

The Rooftop Solar Commercial & Industrial Market in India

Emerging trends and opportunities in the market since July 2020

Jyoti Gulia, Founder, JMK Research & Analytics
Kapil Gupta, Manager, JMK Research & Analytics
Prabhakar Sharma, Consultant, JMK Research & Analytics
Vibhuti Garg, Director - South Asia, IEEFA



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Key Findings

According to industry estimates, fiscal year (FY) 2024 will see the largest installations of rooftop solar to date of about 4 gigawatts (GW). Out of this, 2GW has already been installed between April and July 2023.

Micro, small and medium enterprises (MSME) remain largely untapped for their rooftop solar potential, currently pegged at around 15GW.

To spur activity in the rooftop market, regulators are actively exploring innovative business models, such as Virtual net metering and peer-to-peer trading.

According to JMK Research-IEEFA's analysis, states like Gujarat, Andhra Pradesh and Telangana, and the union territory of Delhi, have the most favourable ecosystems for setting up rooftop solar projects. States like Tamil Nadu and Uttar Pradesh continue to discourage their high-paying C&I consumers from shifting to rooftop solar-based solutions.



Executive Summary

India's rooftop solar market is bubbling with new energy, even though there are major roadblocks. The country is likely to add a record-high 4 gigawatts (GW) of rooftop solar power capacity in fiscal year (FY) 2024, half of which has already been installed in the first four months, according to industry estimates. While the market for large creditworthy commercial & industrial (C&I) customers for rooftop solar is saturated, micro, small and medium enterprises (MSMEs) offer a large untapped potential. We believe the next phase of growth in the rooftop solar market will come from the MSMEs. Financers have only now started to develop products to cater to the segment. But, they continue to see rooftop solar as a risky investment. We also see the need for state-level policies to support rooftop solar. Although Gujarat, Andhra Pradesh, Telangana and the union territory of Delhi are leading the way, many others need to create an environment that supports rooftop solar through policies as well as approvals by electricity distribution companies (DISCOMs). We note that some regulators have started exploring new and innovative business models like virtual net metering and peer-to-peer trading to spur activity in the rooftop solar market, as these business models are beneficial to both consumers and DISCOMs.

Rooftop solar is an important market segment of India's solar sector. It comprises on-site solar installations connected in a behind-the-meter (BTM) configuration on the consumer's premises. It provides buyers a viable option to green their electricity consumption by procuring on-site cheaper and cleaner renewable energy.

JMK Research and IEEFA's previous work in this segment provides details about the evolution of this sector.¹ This report attempts to capture recent market trends that have shaped this sector, especially in the last two years, new regulatory updates across central and state levels, new financing trends, and innovative business opportunities that can spur activity in the rooftop commercial and industrial (C&I) segment.

According to the Ministry of New and Renewable Energy (MNRE), as of July 2023, the cumulative installed capacity of rooftop solar in India was 10.9 gigawatts (GW). This represents a share of around 15% of the total solar installations in India. Until fiscal year (FY) 2019, rooftop solar installations in India were a meagre 1.8GW. Since then, the rooftop solar market has consistently grown by around 1.9-2.2GW annually. According to industry estimates, FY2024 will see the largest

¹ JMK Research and IEEFA. [Powering Up Sunshine – Untapped Opportunities in India's Rooftop Solar Market](#). July 2020.

installations to date of about 4GW. Out of this, 2GW has already been installed between April and July 2023.²

According to JMK Research-IEEFA's analysis, states like Gujarat, Andhra Pradesh and Telangana, and the union territory of Delhi, have the most favourable ecosystems for setting up rooftop solar projects. Conducive net metering policies, ease of regulatory approvals and potential monetary savings that a C&I consumer can realise by adopting rooftop solar influence a state's attractiveness. States like Tamil Nadu and Uttar Pradesh continue to discourage their high-paying C&I consumers from shifting to rooftop solar-based solutions.



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As part of India's overarching National Solar Mission, the government envisioned the installation of 100GW of solar capacity by 2022. Out of this, 40GW was assigned to rooftop solar. To achieve the 40GW target, the central government launched two phases (in 2015 and 2019) of the Grid-Connected Rooftop and Small Solar Power Plants Programme. The programme provided incentives through central financial assistance (CFA) to install rooftop solar plants.

Despite the government's efforts, by the end of 2022, only 8.1GW had been installed, according to data from the MNRE. This massive shortfall (around 80%) in the target forced the MNRE to extend the timeline of Phase-II of the programme by more than three years to March 2026.

There are several major roadblocks hindering the growth of the rooftop solar market in India. These include regulatory issues, such as inconsistent net metering policies across states. Net metering is a crucial parameter that influences the financial viability of a rooftop solar plant. Fearing loss of revenue from their high-paying C&I consumers, certain state electricity distribution companies (DISCOMs) sometimes delay the net metering approval or fail to provide approval altogether.

In some states, the implementation of Green Open Access Rules, 2022 shifted the market attention for solar development from rooftop solar to open access (OA), leading to state regulators prioritising OA approvals over rooftop solar.

In addition to regulatory concerns, financing continues to be a major challenge for the rooftop solar market. Compared to other solar segments (utility-scale and OA), leading financiers generally perceive rooftop solar plants to be riskier investments. Loans for rooftop solar installations generally carry a higher interest rate and have longer approval times, ultimately defeating the purpose of installing rooftop solar, which has a better rate of return and low payback period.

² MNRE

To spur activity in the rooftop solar market, regulators are actively exploring new and innovative business models, such as virtual net metering and peer-to-peer (P2P) trading.

Through virtual net metering, consumers at different locations can aggregate and source rooftop solar power from a single, large solar plant. Virtual net metering can help bridge the gap between utility-scale and rooftop solar installations as it helps consumers set up large-sized installations by taking advantage of economies of scale.

In P2P trading, consumers in the same DISCOM jurisdiction can trade excess solar power. Providing an alternative to net metering, this model ultimately allows energy consumers to become energy prosumers.

Despite accounting for around half of the industrial electricity consumption in India, micro, small and medium enterprises (MSME) remain largely untapped for their rooftop solar potential, which is currently pegged at around 15GW.³ The lack of adequate financing avenues for MSMEs is the key reason for this situation. However, MSMEs have recently undergone an evident yet gradual behavioural shift towards green energy. To address this demand, several rooftop solar financiers are formulating MSME-focused lending plans and allowing them collateral-free loans.



The onus is now on policymakers and regulators to develop solutions to accelerate deployment in the rooftop solar segment in India.

Of all the solar market segments in India, rooftop solar has historically remained a laggard. The onus is now on policymakers and regulators to develop solutions to accelerate deployment in the rooftop solar segment in India. Some of the solutions that they can consider are:

- Create separate renewable purchase obligations for decentralised renewable energy systems, which can include rooftop solar.
- Permit BTM systems across states irrespective of sizing constraints. Once recognised, this segment can help DISCOMs accurately forecast their load schedule and will be key to achieving the government's 40GW rooftop solar target by 2026.
- Have uniform regulatory provisions across states. Blanket guidelines and rules for the rooftop solar market issued by a central authority, similar to the Green Open Access Rules, will be hugely beneficial.
- Strictly enforce solar procurement targets so that state and central regulators can facilitate the adoption of rooftop solutions by MSMEs.

With the right policies and support, it is possible to unlock the massive potential of rooftops across India.

³ Financial Express. [Why MSMEs are hesitant in embracing non-conventional energy sources like rooftop solar](#). April 2022.

