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Powering Up Sunshine – Untapped Opportunities in India's Rooftop Solar Market

How the Commercial and Industrial Sector Can Cut Costs and Reduce Emissions

Executive Summary

The Government of India has set a target of 40 gigawatts (GW) of rooftop solar capacity to be installed by 2022. As of December 31, 2019, total rooftop solar capacity stood at 5.4GW[1], well below the installation rate required. Nonetheless, the basic framework including net metering policies for rooftop solar arrays now exists across all states and the implementation of rooftop solar power installations has started in a true sense. Given such momentum, this sector should be a key economic growth priority post the COVID-19 pandemic.

To promote the deployment of solar rooftop capacity, the Ministry of New and Renewable Energy (MNRE) implemented in 2015 the "Grid Connected Rooftop and Small Solar Power Plants Programme (Phase I)" under which a subsidy of up to 30% of the benchmark cost was provided for general category states, and up to 70% of the benchmark cost for special category states (the North Eastern States including Sikkim, Uttarakhand, Himachal Pradesh, Jammu and Kashmir and Lakshadweep, Andaman and Nicobar Islands) for installation across the residential, institutional and social sectors.

Given its momentum, rooftop solar power should be a key growth priority post COVID-19.

For government installations, achievement-linked incentives of up to 25% of the benchmark cost in general category states / union territories (UTs) and up to 60% of the benchmark cost for special category states / UTs were also provided. About 2,098 megawatts (MW) of solar rooftop systems have been sanctioned/approved under Phase I.

To achieve the 40GW rooftop target by 2022, the government also introduced the Rooftop Phase II Programme in August 2019. Under this program, additional

[1] Bridge To India. India Solar Rooftop Map. December 2019.

rooftop solar capacity of 18GW was targeted through incentives for distribution companies (discoms) and 4GW was targeted for the residential segment, with central financial assistance of 40% of project cost for a system size of up to 3 kilowatts (kW).

Commercial and Industrial (C&I) users consume approximately 49% of the electricity generated in India[2] and account for 70-80% of all the country's rooftop solar installations. This situation is quite different from other economies where the residential segment leads rooftop solar. The reason is that, in India, residential and agricultural users are subsidized while C&I consumers are levied an additional cross-subsidy surcharge leading to higher than average mains electricity tariffs. As a result, rooftop solar is an economically viable solution for C&I consumers.

Electricity demand in the C&I segment was rising at a compound annual growth rate (CAGR) of 5-6% (FY2017- FY2019) while grid tariffs for C&I consumers are increasing at a year-on-year rate of 1-2%. Increasing electricity demand and rising grid tariffs for C&I customers are driving commercial users to rooftop solar which is not only cleaner and cheaper but also gives them tariff certainty for up to 25 years.

Consumer awareness of the benefits of rooftop solar, its cost savings, and the importance of clean energy are other factors playing key roles in the greater adoption of rooftop solar in India, as is increased awareness of operating expenditure (Opex) business models.

Moreover, the payback period for rooftop solar projects is gradually shortening because the cost of equipment is falling. Currently, in a capital expenditure (Capex) model, payback can be realised by a shorter duration of 3-4 years, while for an Opex project the tariff rate is about Rs3.5-4/kWh (USD 0.047 –0.053), which is less than half the average of C&I grid tariffs prevalent across most states.

Rooftop solar is not only cleaner and cheaper, but also provides tariff certainty for up to 25 years.

The next revolution in rooftop solar will be in storage. It is likely that in the next 2-4 years, 20% of all C&I installations will connected to the grid, coupled with battery storage. Technical advances such as higher generation efficiency from bifacial mono PERC modules, which need less rooftop space, is another advance that will define the future growth of this market.

Furthermore, in the C&I segment itself, medium, small, and micro enterprises (MSME) will be the new market to aggressively adopt solar in coming years. MSMEs are the backbone of the Indian economy, contributing 6.1% of gross domestic product (GDP) and about 45% of total manufacturing output.[3] Electricity costs are

[2] Central Electricity Authority. Growth Of Electricity Sector In India From 1947-2019. May 2019.
[3] PIB. SMEs must strive to produce World Class Products. January 2020.

up to 50% of their total expenses, so cutting such costs via solar power sustainably improves their competitiveness in a big way.

Clearly, there are ample growth opportunities in C&I rooftop solar, but two fundamental issues must be tackled to speed up adoption in this segment. The first is financing because it is still difficult for consumers to get credit approved as lenders do not identify a rooftop solar project as a standalone asset. Second, due to low MSME project capacities, rooftop solar projects are not particularly attractive to banks and financial institutions that cannot aggregate portfolios of rooftop assets.

Policy uncertainty is the biggest issue hampering the growth of rooftop solar in India. Discoms are fearful of losing their high paying C&I consumers and are issuing orders and notifications to restrain net metering and power banking provisions (as listed in Table 4). Additional charges for grid support have also been proposed in India's key industrial state of Maharashtra. This uncertainty deters many C&I players from deploying rooftop solar.

The COVID-19 pandemic has also created short-term market disruption. Since most solar rooftop developer firms are small businesses, COVID-19 is likely to have a more significant impact on rooftop solar than the utility-scale segment. Given their low financial resilience, small players would struggle to absorb the losses incurred because of COVID lockdowns. We argue that the cost effectiveness, sustainability, and grid benefits of distributed power generation should make rooftop solar a key recipient of post-pandemic stimulus.

As part of this report, we have analysed in detail new market trends that are emerging in the C&I rooftop solar segment, various policy and regulatory developments across states, new technological advances, and the market challenges and drivers influencing the sector. Last, to substantiate some of the recent rooftop solar C&I market trends and opportunities, we have profiled and analysed actual installed projects in six detailed case studies.

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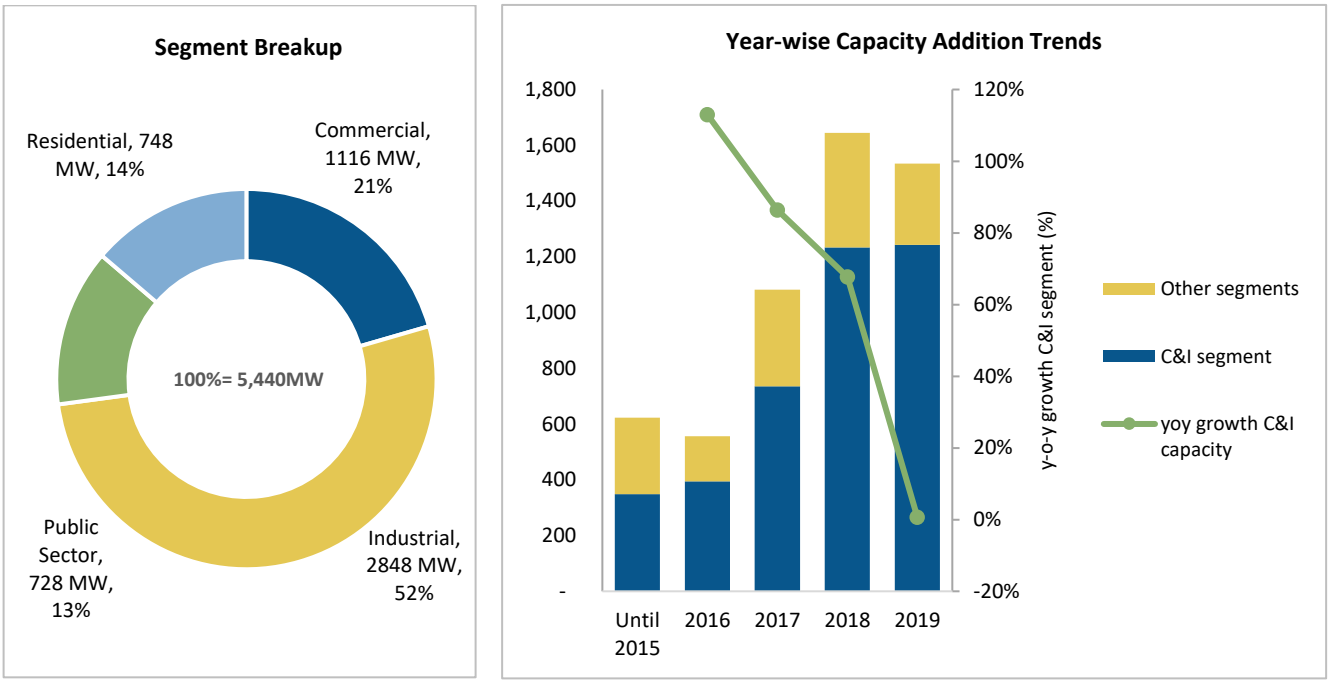
1. C&I Rooftop Market Size

As of December 31, 2019, total installations in the C&I rooftop solar segment in India reached about 3,966MW.[4] This segment makes up 70-80% of all onsite rooftop solar installations in India and accounts for 4.6% of the 86GW of renewable energy capacity that was installed in the country by the end of last year.

