in BU*)	% Share of RE in Generation
2014 - 15	39.55	14.36	61.78	1110.18	**5.56**
2015 - 16	46.58	15.23	65.78	1172.98	5.60
2016 - 17	57.90	17.68	81.54	1241.38	6.56
2017 - 18	69.77	20.24	101.83	1303.37	7.81
2018 - 19	78.31	21.95	126.76	1375.96	9.21
2019 - 20	87.07	23.52	138.32	1390.93	9.95
2020 - 21	92.54	24.53	111.92	1017.81	**11.00**
	(Up to Jan'21)	(Up to Jan'21)	(Up to Dec'20)	(Up to Dec'20)	(Up to Dec'20)

* BU - Billion Units = TWh

Source: Ministry of New and Renewable Energy Annual Report 2020-21[8]

[7] https://economictimes.indiatimes.com/industry/energy/power/renewables-to-account-for-55-of-energy-mix-by-2030-minister/articleshow/72020507.cms?from=mdr

[8] https://mnre.gov.in/img/documents/uploads/file_f-1618564141288.pdf

Renewable Energy Installed Capacity (2014-21)

Year (as on)	Wind (GW)	Solar (GW)	Small Hydro (GW)	Bio-power (GW)
31.03.14	21.04	2.63	3.8	8.04
31.03.15	23.3	3.7	4	8.4
31.03.16	26.7	6.8	4.27	8.59
31.03.17	32.2	12.35	4.38	9.14
31.03.18	34.1	21.7	4.49	9.69
31.03.19	35.6	28.2	4.6	10.1
31.03.20	37.6	34.6	4.69	10.2
31.03.21	39.2	41	4.8	10.2

**As per data received from MNRE (refer to Appendix I)*

Given its timely focus on the development of renewable energy, India has already made considerable inroads towards meeting its energy demands, sustainably. India's net power generation capacity increased by 212 Gigawatt (GW) in the last decade and close to 42 per cent of this addition came from renewable energy sources, including large hydro.[9] As of 28 February 2021, the country's total installed power capacity stood at about 379 GW[10], up from 358.6 GW in March 2019. Of this, the installed power capacity from renewable sources (including large hydro) accounts for about 137.3 GW.[11]

During the Paris Climate Agreement (COP 21) negotiations in 2015, India set ambitious commitments for a New India powered by clean energy sources. As indicated in its Nationally Determined Contribution (NDC) to the United National Framework Convention on Climate Change (UNFCCC), India has undertaken one of the largest renewable expansions worldwide, ramping up 80 per cent from 2015 levels. [12]

[9] https://data.bloomberglp.com/professional/sites/24/2020-06-26-Indias-Clean-Power-Revolution_Final.pdf
[10] https://powermin.gov.in/en/content/power-sector-glance-all-india
[11] https://powermin.gov.in/en/content/power-sector-glance-all-india
[12] https://mnre.gov.in/

India's RE Targets

- *India is committed to install 175 GW [100 GW Solar PV, 60 GW Wind, 10 GW Biomass and 5 GW Small Hydro] of renewable power capacity by 2022 and 450 GW by 2030.*
- *Increase the country's share of non-fossil-based installed electric capacity to 40 per cent by 2030.*
- *Reduce emissions intensity by 33-35 per cent below 2005 levels.*

India's targets build upon the 226 per cent increase in renewable energy capacity over the last five years that has provided an impetus to India's domestic renewable energy revolution.[13] Additionally, the country also ranked third on Ernst & Young's Renewable Energy Country Attractive Index 2021.[14]

In the revolution to harness clean energy, India has taken on a key global leadership role. The International Solar Alliance (ISA), launched by Prime Minister Narendra Modi and former French President François Hollande in 2015, aptly captures the scope of solar energy and India's dedication to harnessing it. The ISA, with 73 member countries, is the first intergovernmental organisation to be headquartered in India. Its goal is to lower the cost of solar technology that can help meet the energy demands of 121 sunshine-rich developing countries. It has been estimated that the Alliance's target of 1 Terra Watt (TW) solar energy by 2030 will require USD 1 Trillion (Tn) in investment.[15] Invest India, along with the World Association of Investment Promotion Agencies (WAIPA) has signed a Memorandum of Understanding (MoU) with ISA to promote and facilitate investments in solar energy for all ISA member countries.

India's commitments have been widely recognised all over the world. A 2020 survey by Climatescope[16] adjudged India the second most attractive emerging market for clean energy investment ahead of Brazil, Jordan and China. The Indian renewables sector, with around 1,500 GW potential, has also been opened to 100 per cent Foreign Direct Investment (FDI) through the direct route. Institutional investment in a clean energy future permits the sector to leverage its inherent strength and become a solution to our warming planet.

[13] https://mnre.gov.in/
[14] https://www.ey.com/en_in/news/2021/05/india-ranks-3rd-in-the-renewable-energy-country-attractiveness-index-released-by-ey
[15] https://www.nature.com/articles/d41586-018-03126-3
[16] https://global-climatescope.org/results

OVERVIEW OF INVESTMENTS IN INDIA'S RENEWABLE ENERGY

THE RENEWABLE ENERGY SECTOR RECEIVED USD 9.83 Bn FDI BETWEEN APRIL 2000 AND DECEMBER 2020.[17]

Total Investments in Renewable Energy (2014-2015 to 2019-2020)*

Year	Wind (INR crore)	Solar (INR crore)	Small Hydro (INR crore)	Bio-power (INR crore)
2014 - 15	13,800	4,400	2,000	3,600
2015 - 16	20,500	12,360	1,760	1,900
2016 - 17	33,000	22,120	880	5,500
2017 - 18	11,100	37,440	880	5,500
2018 - 19	8,880	26,120	880	4,100
2019 - 20	12,420	25,800	720	1,000

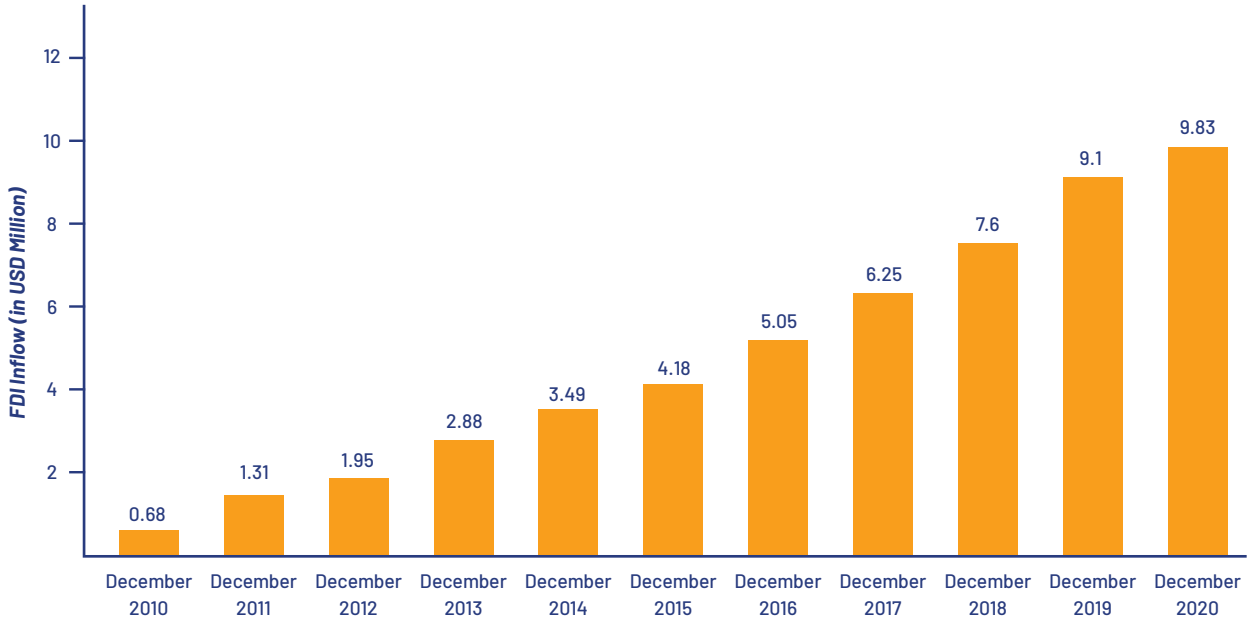
**Calculations as per following assumption from MNRE: Cost of setting up per MW (1 GW=1000 MW):*
- *Wind: INR 6 crore*
- *Solar: INR 4 crore*
- *Small Hydro: INR 8 crore*
- *Bio-power: INR 10 crore*