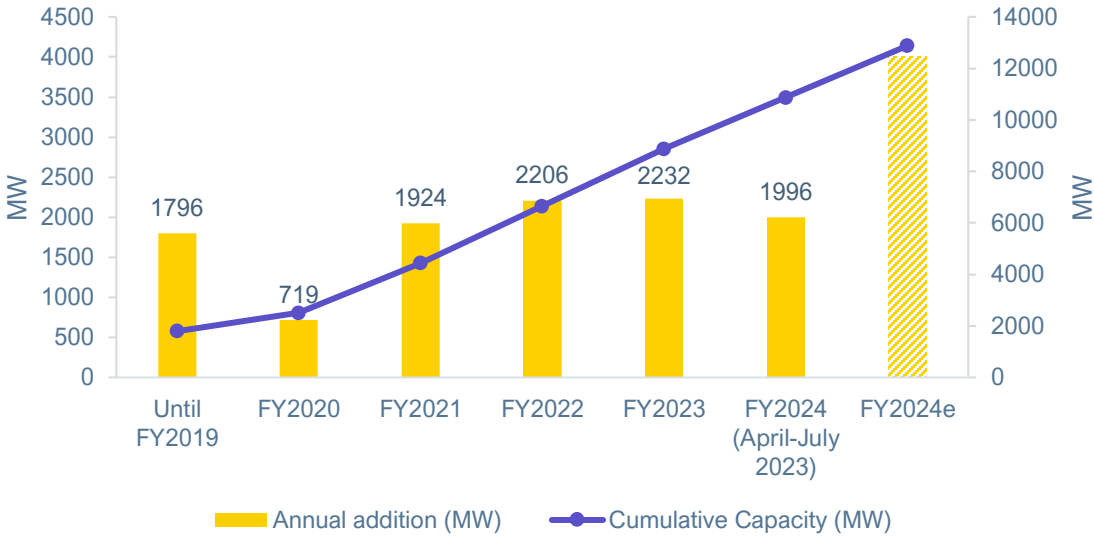
Introduction

India’s total installed capacity of grid-connected rooftop solar plants as of 31 July 2023 was 10.9 gigawatts (GW).⁴ Of this, more than 75% or approximately 8.4GW, was installed between April 2021 and July 2023.

Until the fiscal year (FY) 2019, the total installed capacity of rooftop solar in India was a meagre 1.8GW. Since then, India has seen an annual installed capacity addition of 1.9-2.2GW, with cumulative installations reaching 8.1GW by the end of 2022. In the April-July 2023 period, about 2GW was added, which was a record high for any such period.

According to industry estimates, rooftop solar installations in FY2024 will likely reach a record high of around 4GW. This growth can be attributed to the easing prices of solar modules, the partial deferment of the Approved List of Models and Manufacturers (ALMM) until March 2024 and an increase in domestic module manufacturing capacity.

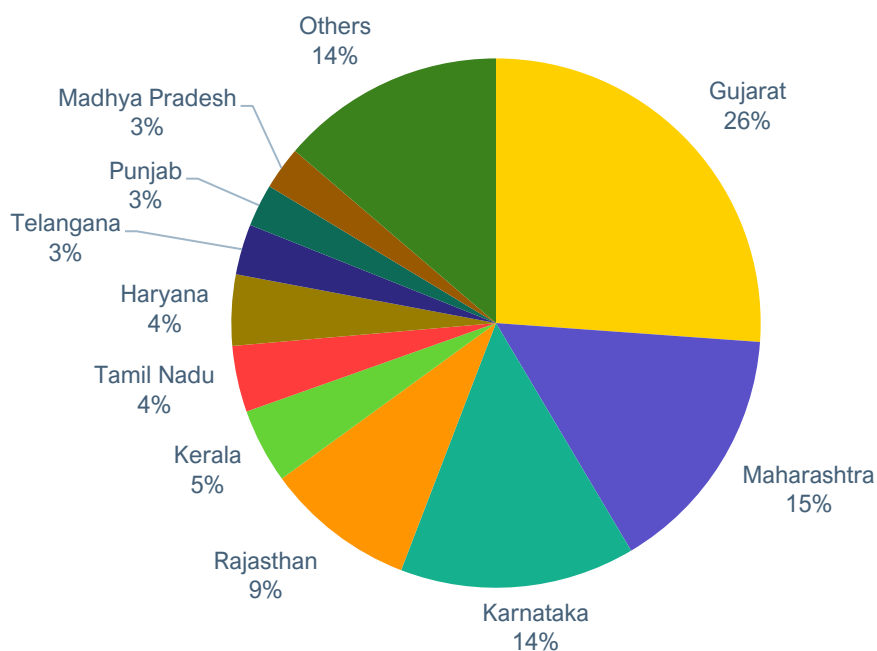
Figure 1: Grid-connected Rooftop Solar Installation Trends in India



Source: MNRE

In terms of states, Gujarat leads the way with a 26% share. Gujarat’s success story is due to its favourable policies and other initiatives that Gujarat’s electricity distribution companies (DISCOMs) have introduced in the last few years. Maharashtra (15%), Karnataka (14%), Rajasthan (9%) and Kerala (5%) have also added significant capacity of grid-connected rooftop solar plants. The top 10 states comprise around 86% of India’s rooftop solar installations.

⁴ MNRE

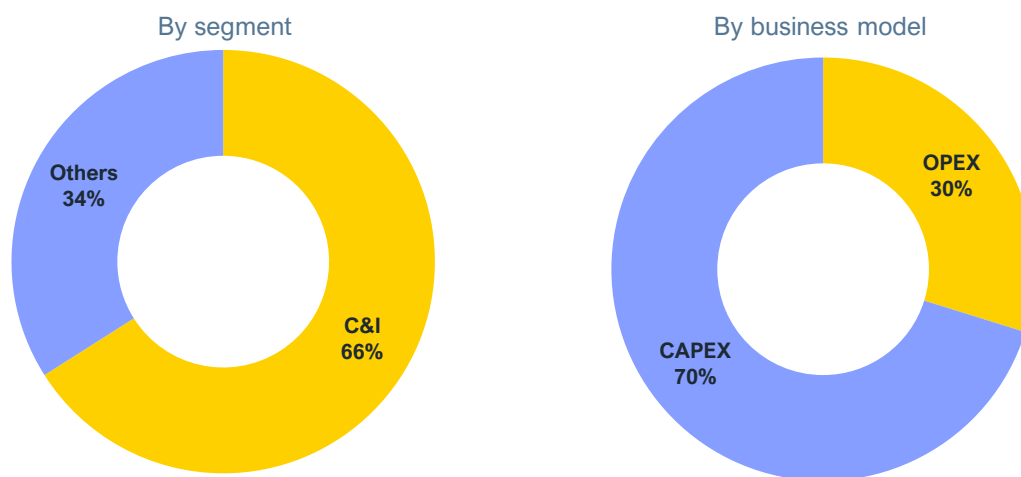
Figure 2: State-wise share in rooftop solar installations (as of 31 July 2023)

Source: MNRE, JMK Research

In terms of consumer segments, commercial and industrial (C&I) consumers added the bulk (~66%) of rooftop solar capacity in India. The other 34% of rooftop solar installations are in residential and government buildings. The lack of consumer awareness, the dearth of suitable financing options and regulatory issues around net metering have hindered the uptake of rooftop solar in the residential segment.

Regarding the split by different business models,⁵ the capital expenditure (CAPEX) model is more prevalent, with around 70% additions. The primary reasons for the smaller operating expenditure (OPEX) share are the substantial contractual and payment risks that project developers encounter because of a lack of creditworthy C&I consumers.

⁵ For further information about business models and other details about the rooftop solar market, readers can refer to IEEFA-JMK Research's previous work on this market segment: [Powering Up Sunshine – Untapped Opportunities in India's Rooftop Solar Market](#).

Figure 3: Breakup of Rooftop Solar Installations (as of 31 March 2023)

Source: JMK Research

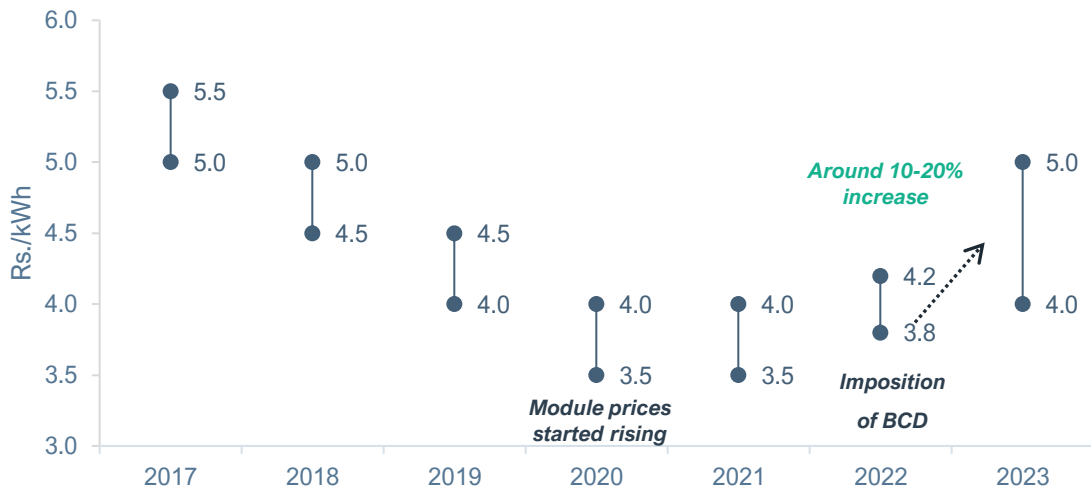
Note: The category of 'Others' includes residential and governmental rooftop solar installations.