Figure 1: Onsite Rooftop Solar Installed Capacity Trends in India



Source: Bridge To India Rooftop Map Dec-2019.

Between 2016 and 2019, the C&I segment grew consistently with a compound annual growth rate (CAGR) of 47%. However, significantly reduced economic activity and increasing regulatory headwinds resulted in a 7% year-on-year fall in total solar rooftop capacity addition last year. These hindrances, along with marginal growth of just 1% in the C&I segment, has brought India's rooftop solar market growth under pressure. This pressure is likely to become more severe in 2020 as demand declines because of disruption caused by the COVID-19 pandemic.

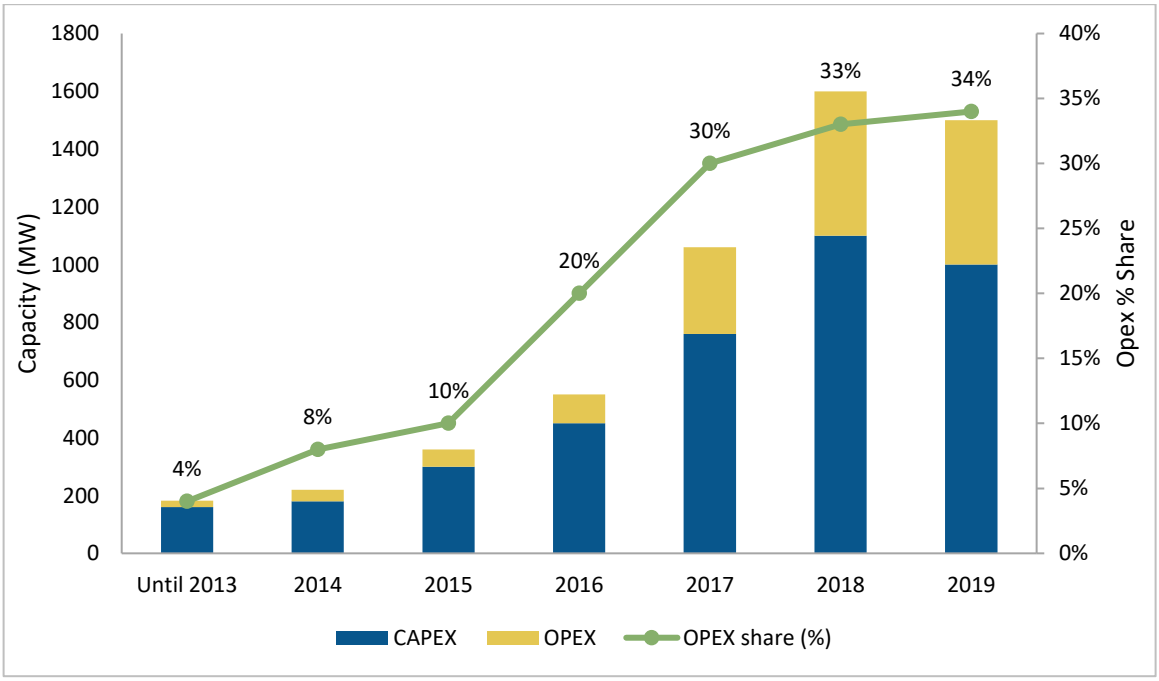
On a state-by-state basis, the top five states of Gujarat, Rajasthan, Karnataka, Maharashtra, and Tamil Nadu account for 50% of total C&I rooftop solar installations in India. Rooftop solar makes good business sense in big industrial states such as Maharashtra, Gujarat, Tamil Nadu and Karnataka where grid tariffs for C&I consumers are high, typically in the range of Rs7-10/kWh.

[4] Bridge To India. India Solar Rooftop Map. December 2019.

2. Business Models

India's rooftop solar market has, broadly, two business models – Capex & Opex. From the perspective of a power consumer, Capex is a self-financing model while Opex is a third-party financing model. Opex accounted for nearly a third of all cumulative rooftop solar installations in India at the end of last year.

Figure 2: Business Models of C&I installations in India



Source: Bridge To India Rooftop Map Dec-2019.

The Opex Model

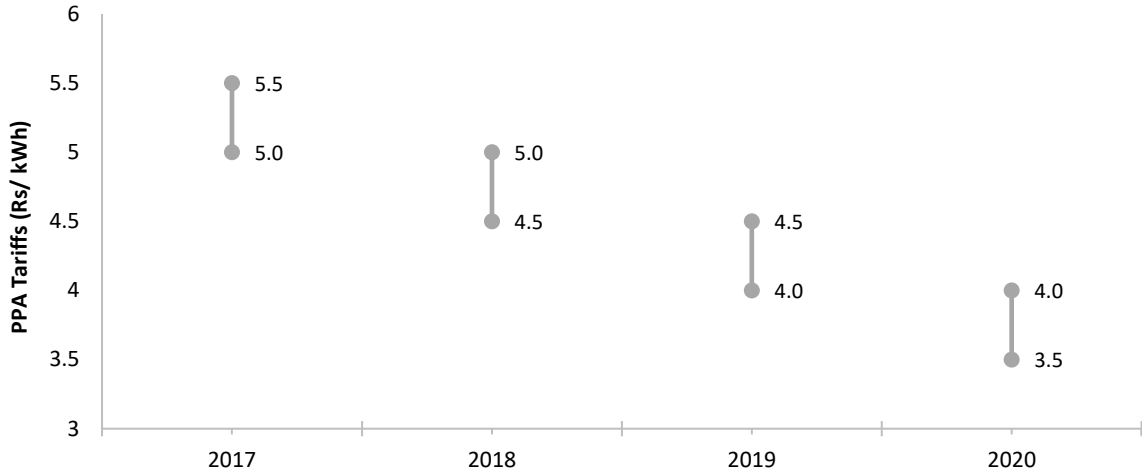
As of December 31, 2019, Opex projects made up nearly 30% (1,579MW) of the cumulative onsite solar installations in India.

Under the Opex model, a renewable energy service company (Resco) funds, builds and maintains a rooftop or onsite solar power plant. The end-consumer pays for the power generated under a long-term power purchase agreement (PPA) at an agreed tariff for a fixed period, typically 15-20 years.

Use of the Opex model rose from 4% in 2013 to 34% in 2019. The Opex model is preferred by companies that do not wish to invest their limited capital in non-core operations. Outsourcing their rooftop solar provides the well-priced power they need, conveniently financed and managed by a third-party player.

PPA tariffs for projects installed under the Opex model are falling in line with declining module prices. The tariff trend for Opex PPAs in recent years is highlighted below. In the past year, module costs in India fell by 12-15% as did corporate PPA tariffs.

Figure 3: Tariff Trends for Opex-based PPA Projects



Source: Industry Interviews, JMK Research.
Note: Tariffs assuming good industrial site with net metering connection, >1MW size, no curtailment, 25-year flat tariff.

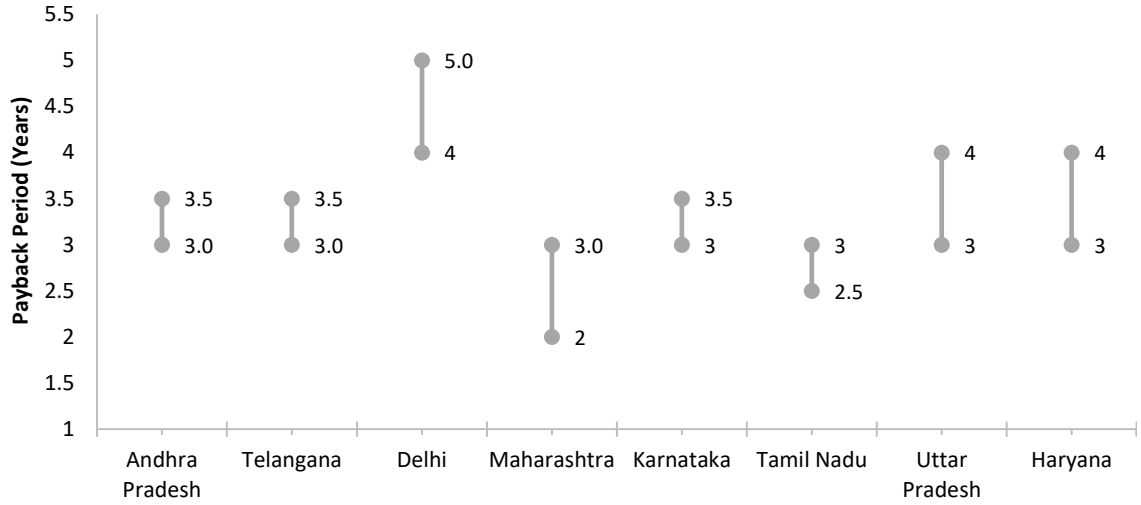
Given the economic effects of the COVID-19 pandemic, the Opex model is likely to gain traction because C&I consumers with liquidity issues would opt for this model to limit capital investment while still being able to save on electricity.