For year wise installations please refer to Appendix I
**USD 1 ~ INR 73.41 (on 10.05.21)*

To achieve its target of 175 GW by 2022 and 450 GW by 2030, the government of India estimates an investment of USD 30 Billion (Bn) annually, USD 100 Bn between 2019 and 2022, and USD 500 Bn over the next decade, respectively.[18] These targets require increased capital inflow from both domestic and international investors. So far, in India between 2014-2019, renewable energy programmes and projects have attracted an investment of USD 64.2 Bn (INR 4.7 lakh crore).[19]

[17] DPIIT FDI StatisticsDPIIT FDI Statistics
[18] https://economictimes.indiatimes.com/budget-2021/sectors-in-focus/energy/indian-renewable-energy-sector-will-need-investments-of-500-billion-to-meet-450-gw-target-report/articleshow/80959834.cms?from=mdr
[19] https://mnre.gov.in/img/documents/uploads/file_f-1618564141288.pdf

Cumulative FDI Equity Inflows in the Renewable Energy Sector From April 2000



Source: https://dipp.gov.in/publications/fdi-statistics

At present, wind, solar and hydro power dominate the Indian renewables segment even as the country is exploring newer sources like hydrogen, geo-thermal and ocean energies, among others. India has the fourth largest installed capacity (including hydro) in the world. We also have the fourth largest installed capacity for wind energy and the fifth largest for solar power. Between April 2014 and January 2021, the installed renewable energy capacity of India has increased 2.5 times, and the installed solar energy capacity has increased 15 times.[20] As of February 2021, India's solar capacity stands at 39 GW.[21] This implies the strength of our solar power sector and its immense potential in the near future.

[20] https://mnre.gov.in/img/documents/uploads/file_f-1618564141288.pdf
[21] https://mnre.gov.in/the-ministry/physical-progress

THE SOLAR SECTOR IN INDIA

India experiences clear sunny weather for 250 to 300 days a year.[22] This exposure to the sun is estimated to be worth 5,000 Tn Kilo Watt Hour (kWh) of energy in a year over India's land area, of which most parts receive 4-7 kWh per square metre (sq. m) each day.[23] If India were to capture even a fraction of this energy potential, it could far exceed the energy demands of the country. Given India's long sunny days and prevalent clear weather conditions, solar energy holds tremendous potential in and for India. As a pollution-free clean energy with zero emissions, successful harnessing of solar power can be India's answer to rural electrification, rapid urbanisation and grid -decentralisation, not to mention its contribution to replacing planet warming fossil fuel-based energy production.

Incident energy of 5,000 Tn kWh per year; most parts receive 4-7 kWh per sq. m per day

National Institute of Solar Energy assessed the solar potential of about 749 GW assuming 3% of the waste land area to be covered by Solar PV modules[24]

Most parts of country experience 300 sunny days

[22] http://164.100.94.214/solar-rpo#:~:text=In%20most%20parts%20of%20India,GWh%20of%20energy%20per%20year
[23] https://mnre.gov.in/solar/current-status/
[24] https://mnre.gov.in/solar/current-status/

ADVANCES IN THE INDIAN SOLAR SECTOR

With a view 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," the Jawaharlal Nehru National Solar Mission was launched in January 2010 under the National Action Plan on Climate Change (NAPCC).[25] The initial target of installing 20 GW of grid-connected solar power plants by 2022 has since been revised to 100 GW by the end of the scheduled period. The Mission recognised that solar power has the power of enabling decentralised distribution of energy, thereby empowering people at the grassroots.[26]

Remarkable advances are being made both in increasing on-grid capacity and off-grid installation. In 2015, Kerala's Cochin International Airport became the first fully solar powered airport in the world. The airport's solar power plant produces 50,000 to 60,000 units of electricity per day that covers all its operational functions.[27] In September 2016, India commissioned the Kamuthi solar power project in Tamil Nadu within a record eight months, making it one of the world's largest single location solar power projects with a capacity of 648 Megawatt (MW).

Between 2014 and 2019, the number of solar pumps installed, at 2.25 lakh, was 19 times higher than those installed before 2014 (11,626). Tariffs on solar power reduced by over 75 per cent using the plug and play model.[28] As of February 2021, the solar installed capacity stands at 39 GW.[29] In 2019 alone, India installed 7.3 GW of solar power across the country,[30] which is approximately 18 per cent of the total installed solar capacity.[31]

SOLAR PARKS

The Ministry of New and Renewable Energy (MNRE) launched the Development of Solar Parks and Ultra Mega Solar Power Projects scheme in December 2014. At least 25 Solar Parks and Ultra Mega Solar Power Projects with over 20,000 MW (20 GW) total installed solar power capacity were to be set up under this scheme, within a span of five years starting 2014-15. In 2017, the government revised these targets upwards, from 20,000 MW to 40,000 MW, to be met by 2021-22. The goal of the scheme is to facilitate and accelerate the installation of grid connected solar power projects for electricity generation on a large scale.[32] The scheme intends to extend support to Indian states and union territories in setting up solar parks across the country and creating the requisite infrastructure to gradually transition to clean energy.

[25] https://mnre.gov.in/img/documents/uploads/file_f-1597797108502.pdf
[26] https://www.seci.co.in/upload/static/files/mission_document_JNNSM(1).pdf
[27] https://cial.aero/Pressroom/newsdetails.aspx?news_id=360
[28] https://mnre.gov.in/the-ministry/physical-progress
[29] https://energy.economictimes.indiatimes.com/news/renewable/india-installed-7-3-gw-of-solar-power-in-2019-report/75448977
[30] https://energy.economictimes.indiatimes.com/news/renewable/india-installed-7-3-gw-of-solar-power-in-2019-report/75448977
[31] https://www.timesnownews.com/india/article/indias-biggest-floating-solar-power-plant-with-100-mw-capacity-to-be-set-up-in-telangana-by-may/731424
[32] https://mnre.gov.in/solar/schemes

As of December 2020, 42 solar parks with a cumulative 26.8 GW had been approved.[33] With an investment of USD 2.5 Bn, a 2 GW capacity solar park has been set up in Karnataka. Bhadla Solar Park in Rajasthan with a capacity of 2.2 GW was commissioned in January 2020. In July 2020, Prime Minister Narendra Modi inaugurated the Rewa solar power project in Madhya Pradesh that has a generation capacity of 750 MW.[34] Later in December 2020, the PM also inaugurated India's largest renewable energy generation park in Kutch, Gujarat that has a generation capacity of 30 GW.[35]

Solar Parks in India

[33] https://mnre.gov.in/img/documents/uploads/file_f-1618564141288.pdf
[34] https://indianexpress.com/article/explained/rewa-solar-power-plant-madhya-pradesh-features-components-explained-6500673/
[35] https://energy.economictimes.indiatimes.com/news/renewable/gujarat-to-get-indias-largest-renewable-energy-generation-park/79713728