Tariff Analysis and Payback

In 2019, photovoltaic (PV) modules cost around Rs19.5/Watt-peak (Wp) (US\$24/Wp). After the government levied a 40% basic customs duty (BCD) on solar modules in April 2022, the prices increased to Rs25/Wp (US\$30/Wp)⁶ by 2023. The price increase affected rooftop solar project costs as well as solar tariffs.

⁶ JMK Research

Figure 4: Year-wise Tariff Trends for OPEX-based Power Purchase Agreement (PPA) Rooftop Projects (March 2023)



Source: Industry Interviews, JMK Research

For installations under CAPEX mode, with a rise in project costs, the payback period also increased across states by six to 12 months. This will likely come down soon as module prices have again started reducing because of falling polysilicon prices globally.

Figure 5: Payback Period of Industrial Solar Installations in the CAPEX Model in India (March 2023)



Source: JMK Research

Note: The cost considered for per kW of rooftop solar installation is Rs50,000. Grid tariff taken from tariff order of respective states.

Policy Updates

India has vast solar energy potential. Policies formulated for the sector play a major role in tapping into that potential. The central government and various state governments have announced several new initiatives and policies in the last two years that will impact the next phase of growth of the rooftop solar market in India. In this section, we discuss some of these policies at the central and state level.



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Central Level

Grid-Connected Rooftop Solar Programme Extended until March 2026

On 30 December 2015, the central government approved the first phase of the Grid-Connected Rooftop and Small Solar Power Plants Programme. The programme aimed to install 4,200 megawatts (MW) of rooftop solar capacity in the country by 2019-20, with 2,100MW planned through central financial assistance (CFA) and the remaining without CFA. State nodal agencies (SNAs), the Solar Energy Corporation of India (SECI), public sector undertakings (PSUs) and other governmental agencies have implemented the rooftop solar projects sanctioned under this programme.

The major issues that plagued the first phase were the involvement of multiple tendering agencies and stakeholders, lack of uniform regulations and lack of consumer awareness. In 2019, the central government approved Phase II of the programme to achieve a cumulative rooftop solar capacity of 40GW by 2022.⁷

However, Phase II achieved only 8.1GW of installations until December 2022, around a 79% shortfall of the 40GW target.⁸ The shortfall forced the Ministry of New and Renewable Energy (MNRE) to extend the timeline for Phase II until March 2026. It granted the extension without adding to the originally approved outlay of Rs118 billion (US\$1.43 billion). The programme's extension will enhance the potential to achieve the 40GW target by March 2026 and present an opportunity to achieve the central government's target of 500GW renewable energy capacity by 2030.

⁷ MNRE. [Operational guidelines for implementation of Phase-II of grid connected rooftop solar programme](#). August 2019.

⁸ JMK Research

Launch of National Portal for Rooftop Solar

In 2022, the MNRE issued a simplified procedure for installing rooftop solar plants for residential consumers. It developed a national portal to implement this procedure and launched it on 30 July 2022. The portal acts as an e-marketplace where consumers, vendors and representatives of banks providing loans can interact. It also serves as an educational and awareness-raising space for consumers. The portal provides information about various aspects of rooftop solar, such as the standards and specifications of a plant. Potential consumers can also access a list of registered vendors in their area, the ALMM, the rules and regulations issued by various authorities, consumer grievance redressal, etc.

Since the portal's launch, the MNRE has received a total of 38,413 applications to set up rooftop solar capacity equivalent to 211MW. According to data furnished by the MNRE, the current rejection rate of applications on the portal is around 14%.⁹

Net Metering Limits Revised

In December 2020, the Ministry of Power introduced the Electricity (Rights of Consumer) Rules, which capped the net metering limit at 10 kilowatts (kW) from 1MW. This revision faced severe backlash from the industry, due to which the Ministry of Power revised it from 10kW to 500kW in June 2021. This reduction in net metering affected the growth of rooftop solar capacity addition, resulting in the failure to fulfil the 40GW rooftop solar target by the end of 2022. The central government's revisions to the net metering policy have caused uncertainty and ambiguity among stakeholders.



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State Level

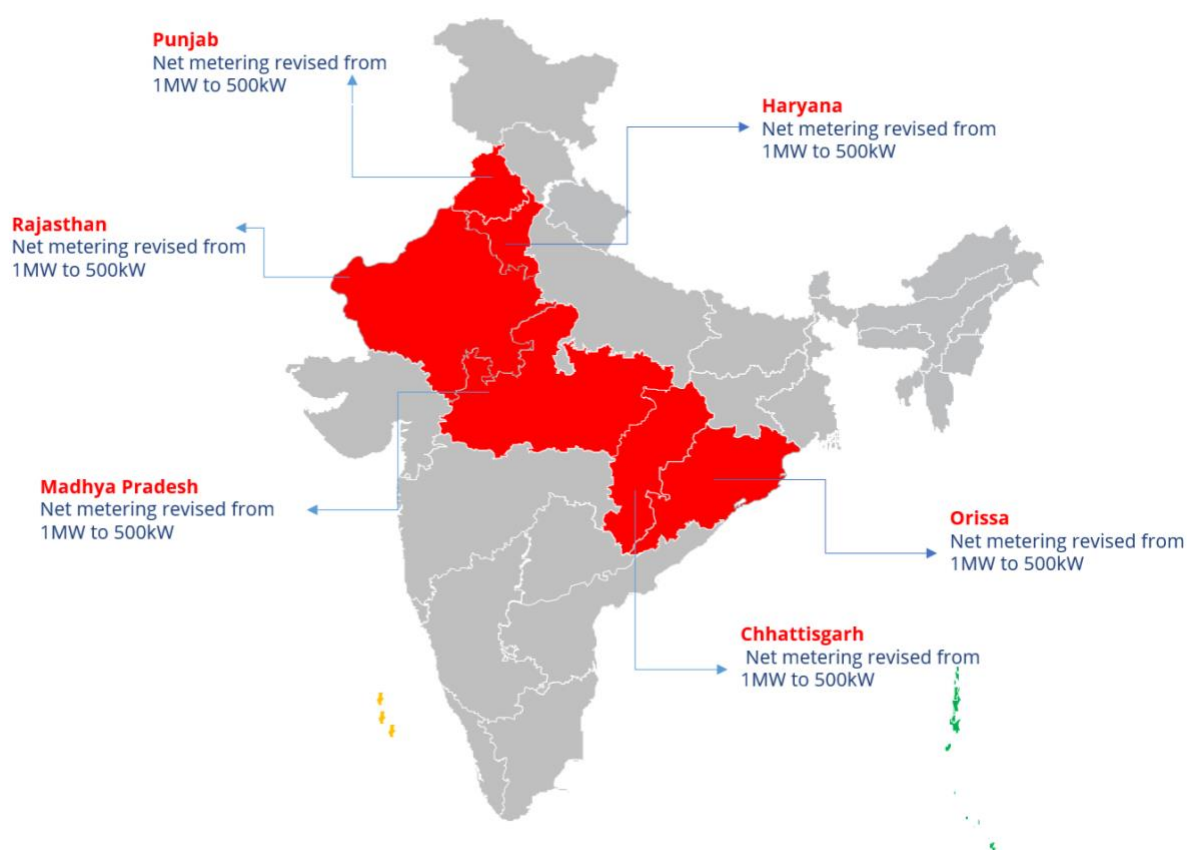
In India, 28 states and union territories have created net metering policies. While 19 states offer net and gross metering provisions, 16 of them provide only net metering for its C&I consumers. In the last two years, there have been multiple state-level regulatory changes, which we discuss in this section.