Capex Model

The Capex model was the first to be used in rooftop solar installations. By the end of last year, the Capex model accounted for about 70% (3,861MW) of C&I rooftop installations. Under this model, the client makes the initial investment and owns the installation. The project expense is recovered through the electricity generated from the system over a payback period of usually 3-4 years. The operation and maintenance (O&M) costs of the rooftop solar plant are borne by the consumer.

Many electricity consumers in the MSME segment still opt for the Capex model, but there few segment-specific financing instruments for consumers that are rated below BBB+ or have collateral issues. Cash-rich companies that do not wish to enter an 8-10-year contract also prefer this model.

Figure 4: Payback Period of Industrial Solar Installations Under Capex Route in India



Source: Industry Interviews, JMK Research.
Typical trend for a good industrial site with substantial size of >1MW and good solar radiation assuming project cost is Rs32 Million/MW.

Lease Model

Even though Capex and Opex are the primary business models in this sector, a lease model is also being adopted. The consumer leases the system at a monthly rate determined by the solar installation's output. At the end of the lease term, ownership of the installation is transferred to the lessee. Unlike outright ownership from the start, leasing can affect elements such as O&M costs, financial offsets, and savings/returns on investment.

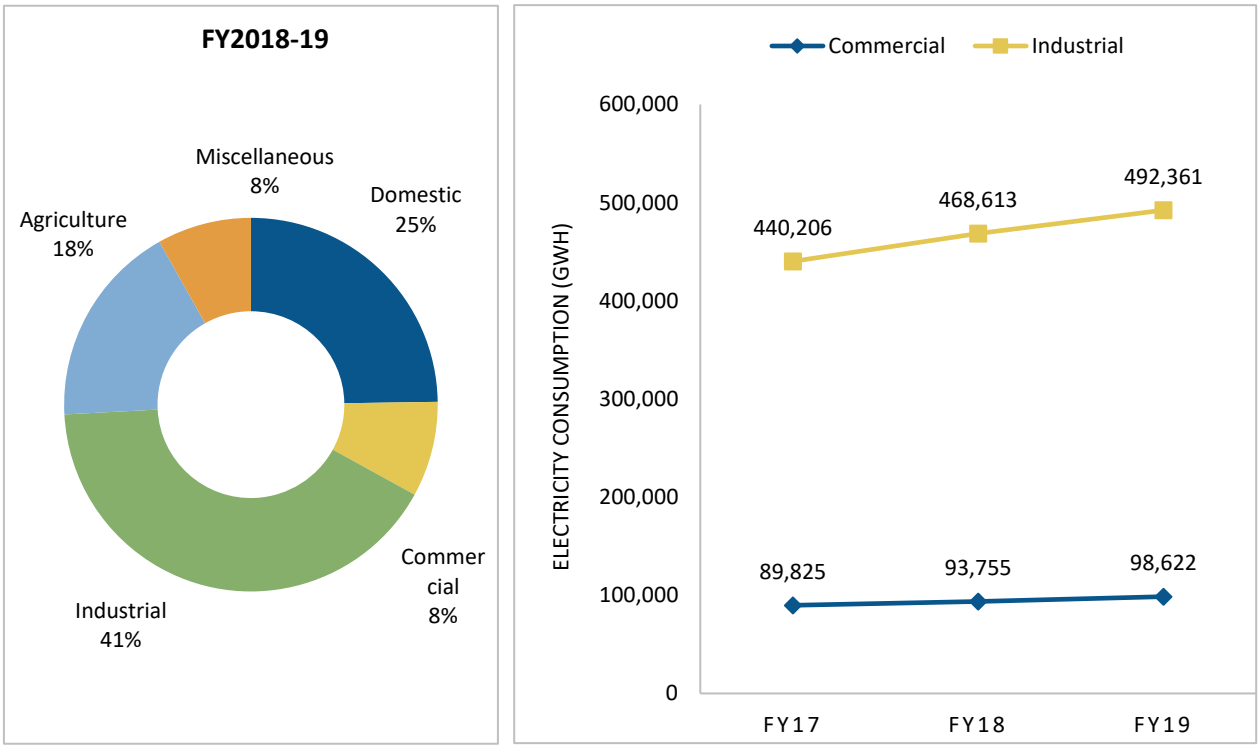
Organizations such as Simpa Networks, which already supply rural households, are adopting the leasing model using pre-paid metering and control technology. Other companies that have installed solar generation using this model include Hero Future Energy, SolarTown, First Green and SunAlpha Energy, to name a few.

3. Market Potential

Electricity Demand in the C&I Segment

C&I customers consume approximately 49% of the electricity generated in India[5] and pay higher tariffs than residential users. From FY2017 to FY2019, electricity consumption across C&I segment rose by a CAGR of 5-6% (refer to the figure below). The expectation of both growing electricity demand and rising grid tariffs for C&I customers is driving them to adopt rooftop solar generation, which is not only cleaner and cheaper, but also offers cost certainty for 25 years.

Figure 5: Electricity Consumption Trends Across C&I Segment in India



Source: Central Electricity Authority (CEA).

C&I Installations for 2020

The leading onsite rooftop solar companies active in India say they expect additions to range from 0.8-1.2GW of new onsite installations across the C&I segment in 2020, a 4-36% change from 2019 installations. Most of these companies believe that the C&I segment is likely to experience a surge in activity for the following reasons:

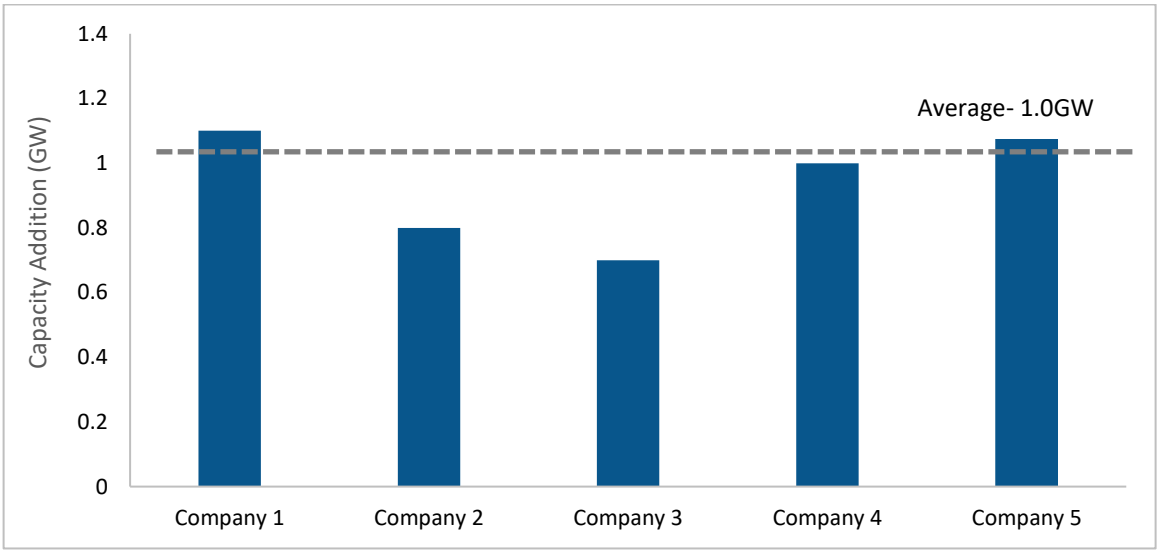
- Cost savings would be imperative for businesses already struggling with low market demand. Adopting rooftop solar could reduce their electricity costs.

[5] Central Electricity Authority. Growth Of Electricity Sector In India From 1947-2019. May 2019.

Consumers that want savings will not delay their decisions and it is likely that the business development cycle for rooftop players will get shorter.