SOLAR CITIES

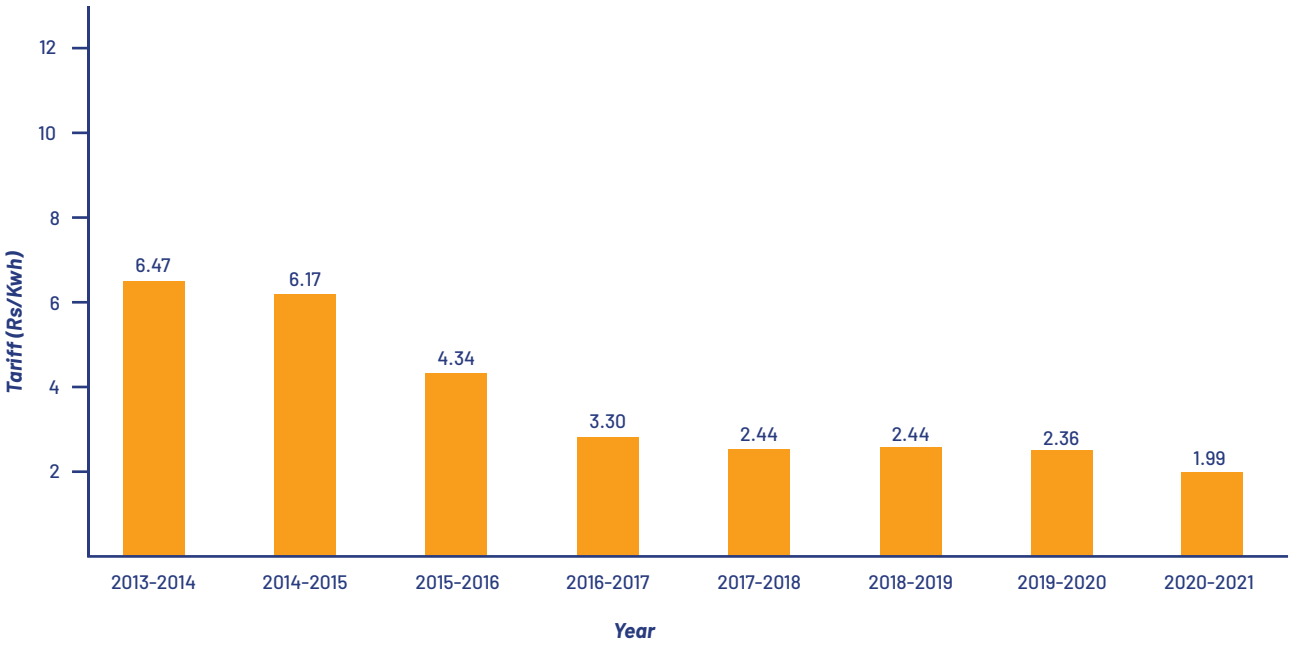
The Development of Solar Cities Programme was launched in 2014 with an aim to reduce urban dependence on conventional energy demand by 10 per cent within five years. The programme has since been revised so that at least one city from each state is developed as a solar city. All renewable energy needs of the city will be met from RE sources, primarily solar energy while all houses in the solar city will have rooftop solar energy plants. Solar cities will also have solar street lights and waste to energy plants. Balance energy needs will be met by ground mounted solar plants.

AWARDING SOLAR DEVELOPMENT PROJECTS IN INDIA

Solar power development projects are awarded in India through a reverse bidding tender process. Government tenders in solar energy projects are released **by the Solar Energy Corporation of India** (SECI) and by the respective state government departments.

At present, solar tariffs in India are very competitive and have achieved grid parity; they will further continue to drop. The Gujarat Urja Vikas Nigam Limited's (GUVNL) (Phase XI) auction in December 2020 for 500 MW of solar projects set a record for the lowest (L1) solar tariffs in India recorded at INR 1.99 (~USD 0.0270)/kWh.vvv

Solar Tariffs in India 2013-2021



*List of recent tenders can be found in the appendix.

Source: MNRE Annual Report 2020

HARNESSING INDIA'S SOLAR MANUFACTURING CAPABILITIES

In view of the ambitious targets set up by the Indian prime minister for the renewable energy sector, India is well on its way towards strengthening its non-conventional energy sources. While India is ramping up its solar energy production, domestic manufacturing of solar components was amiss from the Indian renewable energy scenario. The Indian solar industry was majorly dependent upon imported solar cells and modules since the inception of the National Solar Mission in 2010.

In 2018, the government, in order to support and provide a push to domestic solar manufacturing, had imposed a safeguard duty which was recently extended by the government for another year starting 30 July 2020. A duty of 14.9 per cent was imposed from 30 July 2020 to 29 January 2021, and 14.5 per cent from 30 January 2021 to 29 July 2021, for all solar cells whether introduced in panels or modules, imported from China, Thailand, and Vietnam.

With this scenario in the solar industry, by March 2020, India had already deployed about 87 GW of renewable energy projects whereas about 64 GW additional capacity was under various stages of bidding or installation.

This is where the situation stood when the coronavirus outbreak disrupted global supply chains.

In March 2020, once the lockdown was implemented and restrictions were heightened for protection against the Covid-19 virus, the entire supply chain across the world went into disarray. These restrictions significantly affected the renewable energy sector, since it was majorly dependent on imports, especially from China.

These crossroads offered an excellent opportunity for the government of India in rejigging past plans for making India self-sufficient in the manufacturing of solar cells and modules, and batteries and ancillary equipment. In this way, India decided to curb its import dependency and save tremendous foreign exchange.

Significantly, in an address to the nation on 12 May 2020, the prime minister issued a clarion call for 'Vocal for Local'. The PM emphasised the importance of a new ***Atmanirbhar Bharat***, or a self-reliant India where manufacturing domestically would become a vehicle to achieving the goal.

KEY GOVERNMENT INITIATIVES

As the need to adopt solar technologies across the country becomes more urgent, the government of India has undertaken numerous initiatives to promote solar manufacturing and adoption. Key initiatives are highlighted here:

- ***Production Linked Incentive Scheme***
  In early April 2021, the cabinet, chaired by Prime Minister Narendra Modi, approved the Ministry of New and Renewable Energy's proposal for increasing domestic manufacturing of solar photovoltaic panels under the Production Linked Incentives (PLI) Scheme that, last year, was extended to 13 crucial sectors of the Indian economy. MNRE's 'National Programme on High Efficiency Solar PV (Photo Voltic) Modules' aimed at achieving manufacturing capacity of GW scale in high efficiency solar PV modules has an outlay of USD 616 Mn (INR 4,500 crore).

  Solar PV manufacturers will be selected through a transparent competitive bidding process. PLI will be disbursed for five years post commissioning of solar PV manufacturing plants, on sales of high efficiency solar PV modules. Manufacturers will be rewarded for sourcing from domestic markets and for achieving higher efficiencies in solar PV modules. Thus, the PLI amount will increase with increased module efficiency and increased local value addition.

  At present, the solar PV manufacturing segment in India is still in its very nascent stages. Manufacturers are largely import dependent in their pursuit to develop India's domestic solar manufacturing sector. As India hopes to become more self-reliant, the PLI scheme will be crucial in helping the country reduce dependence in a crucial sector like electricity and also to attain its goal under the ***Atmanirbhar Bharat*** initiative. By incentivising domestic manufacturers, MNRE hopes that India will open access for foreign investors into the Indian market and make India a global supplier of solar photovoltaic modules.

- ***Schemes with Domestic Content Requirement (DCR)***
  The solar power projects under the 12000 MW Government Producers Scheme (CPSU Scheme), the KUSUM Scheme and the new Rooftop Scheme are mandated to source their requirement of solar cells and modules from domestic sources, in a World Trade Organisation (WTO) compliant manner.

- Tenders for setting up solar PV manufacturing capacities in India linked with assured offtake in the form of Power Purchase Agreements (PPAs) for solar power plant.

- **Approved list of Models and Manufacturers (ALMM) of solar photovoltaic cells and modules:** The order provides for enlistment of eligible models and manufacturers of solar PV cells and modules complying with the Bureau of Indian Standards (BIS) and publish it in a list called the "Approved List of Models and Manufacturers" (ALMM). Only the models and manufacturers included in this list will be eligible for use in government/ government assisted projects/ projects under government schemes and programmes, installed in the country. This includes projects set-up for sale of electricity to government under guidelines for tariff based competitive bidding process for procurement of power from grid connected solar PV power projects dated 3 August 2017.

- The **duty** on solar inverters has been increased to 20 per cent (up from 5 per cent earlier), and the duty on solar lanterns has been increased to 15 per cent (up from 5 per cent earlier).

- MNRE finalised the new **Basic Customs Duty (BCD)** on solar PV cells and modules. The Ministry has notified a 25 per cent BCD on solar PV cells and 40 per cent duty on solar modules without grandfathering of bid-out projects. The proposed date of implementation of the new duty cycle is April 1, 2022.

With the focus shifting towards manufacturing in India, India has already achieved a 3GW/ year manufacturing capacity for Solar PV Cells and a 10 GW/year solar PV module manufacturing capacity. With the strong focus and push on India's solar manufacturing, the detailed list of solar component capacities and clusters in India are mentioned in the appendix.