⁹ MNRE. [STANDING COMMITTEE ON ENERGY \(2022-23\)](#). March 2023.

Revision in Net Metering Limits by States

Since 2020, in line with the Ministry of Power's Electricity (Rights of Consumers) Rules, there have been multiple revisions in net metering regulations, with the cap revised from 1MW to 10kW in December 2020 and further to 500kW in June 2021.¹⁰ Consequently, several states revised their net metering policies, thereby hindering the growth of the rooftop solar market in India.

Figure 6: Change in Net Metering Limits Across States



Source: JMK Research

Introduction of Net Billing by States

States like Uttar Pradesh and Tamil Nadu have withdrawn the net metering provision for C&I consumers. Instead, only net billing is available for them. Net billing is a market-based compensation

¹⁰ Ministry of Power. [Electricity \(Rights of Consumers\) Amendment Rules](#). June 2021.

mechanism under which a distribution licensee purchases electricity generated by renewable energy generating systems. The distribution licensee raises bills on the consumer for their consumption at the approved grid tariff after giving credit for the total generated electricity against a predetermined tariff.

The net billing option offers an alternative solution that would not negatively impact DISCOMs' revenues and would still benefit the end consumer compared to net and gross metering.

Some other states, including Punjab, Rajasthan, Himachal Pradesh, West Bengal and Maharashtra, have also introduced net billing. It is highly likely that these states will also shift away from net metering to net billing in the near future. This is because DISCOMs are reluctant to approve net metering regulations owing to fears of losing high-paying C&I consumers.

Imposition of Grid Charges by Tamil Nadu and Maharashtra

Historically, one of the most significant benefits of installing a rooftop solar system for any consumer has been zero-grid support or network charges, which result in higher savings. However, over the last two years, states like Tamil Nadu and Maharashtra have introduced these additional intrusive charges that can derail the growth of the C&I rooftop solar sector.

Tamil Nadu started levying a network charge on all types of consumers starting October 2021. The network charge for the low-tension commercial category is Rs1.27/kilowatt-hour (kWh) (US¢1.5/kWh) and Rs0.83/kWh (US¢1/kWh) for high-tension consumers.¹¹

Maharashtra has also proposed a grid support charge of Rs1.45/kWh (US¢1.8/kWh) on high-tension consumers once the cumulative rooftop solar capacity in the state reaches 2GW.¹² The state has 1.7GW¹³ of rooftop installations as of 31 July 2023. It is highly likely that from 2024, these charges will be applicable. Levying such grid charges affects the long-term financial viability of rooftop solar projects.

Sanctioned Load Limits Removed in Gujarat

In 2023, as part of its third amendment to net metering regulations, Gujarat removed the limitation on sanctioned load for solar rooftop capacity. According to the revised policy, in Gujarat, a consumer can install a solar rooftop plant irrespective of its sanctioned/connected load within the limit of net metering limitation, which is 1MW. This is a first-of-its-kind approach that other states can also follow.

¹¹ Citizen consumer and civic action group. [Network charges on grid connected rooftop solar](#). July 2022.

¹² Bridge to India. [Facilitating growth of corporate renewable market](#). May 2023.

¹³ MNRE

Regulatory Roadblocks

As seen from the above updates, there are many restrictive measures for rooftop solar projects in the C&I sector. Frequently changing regulations and the imposition of new charges create uncertainty among investors about the long-term profitability of these projects. We discuss the impact of some of the recent regulatory challenges below.



Frequently changing regulations and the imposition of new charges create uncertainty among investors about the long-term profitability of these projects.

Impact of ALMM (Non-Tariff Barrier)

ALMM is a list of models and manufacturers of solar PV modules approved by the MNRE. According to the ALMM order, solar projects in India can only use listed solar PV models and module manufacturers.

Under the current ALMM, only 7% of the approved models are available in sizes above 500Wp, and merely 12.5% are above 400Wp.¹⁴ In addition, due to the significant focus on utility-scale solar projects, local cell and module manufacturers could only supply solar modules to these large projects. This highlights a significant demand-supply gap in India, which is affecting the growth of the rooftop C&I market.

Impact of Basic Customs Duty (Tariff Barrier)

BCD is the tax that the central government levies on imported goods to promote the domestic manufacturing industry. The MNRE announced that the government would levy a BCD on imported solar cells (25%) and solar modules (40%) from 1 April 2022.

The introduction of the BCD marks a turning point in the pricing of modules. Prices of imported solar modules have increased substantially, resulting in increased project costs. In 2019, the cost of solar PV modules was around Rs19.5/Wp (US\$24/Wp), while in 2023, it increased to Rs25/Wp (US\$30/Wp).¹⁵

¹⁴ MNRE. [Updation of List-I of ALMM](#). August 2023.

¹⁵ JMK Research

Restrictions Due to Open Access

Open access and rooftop solar are currently the two dominant renewable procurement routes for C&I consumers. Both routes provide long-term certainty of green electricity at a low cost.

States like Maharashtra, Karnataka and Haryana do not allow net metering connectivity to several C&I consumers availing open access. In such a scenario, C&I consumers are either moving towards a behind-the-meter (BTM) configuration for setting up a solar project or settling for less profitable gross metering/net billing mechanisms. Additionally, only CAPEX-based systems are accorded net metering approvals in these states.

Restrictions on BTM Installations

After imposing restrictions on net metering, DISCOMs now seem to be targeting BTM solar installations. BTM installations are those where the solar system is on the consumer's side of the meter, and the consumer uses the electricity generated directly on-site. The excess electricity generated does not go to the grid and thereby goes waste. Although, this wastage happens because the BTM capacity estimation is in kWh terms and not on real-time demand i.e., in kW terms. Despite this BTM can help in adding capacity in rooftop solar system.



Maharashtra and Gujarat DISCOMs are also asking consumers seeking open access to switch from BTM systems to gross metering, while some other states are denying approvals for such systems.

Historically, C&I consumers mostly opted for BTM systems because of a lack of net metering provisions in states' regulations. C&I consumers in states like Tamil Nadu and Uttar Pradesh that do not provide net metering were shifting to the BTM system for optimisation. C&I consumers in states like Maharashtra, Gujarat and Rajasthan were shifting owing to lack of regulatory approvals and DISCOMs' resistance.

Maharashtra and Gujarat DISCOMs are also asking consumers seeking open access to switch from BTM systems to gross metering, while some other states are denying approvals for such systems, making them financially unviable. In some states, like Rajasthan, DISCOMs have started imposing electricity duty, additional surcharge (AS) and cross subsidy surcharge (CSS) on BTM systems, thereby making such systems financially unviable.

State Attractiveness Index for Rooftop Solar C&I Market in India

In Table 1 below, we analyse various states based on several contributing factors that will impact the participation of C&I consumers in the rooftop solar market. We assessed the following factors across states:

- **Net metering availability:** The existence of net metering provision without any impeding restrictions enhances the prospect of solar rooftop potential in a state.
- **Electricity cost savings:** States with higher grid tariffs for C&I consumers translate to higher electricity cost savings from installing a rooftop project.
- **Ease of regulatory approvals:** Easier and faster approval of net metering applications by state authorities is key to the growth of the rooftop solar market in a state.
- **Surplus compensation:** Compensation for surplus injected power that remains at the end of the control period enhances the attractiveness of rooftop solar projects.