- Change in preferred business model from Capex to Opex. New markets will open up for cash-rich companies in fast-moving consumer goods (FMCG), while multinationals (MNC) that previously preferred the Capex model are now likely to explore the Opex model because of liquidity issues and other business uncertainties.

Figure 6: Likely Onsite C&I Solar Installations in 2020



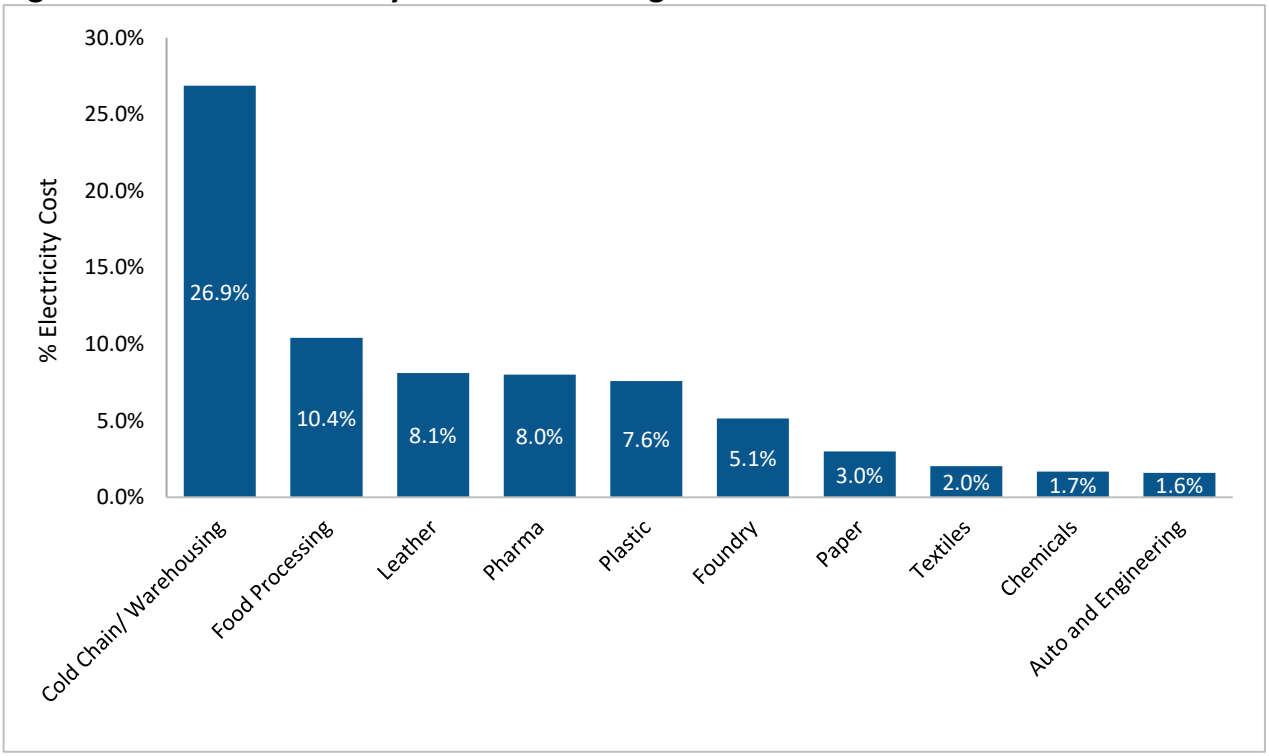
Source: Industry Interviews, JMK Research.

MSME Potential

In the C&I segment, MSMEs will be the new market to start adopting rooftop solar aggressively in the next few years. MSMEs are the backbone of the Indian economy contributing 6.1% of the manufacturing GDP, 24.6% of the GDP from service activities and about 45% of total manufacturing output[6]. For MSMEs, electricity costs can be high as 50% of total expenses, so cutting these costs can improve their competitiveness considerably.

[6] PIB. SMEs must strive to produce World Class Products. January 2020.

Figure 7: Share of Electricity Cost as Percentage of Total Production Cost



Source: E&Y study on "Identifying barriers for rooftop solar uptake in MSMEs and development of a mitigating financial framework", January 2020.

According to an Ernst & Young study, it was estimated that MSMEs hold a potential of 16-18GW of rooftop solar. The MSME segment also accounts for 25% of the overall energy consumption in the industrial sector[7]. Rising energy consumption is one of the top challenges faced by MSMEs. Given increasing consumption and high electricity tariffs, many MSMEs are willing to switch their electricity supply to rooftop solar. However, obtaining external financing is a major challenge for most of these businesses because lenders are generally reluctant to issue a letter of credit (LC) to MSMEs. Since most MSMEs have no or poor (BBB+ and below) credit ratings, lenders see a significant risk of non-repayment and loan defaults. Consequently, MSMEs hold a small share in the rooftop solar market, even though they have shown increasing interest in switching to solar power in recent years.

[7] BEE. Energy Conservation Guidelines for MSME Sector. September 2019.

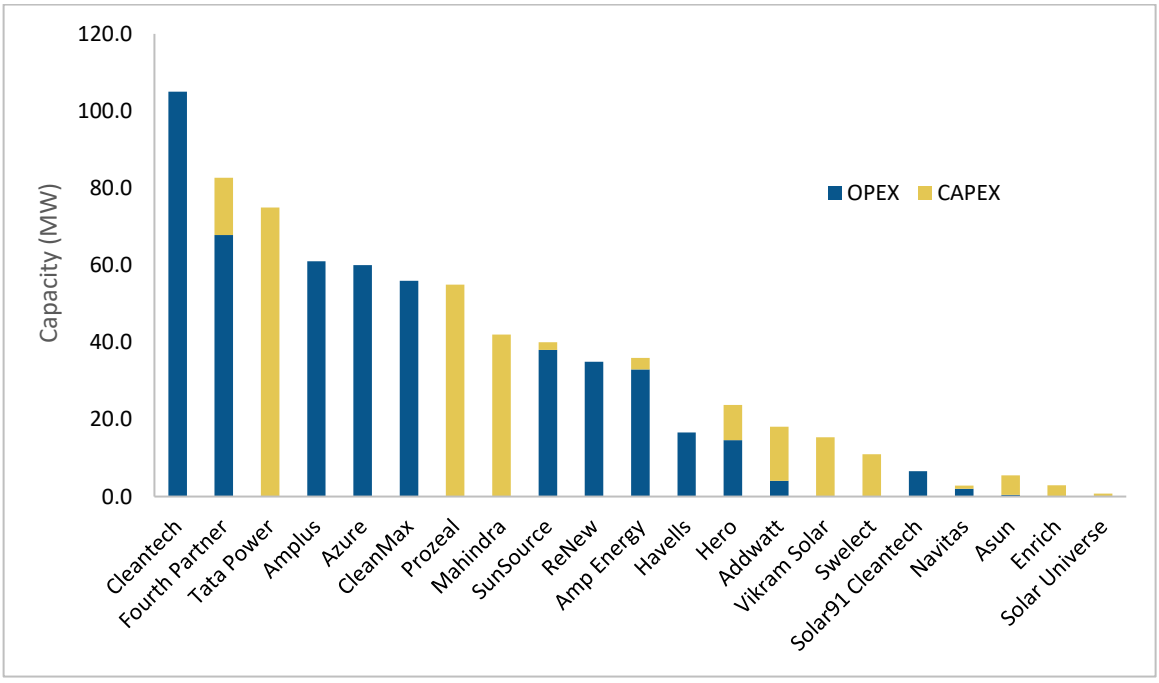
4. Key Players

Rooftop C&I market is primarily dominated by Resco players such as Amplus, Cleantech Solar, Fourth Partner, CleanMax, SunSource Energy and AMP Energy. As the market has matured, pure play engineering, procurement, and construction (EPC) players such as Fourth Partner and SunSource Energy have completely shifted their focus from Capex-based installations to Opex installations.

The Capex rooftop solar market is largely dominated by Tata Power, the oldest player in this sector. Two leading EPC players – Mahindra Susten and Sterling & Wilson, whose major focus had been only on utility scale projects, have also built significant capability around rooftop solar in the last few years.

Key independent power producers (IPPs) such as ReNew Power, Azure and Hero Future Energies who are mainstream players in utility scale solar market have also built their rooftop divisions and are focused mainly on tender-based government renewable energy service company (Resco) projects in order to secure scale with a low-risk counterparty.

Figure 8: Leading Onsite Rooftop Solar Players in India in 2019



Source: JMK Research.