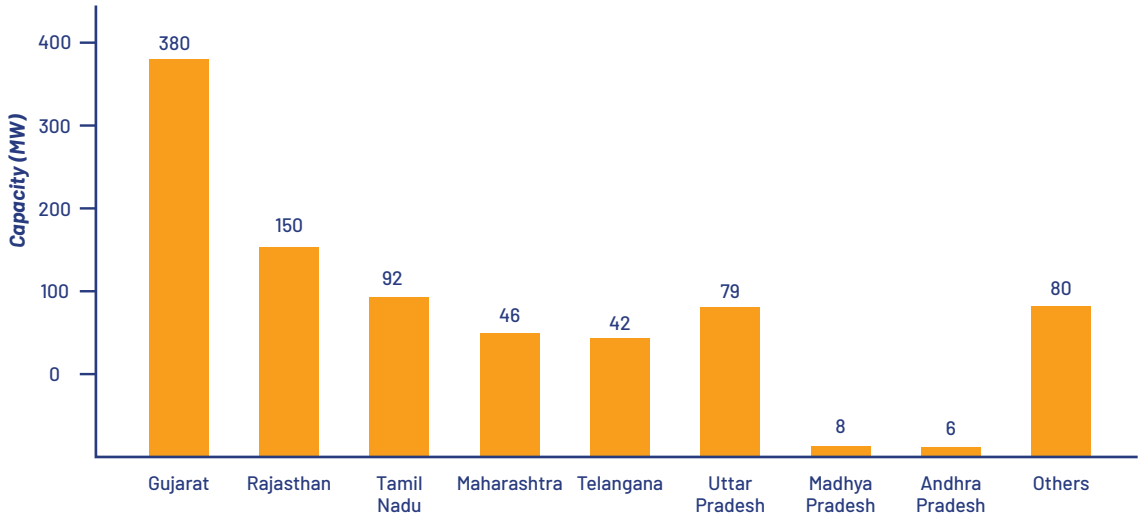
LOCALISING SOLAR POWER: INDIA'S ROOFTOP SOLAR SECTOR

India has set an ambitious path to achieve 100 GW of its energy capacity by 2022, through grid-connected solar energy, out of which 40 GW is expected to come from rooftop solar installations.[37]

Given the strong focus on achieving clean energy sources in the country, considerable efforts have been undertaken by the government, regulatory commissions and other relevant agencies to further develop the rooftop solar photovoltaic sector in India. The basic framework has now been setup in the country and implementation of rooftop solar power plants has started in its true sense.

Despite the Covid-19 related lockdown, the installed capacity of India's rooftop solar segment grew to a total of 4,324 MW by February 2021.[38] In terms of highest rooftop installations, Gujarat ranks first with 380 MW capacity addition, contributing nearly 43 per cent of the total rooftop installations in the first nine months of 2020, followed by Rajasthan (150 MW) and Tamil Nadu (92 MW).[39] The detailed state-wise rooftop solar capacity installation trends are shown in the chart below:

State-wise Rooftop Solar Capacity Addition in India (Jan 2020 - Sep 2020)



Source: MNRE, JMK Research

[37] https://energy.economictimes.indiatimes.com/energy-speak/india-s-rooftop-solar-sector-a-success-story-but-challenges-remain/2465
[38] https://mnre.gov.in/the-ministry/physical-progress
[39] https://jmkresearch.com/despite-covid-19-india-added-883-mw-of-rooftop-solar-capacity-in-the-first-nine-months-of-2020/

Over the period of 2020-2025, the Indian rooftop solar market is expected to grow at a Compounded Annual Growth Rate (CAGR) of more than 25 per cent with factors such as rising environmental concerns, favourable government policies, incentives and tax benefits for solar panel installation, and high cost of grid expansion especially in rural areas.[40] Additionally, increased government focus and advancement in technology has led to a reduction in the cost for manufacturing solar panels, while increased efficiency has also been a major factor for the growth of the Indian rooftop solar market.

The rooftop solar PV systems provide multi fold benefits:

- Highly adaptable for use on vacant rooftops due to the modular nature of the solar PV.
- Reduced land and interconnection costs.
- Higher tariffs for the developer due to increasing commercial and industrial tariffs lead to increased profitability.
- Assists Distribution Companies (DISCOMs) by reducing the peak demand during daytime.
- Decreases Transmission and Distribution (T&D) losses since the power is consumed at the point of generation. More than 10,000 Mega Unit (MU) of electricity will be saved through avoidance of T&D losses in 2022 alone if 40 GW rooftop PV is achieved.[41]
- Commercial benefits in avoiding investments in transmission system.
- Offers the benefits of modern electricity services to households with no access to electricity, reduces electricity costs on islands and in other remote locations that are dependent on oil-fired generation.
- Enables residents and small businesses to generate their own electricity.

Within the solar rooftop industry, commercial and industrial systems remain the largest segment because their electricity tariffs are relatively higher than other sectors and they also have a relatively stable load profile during the day that can enable larger savings on electricity bills, depending on the policy scheme in place.

However, considering the targets committed by India including at the international forums with respect to rooftop solar photovoltaic plants, there is still tremendous scope and opportunity presented by the segment.

[40] https://www.mordorintelligence.com/industry-reports/india-rooftop-solar-market
[41] https://energy.economictimes.indiatimes.com/energy-speak/india-s-rooftop-solar-sector-a-success-story-but-challenges-remain/2465

Some of the key players in this market include:

CLEANTECH SOLAR

TATA POWER SOLAR

AMPLUS SOLAR WITH YOU AT THE CORE

FOURTH PARTNER ENERGY

GROWATT

EXTENDING INDIA'S SOLAR NETWORK: OFF-GRID SOLAR PRODUCTS

In contrast to on-grid solar systems, which are the most commonly found solar power systems, off-grid solar power generation is one where the user is not connected to the local utility grid. Whereas in an on-grid solar system, excess energy generated is sent back to the grid, in an off-grid solar system, a generator must provide for back-up batteries that can store the excess solar energy.

Off-grid solar power production is among the oldest programmes run by the MNRE. Its aim has been to provide energy in areas where grid power is either unavailable or impossible. The programme covers applications such as solar home lighting systems, solar street lighting systems, solar power plants, solar pumps, solar lanterns and solar study lamps, among others.[42]

Targets for power production in off-grid solar systems have been maintained since the National Solar Mission was launched in 2008. They have been consistently revised upwards in each phase of the mission; under Phase-III, the most recent phase, a target of 118 MW was set for off-grid and decentralised solar PV applications. In this phase, off-grid solar power projects of individual sizes up to 25 Kilo Watt (kW) may also be installed in areas where grid power is unreliable or absent.[43] This does not include solar pumps, which are to be installed under the PM KUSUM scheme, which will solarise existing grid connected agricultural pumps. Solar home lighting is also being pursued under the 'Saubhagya' Scheme of the Ministry of Power.

More recently, MNRE issued guidelines for the implementation of off-grid solar power projects under the renewable energy service company model, or RESCO, a zero-investment model in which the consumer pays only for the electricity generated, while the solar system is owned by the developer.

Despite a push towards electrification in the country, especially under the government of Prime Minister Modi, India has remained a leading consumer of standalone solar products. In 2018, the country represented over 30 per cent of the global volume share of sales in the sector as per a report published by GOGLA and the World Bank Group's Lighting Global program. It also remains the largest market for portable lanterns.[44]

[42] https://mnre.gov.in/solar/solar-offgrid
[43] https://mnre.gov.in/solar/solar-offgrid
[44] https://sun-connect-news.org/fileadmin/DATEIEN/Dateien/New/report_india_and_the_solar_standalone_market_sizing_in_india_web_opt.pdf

At present, the Indian market is driven primarily by the government while private players have gradually, over the last ten years, increased their presence. Decreasing prices of products (due to reduced costs of components and economies of scale) has helped private players expand their footprint and increase revenues through sales. By 2023, the private market is estimated to reach a market value between USD 206 Million (Mn) and USD 327 Mn.[45]

Cumulative off-grid installed systems

	Up to 31.12.2020
Lanterns and Study Lamps (No.)	78,30,685
Home Lights (No.)	17,23,479
Street Lights (No.)	8,13,132
Solar Pumps (No.)	2,72,700
SPV Plants (MWp)	216.4

Source: MNRE Annual Report 2020

[45] https://sun-connect-news.org/fileadmin/DATEIEN/Dateien/New/report_india_and_the_solar_standalone_market_sizing_in_india_web_opt.pdf

CUTTING EDGE TECHNOLOGY IN INDIA'S SOLAR SECTOR

The solar industry in India is booming and growing at a tremendous pace. In addition to the traditional solar products and technology, recently there have been some exciting innovations in the space. While some upcoming technologies such as floating solar and battery storage have already made strides, a few innovations are just brewing up in the ecosystem.