Table 1: Attractiveness Index of States in Solar Rooftop Installations for C&I Consumers

S no	States/UTs	Net metering for C&I	Percentage savings for C&I customers	Ease of approvals process for net metering	Surplus compensation payable	Other remarks
1	Chhattisgarh	Allowed with restriction	30-35%	Moderate	Rs3.51/kWh (US\$4.2/kWh)	
2	Odisha	Allowed	10-15%	Moderate	Excess generation lapsed	
3	Punjab	Net metering and net billing allowed	25-30%	Moderate	Excess generation lapsed	
4	Bihar	Allowed	40-45%	Low	Excess generation lapsed	
5	Gujarat	Allowed	10-15%	High	Rs1.75/kWh (US\$2.1/kWh)	
6	Rajasthan	Net metering and net billing allowed with restrictions	30-35%	Moderate	Excess generation lapsed	Levied grid charges
7	Haryana	Allowed with restrictions	40-45%	Moderate	Excess generation lapsed	Net metering connectivity is denied to consumers availing open access
8	Uttar Pradesh	Net metering not allowed	40-45%	Low	Not applicable	
9	Delhi	Allowed	35-40%	High	Rs4.51/kWh (US\$5.5/kWh)	
10	Telangana	Allowed	30-35%	Moderate	Rs4.36/kWh (US\$5.3/kWh)	

11	Andhra Pradesh	Allowed	30-35%	High	Rs4.32/kWh (US\$5.2/kWh)	
12	Karnataka	Allowed with restrictions	45-50%	Moderate	Rs2.84/kWh (US\$3.4/kWh)	1. Net metering connectivity is denied to consumers availing open access 2. Restricts net metering availability to CAPEX-based system
13	Tamil Nadu	Net billing allowed	30-35%	Low	Based on preferential tariff	1. Network charges are levied on all types of consumers
14	Maharashtra	Allowed with restrictions	50-55%	Moderate	Rs3.05/kWh (US\$3.7/kWh)	1. Net metering connectivity is denied to consumers availing open access 2. Restricts net metering availability to CAPEX-based system
15	Madhya Pradesh	Allowed with restrictions	30-35%	Moderate	Rs3.63/kWh (US\$4.4/kWh)	

Source: SERCs/JERC, JMK Research

The analysis shows that rooftop solar regulations vary widely across states. There are few states where the attractiveness across influencing parameters is apt for rooftop solar market growth.

- Gujarat, Delhi, Andhra Pradesh and Telangana have the most favourable ecosystem for setting up C&I rooftop solar projects. In Maharashtra, owing to its high grid tariffs for C&I consumers, cost savings will be highest by adopting rooftop solar. However, its unfavourable regulatory scenario when it comes to approvals and net metering restrictions mars this favourable parameter.
- Some states do not provide compensation for excess injection of solar power, while in others, the surplus injection compensation is not attractive enough. Compensation is very low compared to the current corporate power purchase agreement (PPA) rates of around Rs5/kWh (US\$6/kWh).
- Even the implementation of net metering has been sluggish, and certain states set arbitrary constraints and limits. For example, some states do not allow net metering for high-tension power consumers, i.e., large off-takers of power.
- In most states, there is a cap on the size of the solar plant linked to the distribution transformer's capacity or connected load capacity under net metering.
- Karnataka has revised its period of compensation for surplus electricity from annual to monthly, even though most other major states currently have an annual compensation period for surplus injections of electricity.

Emerging Trends in the Rooftop Solar C&I Sector

The Indian rooftop solar C&I market is continuously seeking innovative solutions to boost the share of renewable electricity generation within limited on-site/rooftop spaces. Some solutions offer significant energy generation benefits, while others are viable only in specific scenarios.

The continuous and gradual sectoral shift towards large-sized (>500Wp) and high-efficiency modules such as bifacials has been ongoing for some time now. In addition, some new trends are shaping up. They include the adoption of:

- Battery energy storage for rooftop solar
- Virtual net metering
- Peer-to-peer (P2P) energy trading

Adoption of Battery Storage in Rooftop Solar

Battery energy storage systems (BESS) enable the storage of electricity in a battery at a certain time for use later, depending on the C&I consumer requirements. The Electricity (Rights of Consumers) Rules, 2020 mandate that consumers must avoid diesel generators as an essential power backup system and use energy storage technology instead.

According to a report by the Gujarat Energy Research and Management Institute, the capacity of BESS for rooftop photovoltaic installations can cross 7,000 megawatt hours (MWh)¹⁶ by 2030 in India.

Some of the factors driving battery storage in India are:

- **Increasing diesel cost:** The country's diesel genset capacity was about 95GW¹⁷ in April 2022 and was only in use as backup power, with an operating cost of about Rs30/kWh (US¢36/kWh) for the C&I sector. BESS can replace diesel gensets with almost negligible operating costs and minuscule maintenance.
- **Falling battery prices:** Batteries play a major role in boosting the adoption rate for BESS as it is solely dependent on the cost of the battery being viable, which had come down drastically from US\$1,220/kWh in 2010 to US\$151/ kWh in 2022, and is expected to fall to US\$59/kWh by 2030.¹⁸

¹⁶ GERMI. [Battery Storage System \(BSS\)-Rooftop PV \(RTPV\) Roadmap for India](#). January 2023.

¹⁷ Financial Express. [Power supply crunch: Diesel Gensets capacity at close to 100 GW](#). May 2022.

¹⁸ BloombergNEF. [Lithium-ion Battery Pack Prices Rise for First Time to an Average of \\$151/kWh](#). December 2022.

- **Restrictive policies:** BESS systems provide a means to absorb excess generation in states having restrictive net metering policies against C&I consumers. The attractiveness of BESS is also higher in states that have higher grid tariffs for C&I consumers.
- **Increased adoption of Time of Day (ToD) tariff structures:** The delta between peak and non-peak hour tariffs is an important parameter to ensure the financial viability of a BESS system. Over time, states such as Maharashtra, Tamil Nadu and Karnataka have adopted this ToD tariff structure. Increased adoption of ToD tariff structure in other states with significant delta (at least Rs3/kWh) between peak and non-peak hours can play a major role in developing the C&I BESS market. In June 2023, as part of its latest amendments to the Electricity (Rights of Consumers) Rules, the Ministry of Power declared that from 1 April 2024, a ToD tariff would be universally applicable to all C&I consumers across India with demand greater than 10kW.¹⁹ The amendments specify a delta of at least 40% of the base electricity tariff between peak and non-peak hours.

Adoption of Virtual Net Metering

Virtual net metering is an arrangement in which electricity generated from a solar project installed on a consumer's premises or any other location is injected through a solar electricity meter. The exported electricity is adjusted in one or more than one electricity service connection of the participating consumer(s) within the same distribution licensee's supply area.

Rooftop solar has not grown as consistently as utility-scale solar in India and needs a new policy framework to succeed. Virtual net metering can be an important aspect of such a framework. Virtual net metering can help bridge the gap between utility-scale solar and rooftop solar as it allows consumers to plan for high-capacity solar installation and take advantage of economies of scale in module procurement.

The main benefit of virtual net metering is that it expands the potential pool of stakeholders. By enabling them to aggregate capacity, it increases the effective availability of sites suitable for deploying rooftop solar across the country. It achieves this by eliminating policy barriers that may hinder such participation from stakeholders.

The reasons why virtual net metering can boost rooftop solar installations in India include:

- Smaller connected loads, despite having enough roof space and financial power, compel consumers to install rooftop solar systems of lower capacities. This applies to warehouses and domestic consumers in semi-urban areas.
- Consumers with large rooftops with significant loads for installations, but at different locations, cannot avail the benefits of net metering under current policies. This applies to large commercial buildings, the Indian Railways, etc.

¹⁹ Economic Times. [Consumers can now save upto 20% in electricity bills with the new tariff rule.](#) June 2023.

- Virtual net metering expands the scope of net metering benefits by making it applicable to a larger set of consumers. This is because it helps allocate credits from shared electricity generation to multiple consumers and allows a single consumer to install a generation system with higher capacity equivalent to aggregated loads from multiple premises.