Table 1: Leading Onsite Rooftop Solar Players in India

Company Name	Company Description	Rooftop Solar Capacity
ReNew Power	Leading renewable IPP with 10GW portfolio, half operational and half under development Access to low cost international funding Rooftop just 1% of total renewable portfolio Focus on government rooftop tenders mainly	118MW of rooftop solar capacity commissioned till Mar 31, 2020. 98% of installations are on Opex model
Amplus	Acquired by PETRONAS Group of Malaysia in 2019 with deal size of US$391m C&I is the major focus segment. In late 2019, Amplus opened a new division "Homescape" to cater to the residential segment. Amplus has a portfolio of 257MW of commissioned open access offsite solar parks to cater to the corporate segment under PPA route	Amplus owns and manages a portfolio of 650+MWp of operational and under construction distributed solar assets spread over 275 locations Portfolio of 200+ C&I customers
Cleantech Solar	Cleantech Solar was founded in 2014 and has Pan Asia presence across 8 countries. The Company is headquartered in Singapore. The Company develops, finances, owns and operates rooftop and open access projects for large industrial consumers. In January 2019, Shell invested US$100m in a 49% equity stake in the company	The Company has a portfolio of 500MW+ rooftop solar projects across Asia The Company has over 100 C&I customers across Asia
CleanMax	Founded in 2011, CleanMax has developed more than 500 turnkey solar projects The company is funded by marquee investors Warburg Pincus, IFC and UK Climate Investments LLP (UKCI) CleanMax also operates 380+MW of large-scale solar farms in Karnataka and Tamil Nadu, for supply to its corporate customers.	CleanMax has installed total rooftop solar operating capacity of 220+MW. Portfolio of 150+ C&I customers
Fourth Partner	Fourth Partner was established in 2010 and it has since focused on developing solar projects in C&I, governmental and institutional segments across India In June 2018 Fourth Partner received US$70m equity backing by the Texas Pacific Group (TPG).	With over 1,800 installations, Fourth Partner has a portfolio of ~ 400MW installed capacity across 23 states

SunSource Energy	The company was established in 2010 Experience of delivering more than 100 projects across the globe, with a footprint in several countries and nearly 18 Indian states	As of Mar 31, 2020, SunSource Energy has 67MW of Opex and 45MW Capex projects in India
Tata Power Solar	The Capex rooftop solar market is largely dominated by Tata Power, the oldest player in this sector	Tata had completed over 425MW of cumulative rooftop solar installations by March 31, 2020

Source: Company Websites, JMK Research.

5. Key Market Drivers

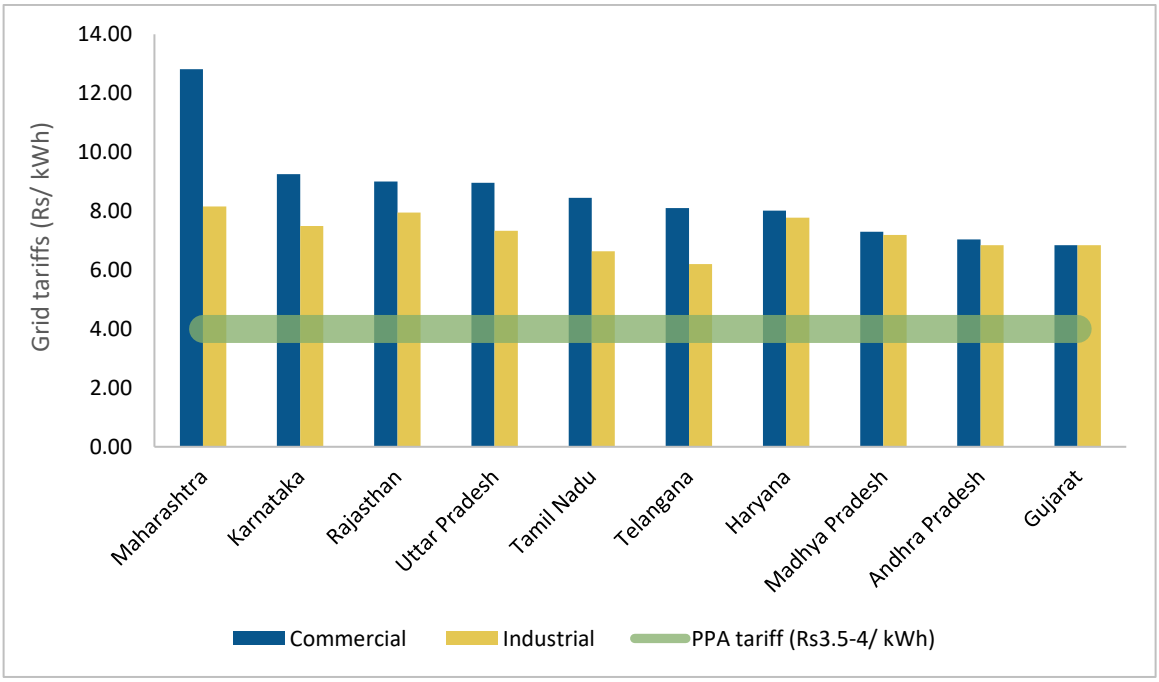
The rooftop solar market is growing consistently and is gaining an increasing share of the total renewable energy market. The C&I segment is adopting rooftop solar to take advantage of savings from falling project costs, rising grid tariffs, and cheaper financing. The clean energy imperative, as well as global renewable energy targets among multinationals such as the RE100+, are also driving the C&I sector's accelerating adoption of rooftop solar.

Improved Cost Savings

The average power grid tariff for the C&I segment ranges from Rs6-11/kWh (USD 0.080 –0.150 across India's top 10 states, while the average levelized cost of energy (LCOE) from a rooftop solar system is Rs3-5/kWh. C&I consumers can achieve cost savings of up to 50% by switching from grid-connected power to rooftop solar, adding real momentum to the adoption rate.

In addition, the payback period for rooftop solar projects is gradually shortening as the cost of equipment declines. Full payback under a Capex model can now be achieved in as little as 3-4 years. For an Opex project the cost of power is about Rs3.5-4/kWh, which is well below prevailing grid tariffs in most states.

Figure 9: Industrial and Commercial Grid Tariffs in India in 2019



Source: State Electricity Regulatory Commission (SERCs), JMK Research.
Note: Grid tariffs considered for the 33 kV HT category. Grid tariffs include variable energy charges, fuel surcharge and electricity duty, but do not include fixed (demand) charges.

Rising Consumer Awareness

Most C&I consumers who installed rooftop solar plants at some of their facilities are now expanding and planning to adopt rooftop solar across their other industrial assets. Consumers are driven by the popularity and the benefits of rooftop solar, especially the guaranteed cost savings and zero upfront capital investment under Opex model. C&I users have also become more socially responsible and are aware that using clean power improves goodwill among clients, staff, and industry peers. Additionally, the central government has distinguished itself as an early mover by earmarking Rs660m for capacity-building and awareness-raising under its Solar Rooftop Phase II programme.

Global Corporate RE Targets

Currently, only 3.5% of India's commercial and industrial sector is drawing power from renewable sources.[8] As awareness of the benefits of rooftop solar grows, several large Indian companies are planning to increasingly source power from renewable sources. Infosys, ITC, Godrej, Dalmia Cement, Mahindra Holidays & Resorts and Tata Motors, are Indian-headquartered companies that have voluntarily adopted 100% renewable electricity consumption targets. Additionally, there are more than 40 international RE100 companies that have a presence in India and are switching to renewable energy.[9]

Technical advances and regulatory mandates across specific geographic regions have opened new markets for developers.

[8] WWF India. SECI meets C&I customers to map competitive RE pricing. January 2020.
[9] The Climate Group. Corporate renewable energy sourcing: the way to 100% renewable electricity in India. October 2019.

6. Emerging Trends

With the introduction of supplementary components such as solar trackers and battery energy storage systems (BESS) to rooftop solar installations, and the ever-increasing adoption of high-efficiency solar modules, the ability to raise system efficiency levels has improved. These technologies have upgraded current rooftop solar systems to capture maximum solar radiation to increase input energy which increases their output. Battery systems store this intermittent power and can dispatch stabilised power on demand. And, apart from these technical advances, regulatory mandates across specific geographic regions (Daman and Diu) have opened new markets for developers.