Battery Storage:

With a rise in the need for solar energy, storage would play a vital role in ensuring the flexible operations of power systems. India, with its ambitious renewable energy targets, is already shifting its focus towards storage-based projects to tackle the intermittency of the power generated through clean energy sources.

India's energy storage market was worth USD 2.1 Bn in 2019,[46] which translates to 230 GWh[47] during the 2020-27 period. This coupled with the increased focus of the government in achieving its 2022 target of 100 GW solar capacity and 60 GW capacity of wind power will propel the energy storage market in India. By 2040, India is touted to become the largest market for utility scale energy storage.[48]

The government of India is playing a catalytic role in establishing and developing the energy storage market in India. Piggybacking on government measures to boost adoption of renewable energy in India, energy storage is poised to grow as a promising field for foreign investors looking to leverage India's clean energy ecosystem. Between 2018 and 2020, storage tenders of 169 Mega Watt Hour (MWh) capacity have been issued by the government. In addition to this, SECI has released two more solar tenders with 3,900 MWh of storage capacity.[49] The government of India will also invest around USD 2.4 Bn over the next five years to support the manufacturing of Advance Chemistry Cell (ACC) batteries to help both domestic and international players set up operations in India.

[46] https://ces-ltd.in/india-stationary-energy-storage-market-is-set-to-double-its-annual-capacity-additions-before-2027/#:~:text=The%20market%20overview%20report%20estimates,for%20projections%20is%202020%2D27.
[47] https://indiaesa.info/resources/industry-reports/3106-india-stationary-energy-storage-market-overview-report-2020-2027#:~:text=India%20Energy%20Storage%20Alliance%20(IESA,applications%20making%20up%20the%20rest.
[48] https://timesofindia.indiatimes.com/business/india-business/india-to-be-worlds-largest-market-for-battery-storage-by-2040-iea/articleshow/78668180cms#:~:text=NEW%20DELHI%3A%20India%20will%20become,to%20the%20International%20Energy%20Agency.
[49] https://jmkresearch.com/storage-tenders-of-169-mwh-capacity-issued-in-last-one-year-in-india/

Floating Solar:

Floating solar plants refer to the deployment of photovoltaic panels on the surface of water bodies. The floating solar systems are designed to overcome land acquisition issues and open new and exciting opportunities for the sector. The floating solar technology has started gaining attention worldwide and the annual capacity addition is expected to reach 4.6 GW by 2022 from 1.1 GW in 2018.[50]

In addition to addressing land acquisition issues, floating solar systems also provide a cooling effect that improves the performance of the panels by 5-10 per cent. Reduced grid interconnection costs, improved water quality, reduced water evaporation and algal blooming are some of the other benefits of floating solar systems.[51]

Expected to generate power by 2022-23, the world's largest floating solar energy project is being constructed in Madhya Pradesh. The 600 MW project will be located at the Omkareshwar dam on Narmada River in Khandwa district of Madhya Pradesh. It has an estimated investment of USD 408 Mn (INR 3,000 crore). The International Finance Corporation, the World Bank and Power Grid have granted in-principal consent for providing aid for the development of this project.[52]

Additionally, a second floating solar project has been commissioned by the National Thermal Power Cooperation (NTPC) will be hosted at the Ramagundam thermal power plant reservoir near Peddapalli distric in, Telangana. With an estimated cost of USD 57.64 Mn (INR 423 crore, the project has a capacity of 100 MW and is expected to become operational shortly. The project is set to have 450 thousand photovoltaic panels covering 450-acre area of the reservoir with the possibility of future expansion.[53]

As reported by NTPC, the MahaRatna company is planning to set up more floating solar projects across all thermal power plants in India:[54]

a) 92 MW floating unit at Kayamkulam gas plant in Kerala,

b) 25 MW unit at Simhadri power plant, and

c) 230 MW ground-mounted solar power plant in Ettayapuram near Tuticorin, Tamil Nadu.

[50] https://bridgetoindia.com/report/floating-solar-opportunities-and-way-ahead/
[51] https://www.drishtiias.com/daily-updates/daily-news-analysis/india-s-biggest-floating-solar-power-plant#:~:text=India's%20biggest%20floating%20solar%20power%20plant%20by%20generation%20capacity%20(100MW,in%20Peddapalli%20district%20of%20Telangana.
[52] https://energy.economictimes.indiatimes.com/news/renewable/worlds-largest-floating-solar-project-to-start-in-mp-by-2023-state-govt/80125623
[53] https://www.thehindubusinessline.com/companies/ntpc-to-commission-indias-largest-floating-solar-power-plant-at-ramagundam-by-may/article34034626.ece
[54] https://www.timesnownews.com/india/article/indias-biggest-floating-solar-power-plant-with-100-mw-capacity-to-be-set-up-in-telangana-by-may/731424

Innovations:

1. Dual Axis Solar Tracking

To profit from the sun's continuously changing position through the year, a dual rotating axis has been developed for the PV modules to move from east to west and north to south simultaneously. This allows the solar panel to angle itself so as to maximise the incidence of solar radiation.

2. Solar Coating

Solar panels are constantly exposed to natural elements like rain and wind. This leads to dust accumulation on the surface of the panel that lead to reduction in efficiency. Multifunctional thin films or coatings combat this by enhancing self-cleaning, anti-reflection, anti-fogging and energy transmittance properties of solar panels.[55]

3. Geometric patterns

Researchers at Northwestern University have developed an algorithm based geometric pattern that enhances energy trapped in thin or organic solar cells. Using geometric patterns results in a three-fold increase over a thermodynamic limit reached at in the 1980s that statistically describes how long a photon can be trapped in a semiconductor.[56]

4. Uninterrupted Power Supply (UPS) with Solar Power

Uninterruptible power supply (UPS) allows electricity-operated objects like solar panels to continue running during an emergency. Solar charged batteries and battery backups may also be used to store excess solar power for later use.[57]

5. High Temperature Solar Technologies

Experimental Solar Furnace for High Temperature Chemistry, a method to converge foci, generated by multiple lenses has been developed. Such convergence of multiple foci leads to generation of ultra-high temperatures with extremely high flux densities in a comparatively small area, leading to greatly reduced re-radiation (T^4) losses. Methods to convey gases and solids through such foci, that lead to enhanced throughputs in the system have been invented. A 1 KW proof of concept has demonstrated temperatures above 2,200 degree Celsius at heat rates of 300 Deg/Sec.

[55] https://www.sciencedirect.com/science/article/abs/pii/S0927024818304574
[56] https://www.sciencedaily.com/releases/2013/01/130125111358.htm
[57] https://gosolargroup.com/backup/uninterruptible-power-supply-ups-with-solar-facts/#

GOVERNMENT POLICIES: STATE AND CENTRAL

GOVERNMENT IMPETUS

The government of India, in conjunction with state governments, provides various incentives for the development of solar power and other renewable energy sources. In addition to funding numerous subsidies and capital tax incentives, the government has undertaken the following steps to boost India's renewable energy sector.

1. Production Incentives

a. The government recently announced **Production Linked Incentives (PLI)** worth USD 606 Mn (INR 4,500 crore) for domestic manufacturing of high-efficiency solar PV modules over a period of five years.[58]

b. Domestic Content Requirement (DCR)

c. Tenders for setting up solar PV manufacturing capacities in India linked with assured offtake in the form of PPAs for solar power plant.

d. **Approved list of Models and Manufacturers (ALMM)** of solar photovoltaic cells and modules.

e. **Wind-Solar Hybrid National Policy** was launched in May 2018. As of December 2020 capacities of 1.4 GW of wind-solar hybrid projects are under implementation in Rajasthan and Tamil Nadu.

f. In 2020, the central government approved setting up an **Empowered Group of Secretaries (EGoS) and Project Development Cells (PDCs)** in each ministry and department within the government. The EGoS and PDCs will attract and facilitate investments into India.

g. A total of USD 1.1 Bn has been allocated towards setting up 50 solar parks with a total generating capacity of 40 GW by 2021-22; 42 parks with 26.8 GW have already been approved as of December 2020.

h. Financial support will be extended to renewable energy industries for undertaking research and development in association with technology institutions.

i. Private sector companies will be given an allowance to establish enterprises to operate as license or generating companies.