Table 2: Various Virtual Net Metering Models and their Applications

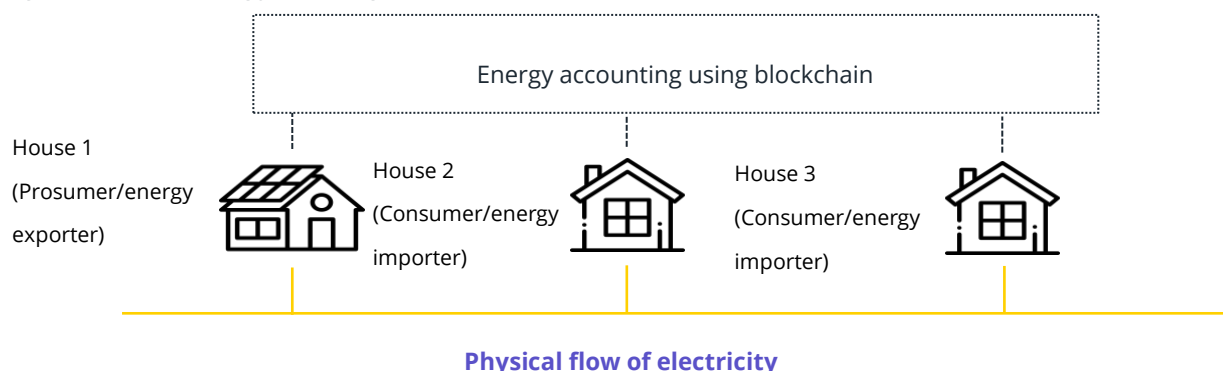
Model	Consumer	Generation	Location of generation and consumption	Example
One-to-one model	Single	Single	Different	A consumer generates electricity by installing a rooftop solar plant at one location and consumes electricity at a different location.
	Multiple	Single	Same	Multiple consumers generate electricity by installing a rooftop solar plant at one location on a common roof and consume at the same location.
One-to-many model	Multiple	Single	Different	Multiple consumers generate electricity by installing rooftop solar plants at the same location on a common roof and use the electricity at different locations.
	Multiple	Multiple	Same	Multiple consumers generate electricity by installing multiple rooftop solar plants at multiple locations with the same DISCOM and electricity is used at the same location.
	Multiple	Multiple	Different	Multiple consumers generate electricity by installing multiple rooftop solar plants at multiple locations with the same DISCOM and electricity is used at different locations of the same DISCOM.

Source: MNRE

Adoption of Peer-to-Peer Trading Mechanisms

Peer-to-peer (P2P) electricity trading is the buying and selling of rooftop solar PV energy between two or more grid-connected entities. Any excess energy from these entities can be transferred and sold to other consumers via a secure platform, such as blockchain technology – a digitised, decentralised, distributed ledger that records all transactions on a P2P network. All the information transferred via blockchain is encrypted. All involved parties can immediately detect any data manipulation, which lends transparency and security to the billing mechanism.

Figure 7: P2P Energy Trading



Source: JMK Research

P2P trading platforms are tailor-made for a complex distribution network like the one in India because they benefit both consumers and DISCOMs. In India, West Bengal, Uttar Pradesh and Delhi have successfully implemented pilot projects for P2P trading. Through its renewable energy policy, Karnataka has also recognised the P2P trading mechanism for future implementation. We highlight some key benefits of P2P trading for consumers and DISCOMs in Table 3.

Table 3: Benefits of P2P Energy Trading for Prosumers and DISCOMs

Benefit to prosumers/consumers	Benefits to DISCOMs
Freedom to choose an energy supplier	Reduction in distribution loss.
Savings for prosumers or consumers	Reduction in procurement of excess solar power via net metering and no buying with net metering tariffs, which is higher than the average power purchase cost (APPC) for DISCOMs.
Determined tariffs better than net or gross metering	Potential new revenue stream by levying wheeling charges, billing and transaction fees for energy traded in P2P.
Incentives from DISCOMs to participate in demand side management (DSM)	Rapid adoption of smart meters by advocating the usage of blockchain technology will ease the metering, billing and collection processes.
No rooftop capacity limitations – everyone from smaller players to large aggregators can join	Voltage and capacity constraint management solution as consumption of rooftop energy in the local community can stabilise voltage and reverse flow issues.
	Balancing local generation and demand through the preparation of buy and sell orders within the local community.
	P2P energy trading can assist DISCOMs in achieving their renewable purchase obligations (RPO).

Source: JMK Research

Case Study: CESC Ltd's Pilot Project in Kolkata, West Bengal

To understand the dynamics of P2P trading, Kolkata-based DISCOM CESC, in association with India Smart Grid Forum (ISGF) and blockchain provider Powerledger, conducted a pilot with around 1,000 participants (213 prosumers and 788 consumers). The case study aimed to demonstrate how P2P energy trading provides an opportunity for market-based mechanisms and a viable alternative to existing net metering schemes. It also looked to determine what value both CESC and the end consumer would gain.

Table 4: P2P Trading Pilot Project Overview

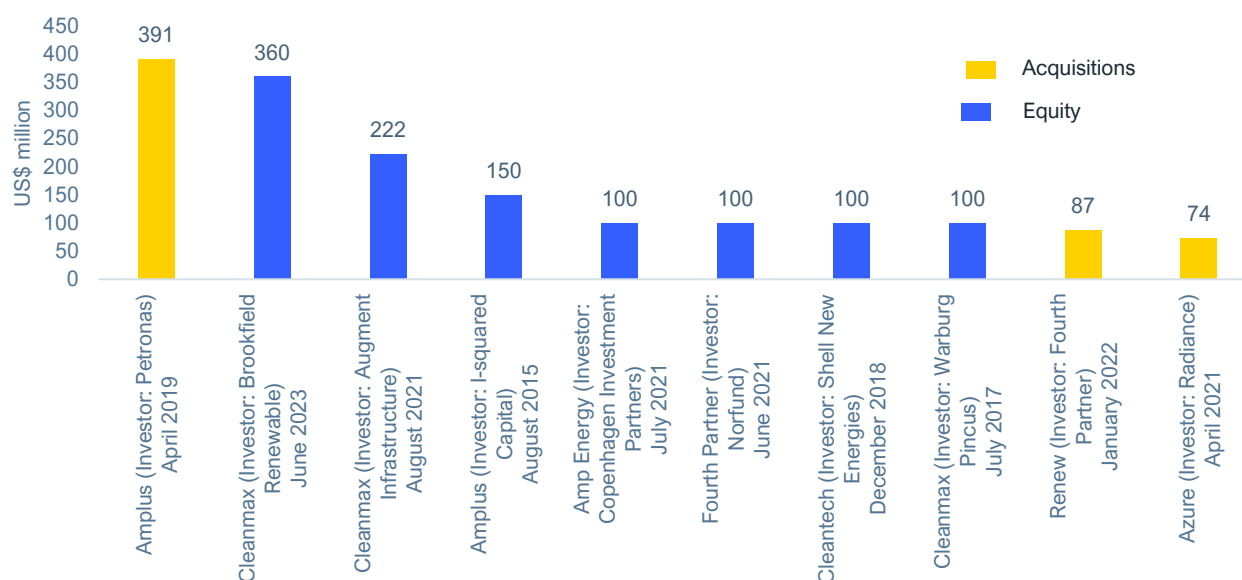
Parameter	Details
Number of participants	1,001 (213 prosumers + 788 consumers)
Energy transacted	7,42,530 MWh
Period of study	Four months
Average consumer savings (per month)	Rs105,000
Average prosumer savings (per month)	Rs312,000
Average reduction in energy rates for consumers	10%

Source: Powerledger, [CESC, ISGF, India, 2022](#)

Financing Trends in the Indian Rooftop Solar C&I Sector

Access to ample financing options for both consumers and rooftop solar developers is critical for the growth of the rooftop solar C&I sector. Several solar developers have raised substantial funding in the past decade to aid their rooftop solar portfolio growth. This funding was through debt (loans/bonds), equity and acquisitions. We summarise some of the most important financing deals in the Indian rooftop solar market between 2015 and 2023 in Figure 8.

Figure 8: Key Financing Deals in the India Rooftop Solar C&I Sector (2015-2023)



Source: JMK Research

It is evident that there has been a marked reduction in rooftop solar financing in India over the last couple of years. In 2022 and 2023 (year-to-date (YTD)), there have been only two major deals in this space: the acquisition of the rooftop solar assets of ReNew Power by Fourth Partner Energy in January 2022 for around US\$87 million and an equity investment of US\$360 million by Brookfield in CleanMax Solar. Notably, the investment by Brookfield is in the overall CleanMax portfolio and includes both on-site (rooftop) and off-site (open access) project development.

Key players exiting the rooftop solar market altogether (such as Azure Power and ReNew Power) also indirectly validate the trend of declining investor confidence in the segment. The main factors contributing to this trend are:

- **Investment flows towards open access and utility-scale market:** Investors are increasingly perceiving rooftop solar as a riskier proposition and diverting their funds towards

the relatively safer open access (OA) and utility-scale solar markets. The recently issued Green Open Access Rules drastically reduced the eligibility for availing OA to 100kW. This policy has potential to further dent investment interest in the rooftop market, as smaller consumers, who earlier could only install rooftop solar, will now have access to the OA market.