Technology Shifting Towards Higher Efficiency Modules

The supply side of leading global module manufacturing companies is shifting to mono passivated emitter and rear cell (PERC) modules, bridging the gap between the prices of mono and poly crystalline modules. Industry participants expect the rooftop solar market to shift completely from poly to Mono PERC or Mono bifacial modules in the next 6-12 months. There are significant advantages of using a mono PERC module. The bifacial mono PERC modules are installed on a flat reinforced cement concrete (RCC) roof at a 15-20-degree tilt and provide an energy gain of approximately 3-4% which can go as high as 10% on a dust-free and sunny site.

The progressive increase in module capacity from 330-Watt peak to 500 Wp helps cut 10-15% from project costs due to the need for less space. Recently, two leading Chinese solar module manufacturers, Risen Energy and Trina Solar, unveiled first-of-a kind 500 W, 50-cell PV modules. These cost-saver modules need fewer racks and trackers per module, have low handling charges, and feature lower overall balance of system costs such as wires, cables, isolators, breakers, switches, and at least one inverter per unit of output. The high efficiency of these panels makes them ideal for C&I rooftops where space is limited.

Battery storage, where the consumer must manage peak load or replace diesel generators, is already feasible.

Chapter 11 has a detailed case study of an onsite solar project by Amplus for LAPP Industries which uses high-efficiency mono modules that increase energy generation.

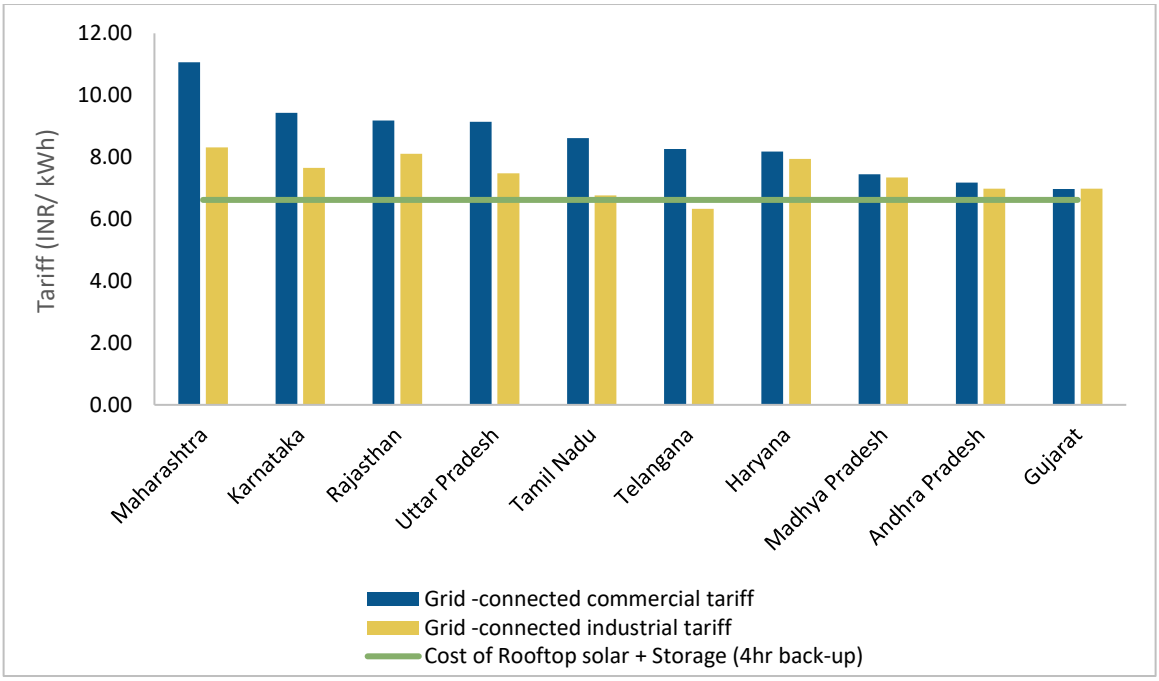
Rooftop Solar+Storage Solutions

Industry participants say storage is likely to constitute about 20% of all C&I installations in India in the next two years. Companies such as Infosys, which have 100% RE targets by 2030, have already started exploring storage solutions across their Indian office buildings. Storage is already a feasible solution in cases where the

consumer must manage its peak load for a certain time of month or year and where diesel generators must be replaced by a clean electricity supply.

Battery storage is one of the proven technologies that help overcome the intermittency of renewable power generation, resulting in stabilised power output. With battery prices declining, the viability of rooftop solar + storage systems in India is increasing. JMK Research finds that the levelized cost of energy (LCOE) for a 1MW rooftop solar system attached to 250 kW of energy storage with a backup of four hours will be around Rs6.6–6.8/kWh by next year[10]. This is less than the grid tariff for most commercial and industrial consumers, and well below the cost of power produced by diesel generators.

Figure 10: Grid Tariffs vs. Solar+Storage Tariffs



Source: JMK Research.
Note: Grid tariffs considered for the 33 kV HT category.
Grid tariffs include variable energy charges, fuel surcharge and electricity duty. Do not include fixed (demand) charges.

With tariffs moving closer towards 'time of day' (ToD) usage, battery storage will be increasingly economically viable for C&I consumers. Storage solutions will start making economic sense if deployed with other measures such as a critical power backup and managing peak load demand so that battery storage capacity is utilised up to the 80% threshold level. In most existing cases, the payback duration is longer because the battery utilisation rate typically varies between 35-50%.

In Chapter 11, a detailed case study on one of the onsite solar projects by U Solar for

[10] JMK Research. Viability of Solar+Storage solutions in India. January 2020.

Big Basket is profiled which uses a solar + storage solution to supply power and replace high-cost diesel generation.

Regulatory Mandates Opening Up New Markets

In September 2019, a change of solar policy in the newly-merged Union territories of Dadra & Nagar Haveli and Daman & Diu mandated that all existing and impending high tension (HT)/ extra high tension (EHT) industrial units must install solar rooftop projects of at least 5% of their contract demand. This mandate affected 3,000 small- and medium-scale industries in Daman & Diu, and about 2,000 small-scale units, 500 medium-scale units, and 28 large-scale enterprises in Dadra & Nagar Haveli.

Lower grid tariffs in union territories make them less favourable for the Opex financing model. As a result, all solar installations in these regions in the last year were mostly done via the Capex model.

Contracted Load Conditions Eased for MSMEs

The state of Gujarat has long pioneered the early adoption of renewable energy in India. To boost solar energy adoption by MSMEs, the state government implemented in September last year a range of measures under which:

- MSMEs are allowed to install solar projects with more than 100% of their sanctioned load or contract demand. Under the 2015 solar policy the permitted installation limit was 50% of the sanctioned load
- MSMEs will save Rs3.80/ kWh if they produce solar energy on their own land. If their land is leased, the profit will be Rs2.75/ kWh. At present, MSME units pay Rs8/ kWh for electricity. The new decision provides them a profit of Rs3/ kWh
- MSMEs will be allowed to buy solar power from third parties
- MSMEs will now be able to sell excess solar energy to the state government at a price of Rs1.75 (US$0.025)/kWh
- More than 33 lakhs (3.3 million) MSME units in Gujarat will be able to fast track their solar adoption plans

A detailed case study of onsite solar projects by Harsha Abakus for Sumip Composite is featured in Chapter 11. It has installed rooftop solar capacity on a MSME roof that exceeds 100% of its sanctioned load or contract demand.

The average size of rooftop solar systems in the C&I segment has increased in recent years. Industry participants say the average onsite rooftop solar plant size for a C&I consumer had been 800 kW to 1MW, but the average project size under discussion has risen to 2-5MW per installation.

7. Financing Trends in Rooftop C&I Segment

Various concessional credit lines for rooftop solar developers are available from multilateral agencies.

Table 2: Details of Concessional Credit Lines Available in India

Year	Lender	Borrower	Loan Approved	Objective	Features	Current Status
2016	World Bank	SBI	US$625m	Financing grid connected rooftop solar projects for C&I + institutional segments	Interest rate: 8–8.5% Repayment period- up to 15 years Debt Equity ratio 75:25	US$419m disbursed by World Bank to SBI. SBI further disbursed US$211m to end-consumer.[11] Key beneficiaries- Cleantech Solar, Amplus, CleanMax, SunSource, Fourth Partner, Azure, ReNew, Hinduja
2016	Asian Development Bank	PNB	US$500m	Funding large C&I-SRT projects on standalone or aggregated basis	Interest rate- 8-8.5% Repayment period- 15 years Debt Equity ratio 70:30	-
2015	KFW	IREDA	US$340m	Financing of wind and solar projects	Interest rates of 9% and >10.75% Repayment period- 9 years 1-year moratorium	Fully disbursed for RE projects with one small component of rooftop solar
2019	Green Climate Fund (GCF)	Tata Cleantech through NABARD	US$250m*	Creation of rooftop systems for C&I and residential segment	Rates of ≥9% depending upon customer credibility Repayment period: 12-15 years	GCF Disbursed US$50m to Tata Cleantech.[12] Key beneficiaries- Amplus Homescape

Source: JMK Research.
*Note: * GCF financing: US$100m, Co-financing: Tata Cleantech US$100m; US$50m from private equity investors.*

[11] World Bank. Grid-Connected Rooftop Solar Program update. December 2019.
[12] Green Climate Fund. GCF funded India solar rooftop programme kicks off. April 2019.