[58] https://www.pib.gov.in/PressReleasePage.aspx?PRID=1710113

j. Under the Smart Cities Mission, provision must be made for rooftop solar manufacturing capacity and at least 10 per cent of energy must be generated renewably.

k. Renewable Purchase Obligation (RPO): All electricity distribution licensees must purchase or produce a specified minimum quantity of their total requirements from renewable energy sources.

2. Fiscal Incentives

a. MNRE and the Ministry of Finance have finalised the new **Basic Customs Duty (BCD)** on solar PV cells and modules. They have notified a 25 per cent BCD on solar PV cells and 40 per cent duty on solar modules without grandfathering of bid-out projects. The proposed date of implementation of the new duty cycle is April 1, 202v2.

b. To promote domestic production and build domestic capacity, duties on solar inverters have been increased to 20 per cent (up from 5 per cent earlier), and the duties on solar lanterns have been increased to 15 per cent (up from 5 per cent earlier).59

c. The centre has waived inter-state transmission charges for both solar and wind energy.

d. Facilities for promotion of export-oriented units of the renewable energy industry.

e. A 100 per cent FDI is permitted in the renewable sector under the automatic route.

3. Disincentivising Fossil Fuels

a. Solar and wind power have been classified under 'white category' for easier environment clearances.

b. Clean Energy Fund: Clean Energy Cess, later renamed as the Clean Environment Cess, introduced in February 2010, imposes a cess on coal, lignite and peat. In 2016, the cess was increased to USD 5.45 (INR 400) per tonne.

c. To enhance adoption of renewable energy, the Indian Railways announced that 960 railways stations have solar installations in place to meet their power requirements. Indian Railways has set a target of 100 per cent electrification by 2023.

d. Green Energy Corridors: Launched in 2015, the Green Energy Corridor aims at synchronising energy produced from renewable sources with conventional power stations in the grid. The project has been implemented in eight renewable energy rich states Tamil Nadu, Rajasthan, Karnataka, Andhra Pradesh, Maharashtra, Gujarat, Himachal Pradesh and Madhya Pradesh for the evacuation of over 20,000 MW of renewable power. The project is being implemented in these states by their respective State Transmission Utilities (STUs).

[59] https://www.investindia.gov.in/team-india-blogs/back-growth-union-budget-2021-22-announcement-renewable-energy

CENTRAL GOVERNMENT SCHEMES:

1. Grid Connected

a. Development of Solar Parks and Ultra Mega Solar Power Projects

b. Scheme for setting up of over 5000 MW Grid-connected SPV power projects under IV of JNNSM PHASE-II

c. Scheme for setting up of over 5000 MW Grid connected Solar PV Power projects in Andaman and Nicobar and Lakshadweep Islands with Capital Subsidy from MNRE

d. Central Public undertaking (CPSU) Scheme Phase-II (Government Producer Scheme) for setting up 12,000 MW grid-connected Solar Photovoltaic (PV) Power Projects by the Government Producers with Viability Gap Funding (VGF) support for self-use or use by Government/Government entities, either directly ot through Distribution Companies (DISCOMs)

e. Grid Connected Solar Rooftop Programme

2. Off-grid

a. Off-grid and Decentralised Solar PV Applications Programme- Phase III

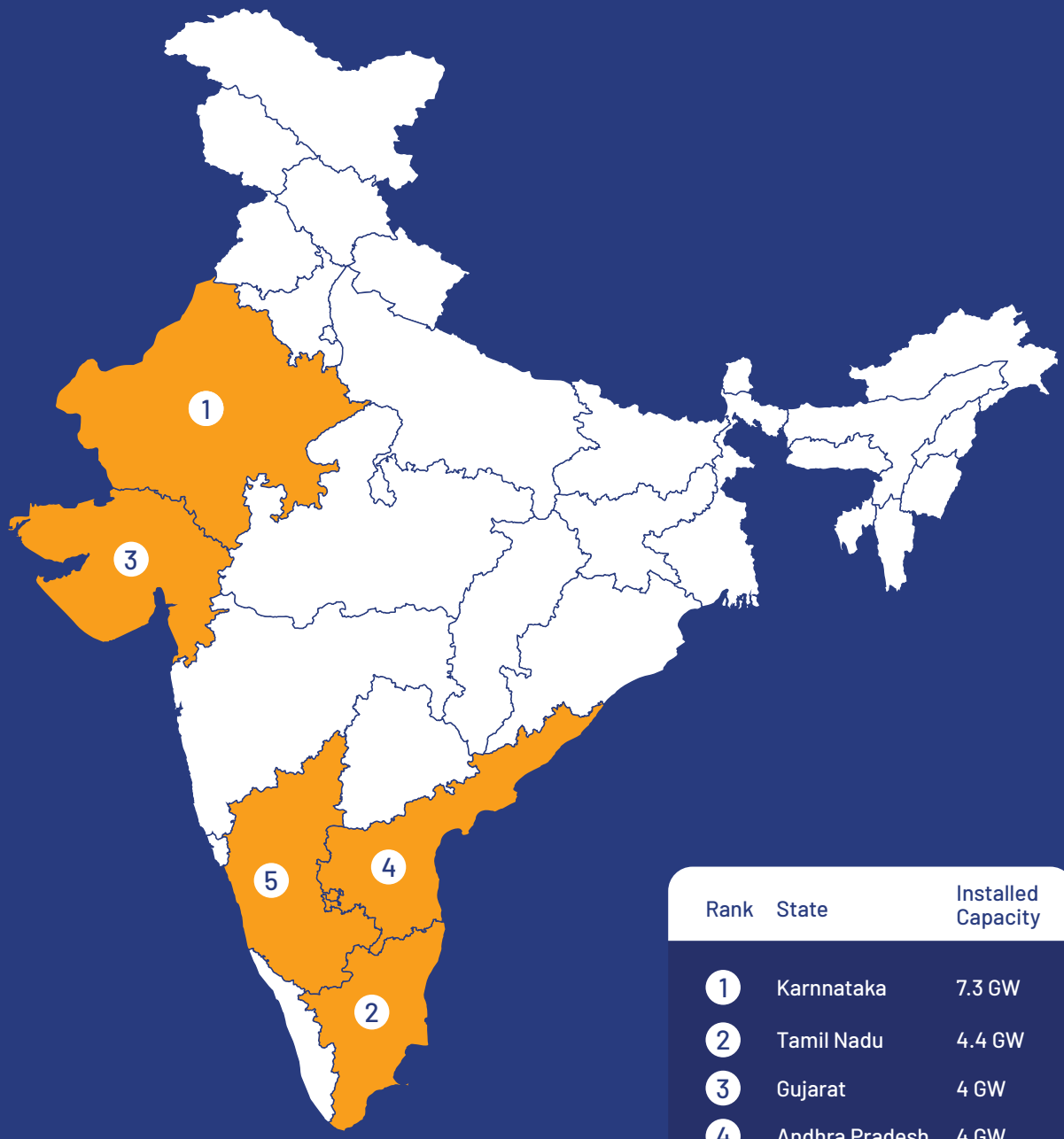
b. Pradhan Mantri Kisan Urja Suraksha evam Utthan Mahabhiyan (PM KUSUM)

c. Atal Jyoti Yojana (AJAY): Phase II

d. Scheme on "Scale Up of Access to Clean Energy for Rural Productive Uses"

e. Seven Million Solar Study Lamp Scheme for School Going Children

The 5 States with Highest Installed Capacity



Rank	State	Installed Capacity
1	Karnnataka	7.3 GW
2	Tamil Nadu	4.4 GW
3	Gujarat	4 GW
4	Andhra Pradesh	4 GW
5	Rajasthan	5.4 GW

(As of 28.02.21)