- **Market saturation:** Most creditworthy C&I consumers (BBB+ rating and above) have already installed rooftop solar systems. The lack of an adequate consumer base is driving developers and investors away from the rooftop solar segment.
- **Regulatory issues:** Recently, several states have rescinded benefits to their high-paying C&I consumers, eventually hindering their adoption of on-site rooftop solar. These include restrictive net metering provisions, stringent conditions on the maximum solar system size installed, etc.

With the creditworthy C&I market being almost saturated, several rooftop solar financiers have identified that micro, small and medium-sized enterprises (MSMEs) remain largely untapped. The MSME sector, thus, offers huge potential for the rooftop solar market in India.

Financing Trends for the MSME Segment

The MSME sector in India encompasses manufacturing entities with turnovers ranging from US\$0.61 million to US\$30 million. The sector is a critical component of India's economy, contributing over 30% to India's gross domestic product (GDP) and 40% to India's exports.²⁰ Additionally, MSMEs account for almost half (~48 %) of all the energy consumed in the industrial sector in India.



In the past few years, the MSME sector has undergone a gradual yet clear behavioural shift towards green energy.

In the past few years, the MSME sector has undergone a gradual yet clear behavioural shift towards green energy. As a whole, the sector has realised that greening its energy consumption from solar or any other renewable source is not only important for energy availability but also for profitability and growth. An on-site rooftop solar plant can help enterprises save a large amount on electricity costs, which essentially pay off their equated monthly instalments (EMIs) towards the loans for setting up the solar plant itself. Additionally, a greener energy portfolio leads to lesser greenhouse gas (GHG) emissions in MSME factory output, which is an attractive proposition to their end clients – usually large corporates with ambitious emissions reduction targets.

²⁰ Business Today. [MSMEs will be a critical sector for pushing India's growth in next 25 years](#). February 2023.

Despite MSMEs' growing desire to use renewable energy, inadequate financing has been a major roadblock in adopting sustainable energy solutions, such as rooftop solar. Some of the key factors that have led to this roadblock include:

- **Lack of creditworthy MSMEs:** The lack of historical financial data and payment track records, coupled with cases of defaults, make lending institutions apprehensive of giving MSMEs loans.
- **Failure to put up collateral:** For large investments, banks generally demand collateral to reduce lending risks, which MSMEs usually fail to provide. Notably, their existing assets are already collateralised in several cases, making it difficult for them to obtain loans.
- **Long-term uncertainty about MSMEs:** At times, it is hard to ascertain the future and longevity of the business viability of an MSME, leading to increased reluctance from banks to lend to this segment.

However, in the past couple of years, the rooftop solar financing situation for the MSME segment has improved. This progress is partly due to increasing awareness of MSMEs towards renewable energy adoption as well as by lending institutions realising the potential of the untapped market for solar lending in the MSME segment. This potential is estimated to be around 15GW, which is around 37% of India's rooftop solar target of 40GW.²¹

Consequently, the number of lenders to the MSME segment for rooftop solar have increased substantially – from around three entities in mid-2021 to nine as of 2023 (see [Annexure 1](#)) Of these nine lenders, seven (except State Bank of India (SBI) and Indian Bank) have issued schemes catering specifically to the MSME segment.



In the past couple of years, the rooftop solar financing situation for the MSME segment has improved.

Currently, Tata Power Solar is the most prominent player in MSME rooftop solar financing, either as a joint fund provider (in the Tata Power - Small Industries Development Bank of India (SIDBI) MSME scheme) or as an engineering, procurement and construction (EPC) partner (in other schemes). The loan disbursing entities range from public and private sector banks such as SBI, Union Bank, Yes Bank, etc. to non-banking financial companies (NBFCs), such as SIDBI, Electronica Finance Limited and others.

Orb Energy, an integrated solar solutions provider based in Bengaluru, is a unique case of a solar developer and manufacturer providing financial solutions. Some international investment firms, such as the United States Agency for International Development (USAID), British International Investment

²¹ Financial Express. [Why MSMEs are hesitant in embracing non-conventional energy sources like rooftop solar](#). April 2022.

(BII) and others, are also vying to provide financing options to MSMEs interested in rooftop solar projects.

IEEFA and JMK Research's previous report provides an in-depth understanding of the financing landscape for the rooftop solar market in India, including innovative financing solutions.²²

Another major trend is the rise of collateral-free loans for rooftop solar installations for the MSME segment – of the nine lenders, five provide loans without any collateral. However, some schemes, such as SBI Surya Shakti and the scheme from Union Bank, require an eligibility condition that the electricity savings from the rooftop solar plant should at least cover the monthly repayment obligation towards the loan.



The World Bank is likely to approve and announce a credit guarantee scheme to limit the risk exposure of financial institutions lending to MSMEs later this year.

In order to limit the risk exposure of financial institutions lending to MSMEs, the World Bank is working on a credit guarantee mechanism (CGM) scheme. The scheme will involve a US\$100 million payment guarantee fund covering up to 50% of the debt financing amount from participating financial institutions to a grid-connected rooftop solar project.²³ The World Bank is likely to approve and announce the scheme this year.

²² IEEFA and JMK. [Financing Trends in the Commercial and Industrial \(C&I\) Rooftop Solar Market in India](#). September 2021.

²³ World Bank. [Project Information Document](#). January 2023.

Policy Recommendations

The downfall in rooftop solar capacity until now is largely because of factors such as policy restrictions, uncertainty surrounding regulations, various unreasonable charges like grid/network charges and administrative delays in approvals from DISCOMs. Going forward, providing potential solutions to these issues within this report is important. Therefore, we propose certain clear steps required from policymakers to address these underlying challenges and aid the next phase of growth of the rooftop solar market in India.

Central Guidelines for Rooftop Solar Projects

The Green Open Access Rules, 2022 resolved a lot of regulatory uncertainty and enhanced clarity and uniformity regarding key parameters such as OA charges, banking settlement, approval processes and timelines.

The central government, through the Ministry of Power or MNRE, can issue similar guidelines for the rooftop solar market. This can go a long way in addressing industry stakeholders' challenges. The guidelines should include the following points:

Table 5: Key Parameters Under “Central Guidelines and Rules for Rooftop Solar”

Parameter	Description
System size	Instead of uniformly capping rooftop solar systems at 500kW or 1MW capacity for availing net metering benefits, the allowed rooftop solar capacity that a C&I consumer can install should be dependent on local grid strength such as distribution transformer capacity, sanctioned load, etc.
Approval process	The net metering approval process should be simplified and the DISCOM's role should be clearly defined at each step.
Approval duration	The connectivity, if pending for a long time – for example, 45 days from the date of the application – will be termed as “deemed approved” if no clarification is provided.
No adhoc charges	Regulators must not impose any intrusive charges, such as grid charges, to hinder the growth of the rooftop solar market until government targets are achieved, i.e. by March 2026.
Clearly defined surplus injection rate	The regulations should clearly define the methodology for surplus injection rates across states. They can be linked to system size and average cost of rooftop solar power supply.
New business models	Clear official policy directives on innovative rooftop solar business models such as group net metering, virtual net metering, P2P trading, etc.

Source: Industry Interviews, JMK Research

Define Renewable Purchase Obligation Targets from Distributed Renewable Energy Systems

Currently, the renewable purchase obligations (RPO) mandate only covers solar and other renewable technologies without distinguishing the type of solar energy purchased. Thus, the government can ask obligated entities (such as DISCOMs, large C&I consumers, etc.) to fulfil a portion of their energy requirements, specifically from distributed renewable energy (DRE) systems, which can include rooftop solar. This would provide a clear directive and a marker in the form of a target for developing the rooftop solar market across India.



The government can ask obligated entities to fulfil a portion of their energy requirements from distributed renewable energy systems, which can include rooftop solar.

Promote BTM Installations

According to industry interviews, BTM solar installations in India comprise about 20-30% of all installations at present. This number does not factor in official government installation figures. The government needs to permit BTM systems across states irrespective of sizing constraints. This is an important element that can support the next growth phase in the rooftop solar market. This segment, once recognised, can not only help DISCOMs to accurately forecast their load schedule but will also help the government achieve its target of 40GW rooftop solar capacity by March 2026.