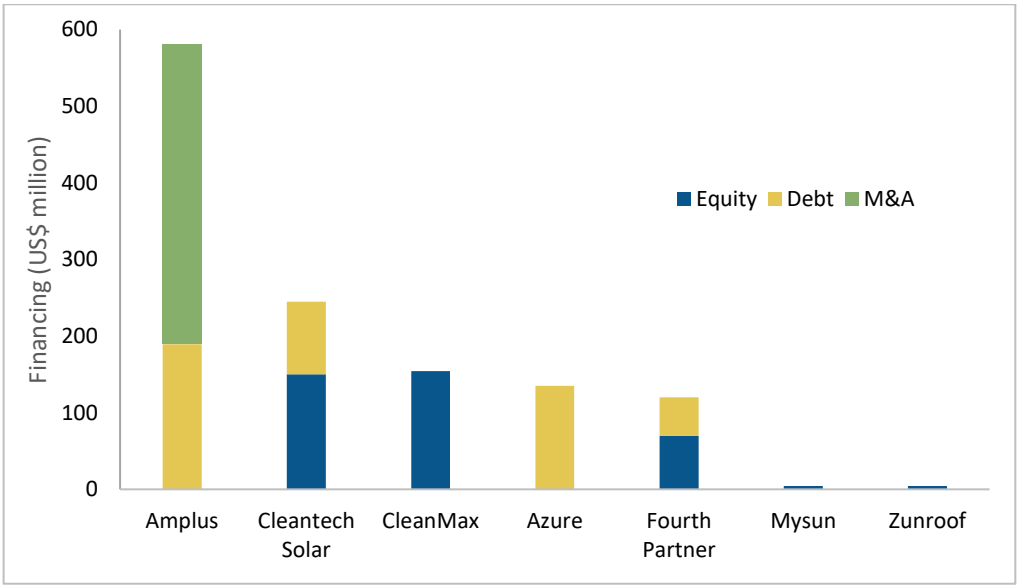
To make rooftop solar more affordable, the Government of India negotiated concessional lines of credit from the World Bank and the Asian Development Bank among others. The Indian Renewable Energy Development Agency (IREDA) formulated a scheme for system aggregators and developers in commercial, industrial and institutional segments, under which low cost loans would be provided for projects with minimum capacity of 1,000 kWp and with minimum capacity of sub-projects not less than 20 kWp.

The State Bank of India (SBI), PNB (Punjab National Bank), ICICI Bank and Axis bank, along with key financing companies such as Power Finance Corporation (PFC), Rural Electrification Corporation (REC), Tata Cleantech, Piramal Finance and L&T Financial Services provide non-concessional credit schemes.

Investments Raised by Key Rooftop Project Developers

Many established rooftop solar project developers were also able to successfully raise substantial equity as well as debt capital in the last three years. The PETRONAS Group acquired Amplus for $391m. Other significant player is Cleantech Solar which raised $240m as both equity and debt.

Figure 11: Key Investment Deals in Rooftop Solar Sector in India (2017-2020)



Source: JMK Research.

From 2017 onwards, rooftop solar sector companies raised about more than US$1,249 m in funding. Of this about 31% (US$383m) is equity funding while 38% (US$475m) is debt. The remaining 31% (US$391m) is PETRONAS Group of Malaysia's acquisition of Amplus in April 2019.

Table 3: Key Financing Deals of Leaders in the Rooftop Solar C&I Segment

Date	Company Name	Deal Type	Investor	Deal Value	Stake Acquired
Jun 2020	Cleantech Solar	Debt	ING Bank NV Singapore	$ 75 m	-
Apr 2020	MYSUN	Equity (Pre-Series A funding)	Existing investors	$4.26 m	-
Apr 2020	Amplus	Debt	Standard Chartered Bank	$96.8 m	
Mar 2020	ZunRoof	Equity	Godrej	$3 m	-
Mar 2020	Fourth Partner Energy	Debt	Gramin Impact India	$0.07 m	-
Feb 2020	Origin Renewables Pvt Ltd	M&A	Everstone Capital and Lightsource BP	-	100%
Dec 2019	Fourth Partner Energy	Debt	Bank of America	$50 m	-
Nov 2019	Amplus	Debt	Standard Chartered Bank	$48.2 m	
Oct 2019	Orb Energy	M&A	Shell New Energies	-	20%
Jul 2019	Amplus	Debt	Standard Chartered Bank	$49.6 m	
May 2019	ZunRoof	Equity	Godrej Properties	$1.2 m	-
Apr 2019	CleanMax Solar	Equity	UK Climate Investments	$39.4 m	-
Apr 2019	Amplus Energy	M&A	PETRONAS	$391 m	100%
Jan 2019	Cleantech Solar	Equity	Shell New Energies	$100 m	49%
Sep 2018	Cleantech Solar	Equity	Climate Fund Managers	$50 m	-
Jun 2018	Fourth Partner Energy	Equity	TPG's The Rise Fund	$70 m	-
May 2018	Azure Power	Debt	IFC, Dutch development bank FMO, French development FI Proparco and Austrian development bank OeEB	$135 m	-
Feb 2018	SunSource Energy	Equity	Neev Fund	-	-
Nov 2017	CleanMax	Equity	IFC	$15 m	-
Nov 2017	Cleantech Solar	Debt	ResponsAbility	$20 m	-
Jul 2017	CleanMax	Equity	Warburg Pincus	$100 m	-

Source: JMK Research.

New Innovative Financing Models to Boost Adoption in MSME Segment

The market growth seen in the C&I segment so far is largely driven by a few entities such as large creditworthy organisations. Because financial institutions prefer borrowers with a strong financial track-record and credit ratings of BBB+, loans and

other financial services are largely provided to a few elite consumers. But this growth also suggests there are myriad market expansion opportunities among micro, small- and medium-sized enterprises if they can get appropriate financing.

To this end, specialised non-banking financial companies (NBFCs) and funds have formed strategic partnerships to develop and scale commercial rooftop solar finance solutions.

In June 2019, Encourage Capital LLC, an impact investment asset manager and advisory firm, announced the first close of its new $40 million Encourage Solar Finance LP private equity fund.

In November 2019, technology-enabled small business lending platform U GRO entered a co-lending programme with Sunvest Capital, India's first dedicated rooftop solar financing NBFC. By leveraging the expertise and market intelligence of Sunvest and the tech-driven knowledge of U GRO in SME lending, the co-lending programme with capital of Rs20 crore ($267,000) intends to power the clean energy initiatives of MSMEs.

Other than these small specific initiatives, innovative financing models supported by MNRE and Ministry of MSME could lead extensive adoption of solar power in this segment.

Some of the models that can be explored for MSME financing are:

- **Partial Risk Guarantee Fund / Credit Guarantee Mechanism**

  This risk-sharing mechanism would act as a shield for the lenders against borrower defaults. If a borrower's business were to shut down, this fund would partially cover the lender's losses. Implementing a CGM would improve the risk profile of rooftop solar projects, reducing the interest rates on project loans for MSMEs.

- **Standardisation of Solar Loan Products**

  A well-structured template for information collection, project assessment and risk evaluation would address the high transactional cost and time taken to finalise Capex loans for rooftop solar projects, especially more modest installations. Such a loan product would enable lenders to make informed decisions more quickly and provide greater clarity for borrowers.

- **First Loss Portfolio Guarantee**

  In some jurisdictions, a first loss portfolio guarantee (FLPG) is established to provide credit enhancement to lenders. A third party such as a government investment fund indemnifies lenders against losses for a given amount or percentage of any losses they might incur from a default, for example.

  In this way a development fund can be a guarantor for banks, enabling them to lend to SMEs because their first risk is already hedged to a certain extent. This

mechanism ease some of the difficulty SMEs face in accessing finance mainly due to their lack of sufficient collateral and credit ratings below BBB+ which leads to high interest rates. Close private and public sector cooperation would be needed for such a mechanism to succeed.