STATE GOVERNMENT SCHEMES

Karnataka

	Karnataka Industrial Policy (KIP), 2020
Capital Subsidy	**MSME*:** Subsidy covering 75% of cost of Effluent Treatment Plants (ETP) (up to INR 60 lakh or ~USD 0.82 Mn). **Large Units:** 50% of cost of ETP (up to INR 2.5 crore or ~USD 0.340 Mn) and 50% of cost of common ETP (up to INR 5 crore or ~USD 0.681 Mn). **Parks:** 50% of cost of secondary treatment plant (up to INR 1 crore or ~USD 0.136 Mn)
Electricity Duty	**MSME:** 100% exemption for up to 7 years in Zone 1 and for up to 6 years in Zone 2. There is no exemption in Zone 3.
Land	**MSME:** Micro and Small Enterprises (MSME) in private industrial parks at 25% of guidance value (up to 1 acre) in Zone 1 and 2 only; reimbursement of land conversion fee.
Tax Reimbursement	Production turnover-based incentives based on percentage of value of fixed assets. Varies for MSMEs, large units and parks depending on zones.
Skill Upgradation	**MSMEs:** Support to artisans: 4% interest on term loans and working capital Loans; 10% market development assistance on turnover of handicrafts; 75% of grant for machineries and tools for artisan associations, etc.
Stamp Duty Exemption	**MSMEs:** 100% exemption on loan agreements and mortgages (up to 5 years), Lease, Lease-cum-Sale, absolute sale deed (from selected industrial enterprises) in zone 1 and 2; **Large Units:** 100% exemption in zone 1 and 75% in zone 2; 100% exemption in all zones for private industrial parks.
Mega Investment	Greater than INR 250 crore (~USD 35-40 Mn)
Special Incentives	50% of total installed capacity is renewable, second largest solar park – globally, eligible for all KIP subsidy in this policy, except Investment Promotion Subsidy.

*Micro, Small and Medium Enterprises

Rajasthan

	Rajasthan Solar Energy Policy 2019, Rajasthan Incentive Promotion Scheme 2019
Capital Subsidy	For enterprises making an investment equal to or above INR 10 crore (~USD 1.36 Mn) in solar equipment sector: **(i)** 5% interest subsidy on term loan taken by enterprise from financial institutions or state financial institutions or banks recognised by Reserve Bank of India, for making an investment in plant and machinery, for a period of five years subject to a maximum of INR 25 lakh (~USD 34,063) per year; or **(ii)** For manufacturing units: capital subsidy equivalent to 20% of investment made on the plant and machinery, subject to a maximum of INR 50 lakh (~USD 68,096). **(iii)** Mega units: 125% of eligible fixed capital investment as approved by the appropriate screening committee.
Electricity Duty	**1.** 100% exemption for 10 years **2.** Enterprises making an investment equal to or above INR 10 crore (~USD 1.36 Mn) in solar equipment sector: Exemption from payment of electricity duty for additional three years. **3.** The electricity consumed by the power producer for captive use within state to be exempted from payment of Electricity Duty for 7 years from COD.
Land	Land allotment at 50% concessional rate in industrial area/any other area
Tax Reimbursement	Investment subsidy on SGST to solar energy equipment manufacturers: 90% of SGST due and deposited for seven years. Enterprises making an investment equal to or above INR 10 crore (~USD 1.36 Mn) in solar equipment sector: 25% additional investment subsidy of state tax due and deposited for seven years.
Skill Upgradation	1. Reimbursement of 90% of contribution paid for employees for 7 years 2. Enterprises making an investment equal to or above INR 10 crore (~1.36 Mn) in solar equipment Sector: 25% additional employment generation subsidy in the form of reimbursement of employers' contributions, subject to upper limit of 75% employment generation subsidy for any employee, towards employees EPF and ESI for seven years.
Stamp Duty Exemption	100% exemption
Mega Investment	Greater than INR 100 crore (~USD 13.6 Mn) and direct employment of 200 persons.

Tamil Nadu

	Tamil Nadu Industrial Policy 2021
Capital Subsidy	**For Large, Mega and Ultra-Mega Projects:** 10% to 25% of Eligible Fixed Assets (EFA) based on project category and district category of the location. OR Flexible Capital Subsidy: Category A district: Up to 35% of EFA Category B district: Up to 37 % of EFA Category C district: Up to 40% of EFA Additional capital subsidy of up to 7.5% of EFA for Mega and Ultra-Mega Projects for "A" Districts, or Large, Mega and Ultra-Mega Projects for "B" & "C" Districts. OR Turnover Based Subsidy: For Mega & Ultra Mega Projects creating employment greater than 2,000: Based on district category, subsidy can range between 1% to 2%. Sub-Large projects eligible for a back-ended capital subsidy of INR 1 crore (USD 0.14 Mn). upon the completion of the investment within the standard investment period of 4 years. Sub-Large Projects in "C" Districts: Fixed Capital Subsidy of 5% of EFA upon the completion of the investment.
Electricity Duty	Electricity tax exemption for a period of 5 years on power purchased from the Tamil Nadu Generation and Distribution Corporation Ltd. (TANGEDCO) or generated and consumed from captive sources.
Land	**SIPCOT A & B Districts:** 10% concessional rate and for C Districts: 50% concessional rate for land up to 20% of EFA. **For FDI:** private land in "C" districts, 50% subsidy will be offered on cost of land as per guideline value up to an extent of 50 acres and subject to land cost not exceeding 20% of EFA and a cap of INR 1 crore (USD 0.14 Mn), at least 70% of the land is used for manufacturing operations.
Tax Reimbursement	SGST Refund: Net SGST reimbursement for goods manufactured, sold and registered in Tamil Nadu subject to a limit of 100% of EFA on a case-by-case basis. OR Special capital subsidy: 5% - 15% of EFA on a case-to-case basis.
Skill Upgradation	Six month training subsidy INR 4,000 (~ USD 54.5) per month per worker who are residents of Tamil Nadu. INR 6,000 (~USD 81.7) per month for women and transgender employees, persons with benchmarked disabilities, persons from SC/ST communities.
Stamp Duty Exemption	100% concession on Stamp duty for land obtained from SIPCOT.
Mega Investment	Mega: INR 500-5,000 crore (~ USD 68.1 Mn 681 Mn) and investment of 4 years
Special Incentives	**Interest Subvention:** 5% rebate in the rate of interest to ultra-mega projects subject to ceiling limits for large, mega and ultra-mega projects. **Quality certifications incentive:** subsidy of 50% of the total cost incurred, as certified by the chartered accountant, limited to INR 25 lakh (USD 34.07 thousand) for the period of investment. Intellectual Property Creation Incentive: 50% of cost; maximum INR 30 lakh (USD 40.89 thousand)

Gujarat

	Gujarat Industrial Policy- 2020
Capital Subsidy	(Excluding land) solar equipment manufacturing is a thrust sector covered in three categories. Category 1: 12% of Fixed Capital Incentive (FCI); Category 2: 10% of FCI; Category 3 Taluka: 6% of FCI.
Electricity Duty	Exemption for five years.
Land	Government to lease government land to industrial enterprises for up to 50 years (extendible) at 6% of market rate.
Skill Upgradation	State will provide fiscal support in setting up skill development anchor institutes, specialised skill development centres, and skill upgradation centres etc. The state will also give incentives for skill enhancement up to INR 15 000 (~USD 204)
Stamp Duty Exemption	100% exemption
Special Incentives	Assistance up to 25% of project cost for set up/ relocation / retrofitting of existing polluting industrial units into Green Industrial Estates: up to INR 25 Crore (~USD 3.4 Mn). Special incentives to companies who relocate from other countries. Interest subsidy to be provided to MSMEs who switch to solar power. MSMEs can bank solar energy at INR 2.25/unit rate (~USD 0.031). Additionally, interest subsidy will be provided on term loan to existing industries that switch to solar power.

Andhra Pradesh

	Industrial Policy
Capital Subsidy	Investment subsidy of 15% on FCI limited to INR 20 lakh (~USD 27 thousand) for MSEs. The subsidy will be released only after three years of continuous operation with at least 80% efficiency in all parameters like employment, production etc.
Electricity Duty	Electricity duty shall be exempted for captive consumption, sale to DISCOM(s) and third-party sale provided the source of power is from solar power projects setup within the state.
Land	Priority allotment of government land in solar parks on long term lease basis. Acquired land will be charged conversion fee of 25% (up to INR 10 lakh or USD 13.6 thousand) and will be given non-agricultural land status.
Tax Reimbursement	Net SGST: 100% reimbursement for 10 years, up to 100% of FCI.
Skill Upgradation	The state will set up 30 skill development centres and two skill development universities.
Stamp Duty Exemption	100% reimbursement
Mega Investment	Mega: >INR 500 crore (>USD 72.0 Mn) Projects with direct employment generation of 2,000.
Special Incentives	Interest subsidy of 3% on the term loan taken for fixed capital investment by new Micro and Small enterprises for 5 years from the date of commencement of commercial production. State, in collaboration with the central government/MNRE/Ministry of Power/multilateral agencies, will take measures to enable gradual replacement of conventional pump sets to solar powered pump sets through subsidy support. Cross subsidy surcharge shall be exempted for third party sale provided the source of power is from Solar Power Projects (SPP) setup within the State for a period of five years from the date of commissioning of the SPP.