Conclusion

The rooftop solar market is yet to truly pick up in India. Slow growth in rooftop solar was the key reason India fell short of its 2022 target of 100GW solar power capacity. Regulatory uncertainties and lack of support from local DISCOMs have forced prominent developers to either shift their focus to other segments or exit the market by selling their rooftop solar business vertical. Examples of such deals include Azure Power selling its rooftop solar business to Radiance in 2021 for around US\$74 million and ReNew Power's US\$87 million deal to sell its distributed segment to Fourth Partner Energy.

Several states are moving away from net metering to lesser beneficial gross metering and net billing arrangements. The realised revenue and associated benefits for consumers under gross metering and net billing are significantly lesser than under net metering, leading to C&I consumers shifting focus to other greening options, such as OA.

The Green Open Access Rules, 2022 drastically reduced the eligibility limit to avail OA to just 100kW sanctioned load/contract demand. This announcement expanded the scope of OA by giving smaller C&I consumers accessibility to off-site solar power. Going forward, consumers will shift their preference from on-site rooftop solar to off-site OA, especially in states like Uttar Pradesh and Tamil Nadu that have net metering restrictions for C&I consumers.



After a dismal 2022, the first half of 2023 has shown remarkable growth in rooftop solar capacity additions.

After a dismal 2022, the first half of 2023 has shown remarkable growth in rooftop solar capacity additions. The 2.7GW installations between January and July 2023 surpassed the entire rooftop solar capacity additions in 2022. Some of the key influencing factors for this growth are the stabilisation of project costs and enhanced module availability in 2023. Looking ahead, with solar module costs continuing to spiral down, a significant uptake in rooftop solar installations is very likely in the near-to-medium term.

In India, at the state level, Gujarat has long been leading the way in rooftop solar installations, mainly due to its successful residential policy and the favourable stance of its DISCOMs towards rooftop solar. Lately, some other states, such as Kerala, Andhra Pradesh and Maharashtra, and the union territory of Delhi, are increasingly promoting rooftop solar. Kerala's Agency for New and Renewable Energy Research and Technology (ANERT) recently announced a systemic plan to install over 700MW of rooftop solar systems in Thiruvananthapuram across the residential, C&I and government segments. Delhi has the best rooftop solar policy framework, with clear official policy directives on innovative business models, such as group net metering, virtual net metering, P2P trading, etc.

For developing rooftop solar, other states can look at Delhi for its policy design and emulate Gujarat for its effective implementation. To improve the accessibility and reach of rooftop solar-based solutions, states must actively promote innovative business models.

Furthermore, going forward, with several states starting to adopt a ToD pricing mechanism, coupling rooftop solar with BESS for C&I will make more economic sense. However, the recent uptick in Li-ion battery prices might delay the BESS adoption trend. Another potential interesting trend will be the aggregation of smaller-sized rooftop solar projects. In such a case, the entire portfolio of projects, being treated as a large single entity, can receive better financing terms from rooftop solar lenders.

Also, since the market for creditworthy C&I consumers is saturated, the next growth phase in the rooftop solar market will likely come from the MSME segment. Recently, with rising awareness about this market, many new lending agencies have developed products to specifically tap into the MSME segment and provide collateral-free loans. To mitigate risk exposure of financial institutions lending to MSMEs for rooftop solar in India, the World Bank is likely to announce a credit guarantee mechanism scheme with an outlay of US\$100 million soon, which will further aid the growth of the MSME rooftop solar market.



For India to attain its target of 500GW of renewable energy by 2030, solar and its verticals (including utility-scale, rooftop solar and OA) will all have to play a crucial role.

For India to attain its target of 500GW of renewable energy by 2030, solar and its verticals (including utility-scale, rooftop solar and OA) will all have to play a crucial role. As demonstrated by countries like Germany and Australia, with the right policy and regulatory environment, on-site solar development can be a game changer to facilitate the organic adoption of solar and greening the overall national energy mix.

Notably, if India were to achieve the national rooftop solar target of 40GW, it would only contribute to about 3-4% of the entire energy generation in the country. This figure represents a minuscule revenue share for DISCOMs. At just about 15GW presently, the rooftop solar market poses no threat to DISCOMs. States must focus equally on OA and rooftop solar to further their clean energy targets. With the right policies and support, it is possible to unlock the massive potential of rooftops across India.

Annexure 1: Financing Schemes Available to the MSME Segment

Name	Launch date	Loan disbursing entity and type	(EPC) partner entity	Financing details
SBI Surya Shakti	January 2022	SBI (public sector bank)	Tata Power Solar	CIBIL score of borrower > 649 Electricity cost savings should at least cover monthly repayment obligations. Loan amount: Up to Rs40 million (US\$0.48 million) Project size: Up to 1MW Repayment period: Up to 10 years Collateral: Not required. External benchmark linked rate (linked to RBI repo rate) (MSME): 10.95%total around ~10-11%
Tata Power and Small Industries Development Bank of India (SIDBI) MSME loan	January 2021	SIDBI – Government non-bank financial company (NBFC)	Tata Power Solar	Only available to Tata Power MSME consumers Loan amount: up to Rs25 million (US\$0.3 million) Project size: 25-500kW Loan amount: Up to 100% of project cost Repayment period: Up to five years Collateral: Not required Interest rate: 9.1%-10.2% Loan turnaround time: seven days
Indian Bank Surya Shakti	September 2022	Indian Bank (public sector bank)		Loan amount: No ceiling Loan amount: Up to 75% of project cost Repayment period: Up to 15 years Collateral: Solar plant assets, property on which the plant is constructed
USAID Loan Guarantee Program	March 2021	cKers Finance, Electronica Finance Limited (EFL) (Indian NBFCs)		cKers Finance Loan amount: Rs20 million crores to Rs150 million (US\$0.24 million to US\$1.8 million) Repayment period: Up to nine years EFL Loan amount: Up to Rs30 million (US\$0.36 million) or 75% of project cost Repayment period: Up to four years Collateral: Not required up to Rs5 million (US\$0.06 million) Loan turnaround time: Three days
Union Rooftop Solar Scheme	November 2022	Union Bank of India (public sector bank)	Tata Power Solar	CIBIL score of borrower > 700 Electricity savings should at least cover monthly repayment obligations Loan amount: Rs1 million to Rs80 million (US\$0.012 million to US\$0.97 million) Project size: 10kW to 2MW Repayment period: Up to 10 years Down payment: 20% Collateral: Solar plant assets
Bank of Baroda solar projects financing scheme	November 2022	Bank of Baroda (public sector bank)	Aerem Solutions	Loan amount: Rs500,000 to Rs10 million (US\$6,057 to US\$0.12 million) Repayment period: Three to six years Collateral: Not required
YES KIRAN	May 2023	Yes Bank (private sector bank)	Tata Power Solar, Goldi Solar, Loom Solar	Loan amount: Up to Rs30 million (US\$0.36 million) Repayment period: Up to six years

Orb Energy Solar Finance for SMEs Scheme	2016	Orb Energy (solar energy solutions provider)	Orb Energy	Repayment period: Four or five years Collateral: Not required Down payment: 0 or 25% Interest rate: 12% Loan turnaround time: seven days
Green Basket Bond (by British International Investment (BII))	June 2022	Symbiotics (international investment platform)		Total outlay for the scheme: US\$75 million The fund targets rooftop solar development in South Asian and African countries

Source: News Articles, JMK Research

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About the Authors

Jyoti Gulia

Jyoti Gulia is the Founder of JMK Research. Jyoti has about 17 years of rich experience in the Indian renewable sector. Her core expertise includes policy and regulatory advocacy, assessing market trends, and advising companies on their business strategy. jyoti.gulia@jmkresearch.com

Kapil Gupta

A clean energy sector enthusiast with over 9 years of experience. Kapil's functional exposure spreads across Business Development, Project Management, Regulatory and Liasoning with Public and private sector stakeholders. kapil.gupta@jmkresearch.com

Prabhakar Sharma

Prabhakar is a Consultant at JMK Research with expertise in tracking renewable energy and battery storage sector. He has previously worked with Amplus Solar. prabhakar.sharma@jmkresearch.com

Vibhuti Garg

Vibhuti Garg, Director, South Asia at IEEFA, has advised private and public sector clients on commercial and market entry strategies, investment diligence on power projects and the impact of power sector performance on state finances. She also works on international energy governance, energy transition, energy access, reallocation of fossil fuel subsidy expenditure to clean energy, energy pricing and tariff reforms. vgarg@ieefa.org

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