Telangana

	Telangana State Solar Policy 2015
Electricity Duty	Electricity duty shall be exempted for captive consumption, sale to DISCOMS and third-party sale in respect of all solar projects set up within the state. Also, electricity duty will be waived for the new manufacturing facilities and ancillaries of the solar power projects.
Land	1. Exemption from land ceiling act. 2. Deemed conversion of non-agricultural land status.
Tax Reimbursement	100% refund of VAT/SGST for all inputs for solar power projects for a period of five years.
Skill Upgradation	Surya Mitra Skill development centres will impart required training and development. Telangana State's Skill Development Mission in general and the Telangana State Accelerated SSI Skills Training (T-ASSIST) programme of the Industries and Commerce Department will aid in skill development of youth and skill upgradation of existing employees.
Stamp Duty Exemption	100 % refund of Stamp Duty for land purchase.
Mega Investment	Projects with an investment of over INR 200 crore (~USD 27 Mn) in plant and machinery or those generating employment of more than 1000 persons.

CONCLUSION

India's ambitious renewable energy targets under various international agreements have set the stage for a country-wide revolution towards clean energy. As the threat of climate change causing conventional energy sources mounts, the push towards other sources has become yet more pressing. This, coupled with India's need for greater electrification to meet its consumer and growth demands, has primed the country for an expansion of its renewable energy programmes. This immediacy has brought solar energy—found easily and abundantly in India—to the forefront of this transformation.

India has various government programmes aimed at expanding its prominent solar programmes, and the central and state government incentives that enable this expansion. This report discusses in detail multiple solar energy production methods most common in India. Apart from grid connected solar systems, this includes rooftop solar systems, off-grid solar energy production, floating solar energy, and various other emerging technologies in the solar energy manufacturing sector. Aided by India's solar manufacturing clusters and supporting policies, Indian solar sector provides ample opportunities for investments to global investors.

As India embarks on a long journey towards 100 per cent electrification and clean energy exploitation, solar energy (and other renewable energy sources) will pave the way for years to come. Solar energy, given India's geographic location, is available in most parts of the country for nearly 300 days. This holds immense untapped potential for India's goals. With the rapid expansion of on-grid and off-grid solar power manufacturing under diverse government programmes and a rising consumer interest in the potential of solar energy, India can edge closer to its goals. This expansion can be aided by investors for whom various investible segments of the solar sector have been highlighted.

APPENDIX

I. Year Wise Installations (in GW)*

	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20
Wind	21.04	2.3	3.42	5.5	1.86	1.48	2.07
Solar	2.63	1.1	3.09	5.53	9.36	6.53	6.45
Small Hydro	3.8	0.25	0.22	0.11	0.11	0.11	0.09
Bio Energy	8.04	0.36	0.19	0.55	0.55	0.41	0.10
Total	35.51	4.03	7.02	11.32	11.89	8.53	8.71

II. Previously Issued Tenders for Solar Projects

S No.	Organization	Title	Deadline	Tender Link
1	Rajasthan Electronics and Instruments Limited	Supply of Solar Cell 5.64-Watt Mono PERC Technology	13.05.21	https://eprocure.gov.in/eprocure/app?page=FrontEndTenderDetailsExternal&service=page&tnid=661665https://eprocure.gov.in/eprocure/app?page=FrontEndTenderDetailsExternal&service=page&tnid=661665
2	Rajasthan Electronics and Instruments Limited	Installation-Commissioning with 5 years maintenance period Grid connected SPV Power Plant(s) at Rooftop of various buildings in Rajasthan from regular/ approved vendors	17.05.21	https://eprocure.gov.in/eprocure/app?page=FrontEndTenderDetailsExternal&service=page&tnid=662342
3	SECI	RfS for Setting up of 1785 MW Grid-Connected Solar PV Power projects in Rajasthan (Tranche-IV)	21.05.21	https://www.seci.co.in/Error-404.aspx?404;https://www.seci.co.in:443/view/publish/view/publish/tender/details?tenderid=53454349303030303435
4	Maharashtra State Electricity Distribution Company (MSEDCL)	Long Term bids for Procurement of 500 MW Solar power (Phase VI)	04.06.21	https://www.mahadiscom.in/supplier/wp-content/uploads/2021/05/1.-NIT.pdf
5	Maharashtra State Electricity Distribution Company (MSEDCL)	Long Term bids for Procurement of 500 MW Wind-Solar Hybrid power	08.06.21	https://www.mahadiscom.in/supplier/wp-content/uploads/2021/05/NIT.pdf

Source: MNRE, 2021

III. Solar Manufacturing Clusters*

Component	Company	Location	Capacity (if available)
Solar Cells	Tata Power Solar	Bangalore, Karnataka	300 MW
	Moser Baer	Noida, UP	185 MW
	RenewSys	Hyderabad, Telangana	130 MW
	Jupiter Solar	Baddi, HP	280 MW
	Indosolar	Noida, UP	~200 MW
	Websol Solar	Falta, West Bengal	280 MW
	BHEL	Bangalore, Karnataka	105 MW
Backsheet	Garware Polyster	Aurangabad and Nashik, MH	-
	Polycomm Associates	Daman, Daman and Diu	-
	RenewSys	Bangalore, Karnataka	3 GW
	Shingi Urja	Silvassa, Dadra and Nagar Haveli	1.8 GW
	Vishakha Renewables	Mundra, Gujarat	1.5 GW
Tempered Glass	Gujarat Borosil	Bharuch, Gujarat	180 tonnes/day - to expand to 400 tonnes/day by 2020
	Allied Glasses	Meerut, UP	-
	Birkan Engineering	Ghaziabad, UP	-
	GSC Toughened Glass	Noida, UP + Navi Mumbai, MH	-
	Pvoltaic	Mundka, New Delhi	-
	Sktuff Glass	Noida, UP	-
Encapsulant	Allied Glasses	Meerut, UP	80L sq.m per annum
	Brij Encapsulants	Bahadurgarh, Haryana	-
	Lucent CleanEnergy	Ahmedabad, Gujarat	-
	RenewSys	Bangalore, Karnataka	1.4 GW
	Shauri Solar Private	Secunderabad, Telangana	-
	Sunlink PV	Pune, MH	23 Mn sq.m per annum
	Vishakha Renewables	Mundra, Gujarat	1.2 GW

Source: Boston Consulting Group (BCG), 2020

IV. Solar PV Technologies*

Technologies	Percentage Occupied	Comments
Polycrystalline	70%	Higher prevalence in India due to cheaper cost and suitability for harsher temp. profile
Monocrystalline	30%	-
Others	< 1% (However new projects expect to push this up to 5% in next 2-3 years)	-

V. Solar Module BOM and Manufacturing Clusters*

Components	HSN Codes	% Cost weightage	Manufacturing concentrations
Solar Cells	85414011	55%	Noida, Gujarat, Maharashtra, Karnataka
Tempered Glass	70071900	8%	Distributed - no concentration observed as materials are not specialized like Cells
Backsheet	No code observed: encompassed in the codes 3920 and 3921 Some key codes observed: - 39206290 - 39201099 - 39209919 - 39219099	4%	
Encapsulant - EVA Film	No code observed: encompassed in the codes 3920 and 3921 Some key codes observed: - 39209999 - 39201099 - 39219099	4%	
Aluminium Frame	Multiple codes: - 85419000 - 76169990 - 76041020 - 76109090	6%	
Solder Wire	83113090	2%	
Silver Paste	71069290	2%	
Silicone Sealant	Multiple codes: - 35061000 - 35069999 - 32141000 - 35069190	4%	

Source: BCG, 2020

Components	HSN Codes	% Cost weightage	Manufacturing concentrations
Junction Box with Cable	Multiple codes: - 85369030 - 85359040	6%	Distributed - no concentration observed as materials are not specialized like Cells
Packaging Box	85414090	5%	
Flux	29029090	2%	

*Source: BCG, 2020

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