8. Challenges

The solar rooftop market in recent years has gained significant traction in India because it has attractive medium-term prospects in the renewable energy sector. But this this market has been grappling with many prolonged challenges such as frequent policy changes, non-standardisation of approval process across states– especially for net-metering – and a lack of good creditworthy consumers. Amid these issues has come the unprecedented COVID-19 pandemic, resulting in a country-wide lockdown. How these factors have affected the rooftop solar market growth are discussed below:

COVID-19's Impact on the Market

COVID-19 has hit the solar rooftop segment much harder than utility-scale solar because most of the rooftop developer firms are small. Given their weak financial resilience, these small players will struggle to absorb losses or to meet extra operational expenses arising from the COVID-induced lockdown. Challenges include:

- **Reduced demand:** It is anticipated that for the first few month's post-lockdown, rooftop solar demand in the C&I segment will be low because consumers will be conserving cash and will focus on finding ways normalise their core business operations. In such cases, most consumers will start looking at Opex model installations. Cash-rich FMCG and multinational companies generally preferred using the Capex option to finance rooftop solar projects, but post COVID-19 they may face liquidity issues and could consider following the Opex route.

- **Higher PPA tariffs for Opex projects:** COVID-19 could severely undermine clients' credit ratings leading developers to factor in greater credit risk, resulting in higher tariff offers.

- **Additional due diligence on end-consumers:** For Resco projects, credit ratings will not be the only acceptable parameter and additional due diligence will be done by developers on their clients' market position, relationships with vendors, GST filing trends and the like.

- **High construction cost:** The cost of materials and labour is expected to increase in the short-term after lockdown because of nationwide shortages, consequently raising overall project costs. Additional expenses will be incurred from implementing more stringent post-COVID standard operating procedures and safety measures.

- **Construction delays:** For projects under construction and in the pipeline before when the nationwide lockdown took effect, project completion and commissioning has been delayed by 3-6 months or longer depending on labour availability. India's supply of solar equipment is hugely dependent on imports from China. As the first country to experience COVID, China has come in for severe disruption of manufacturing and supply chains across different sectors, including renewables, since January 2020. Because of this constricted supply,

India's rooftop solar market was feeling the logistical pinch even before the lockdown was imposed.

- **Payment delays:** The pandemic has caused 2-3-month payment delays across the sector. Developers have had to act fast to ensure that there was no disruption of short-term cash flows. Moreover, risks to developers' financial stability will multiply at if C&I demand remains stagnant long after the lockdown measures are eased.

On a more positive note, virtually every business segment post COVID-19 would like to preserve capital and find ways cut costs. In this case, rooftop solar is the obvious choice to save on electricity costs.

Regulatory Uncertainty

Policy uncertainty is the biggest issue hampering the growth of rooftop solar in India. Regions where discoms are fearful of losing their high paying C&I consumers are issuing orders and notifications (as listed in Table 4) to restrain net metering and power banking provisions.

In addition to the above states, Maharashtra – India's biggest industrial state – has introduced a new impost, namely grid support charges (GSC) for consumers that have a sanctioned load above 10 kW for rooftop solar. These GSC charges will be based on the cost of building distribution infrastructure and the cost of balancing the grid and banking energy. A new notification was later issued, declaring that unless Maharashtra was to achieve its 2,000MW rooftop solar target, no GSC would be applied.

But in the long term, GSC rates will be applicable and will be the deciding factor in the viability of large rooftop solar installations in Maharashtra. Such fluctuations in policy create confusion among all stakeholders and lead to unnecessary delays.

Table 4: Recent Amendments to Rooftop Solar Regulations in India

State Name	Provision in Original Net-metering Regulations	Recent Amendments
Uttar Pradesh	All consumers are eligible for net metering	In the January 2019 notification, C&I consumers are no longer eligible for net metering. These customers can now only opt for gross metering. Under gross metering, electricity for C&I customers will receive compensation at weighted average tariff of large-scale solar projects (>5MW), discovered through competitive bidding in last financial year and adopted by commission, plus an incentive of 25%.
Tamil Nadu	Net metering available for domestic, commercial and government buildings	In the March 2019 notification, C&I consumers (except Low tension (LT) commercial) are no longer eligible for net metering. Gross metering is also not allowed for HT C&I consumers.
Himachal Pradesh	All consumers of discoms are eligible for net metering	In April 2019, only domestic consumers with a letter of approval are eligible for net metering, while C&I consumers are not eligible anymore. Gross metering is also not allowed in Himachal Pradesh.
Karnataka	All consumers are eligible for net metering	In December 2019, in an order passed by Karnataka Electricity Regulatory Commission (KERC), net metering or gross metering was allowed for all LT residential consumers. For all other LT & HT categories of consumers, only gross metering is allowed.
Rajasthan	Banking of power is allowed for a year for C&I consumers	Banking of power is allowed for a month for C&I consumers.
Andhra Pradesh	Banking is allowed for all renewable sources	In November 2019, a notification was issued under which energy banking facility is withdrawn from all solar and wind generators.

Source: JMK Research.

Uncertainty over New Duty Structure for Modules

Any change in duties on modules will have a direct impact on the rooftop solar industry. Even when the safeguard duty was implemented, many utility scale developers were exempted because of the "change in law" / "grandfathering" clause. However, this is not the case with rooftop solar developers. The current safeguard duty regime on modules is also going to end in July 2020 and new duties in the form of Basic Custom Duty (BCD) will be introduced. However, there is no new notification from the government on the new duty structure and, for now, it is a quandary. Rooftop project developers argue that authorities should give a minimum 3-6 months notice to developers before announcing any new policy/ directive. This would allow developers to plan and reflect the impact of such policy changes in their projects.

Slowdown Across Industrial Sectors

There has been an overall slowdown in the industrial segment over the last year. Industrial output for FY2019/20 contracted by 0.7% compared with a growth rate of 3.8% in FY2018/19.[13] Manufacturing and the automotive sector are the worst hit sectors. Last year saw the fewest-ever rooftop solar installations in the automotive sector. As the automotive market transitions to electric power, many domestic original equipment manufacturers (OEMs) and component makers are doubting their businesses' long-term viability. They are not looking to enter into any long-term contractual agreements under the Opex model and neither do they wish to make major capital investments.

Financing Challenges

Rooftop solar financing is non-recourse and rooftop solar projects are not considered as collateral. Lenders do not identify rooftop solar systems as an asset. Because rooftop solar projects are generally small scale, they are not a particularly attractive proposition for banks and major financial institutions, whose focus is always on big ground-mounted solar projects. Concessional credit lines are available to just a select few big developers because of the detailed compliance requirements that must be met. Some companies have set up a dedicated team to manage the compliance process. Over time, however, the compliance processes to access this concessional credit have been streamlined and simplified to some extent, but there is still a potentially large unmet market.

Processes to access concessional credit have been simplified to some extent, but there is still a potentially large unmet market.

[13] Business Standard. Record fall in March as IIP crashes to 16.7%, FY20 growth squeezed by 0.7%. May 2020.

9. Conclusion

The C&I rooftop solar market potential in India is vast, and what this report has explored is just the tip of the iceberg. Only 3.5% of the power procured by India's C&I segment is from renewable sources.[14] To increase the share of rooftop solar in the C&I market, many policy–related changes must be explored. Examples from developed countries can be considered for ways to speed up this sector's growth. California, for example, has mandated that from January this year power companies must take 50% of their total energy from renewable sources (especially solar power).

Policies across India's states must also be streamlined. Uneven and changeable regulations have created confusion in the market. Additionally, policies should not be retrospective and should not apply to already-commissioned projects. All changes under new regulations and policies should be for new projects only.

The government has planned some large-scale investments that will drive this market. One of them is the Ministry of New and Renewable Energy's Rooftop Phase II programme that targets adding 18GW of rooftop solar via discom incentives.

Under the recently issued Draft Electricity Amendment Act 2020, several progressive measures are also planned for the renewable energy sector such as introducing a pan-India renewable purchase obligation (RPO) with a stringent penalty mechanism. RPOs compel discoms and other large electricity consumers to buy a certain percentage of their power requirements from renewable energy sources. Such a measure would provide a significant boost to the uptake of rooftop solar in the C&I segment.

Azure Power is the most recent and prominent name in the list of solar rooftop players to exit the market. Many small engineering, procurement and construction (EPC) players have quit the market in the past year because they could not raise sufficient funding to expand their portfolio. Most of these players have a specific regional focus and any change in policy can make their business unviable. A diversified portfolio across different geographies is needed to stay afloat in this highly price-sensitive and competitive market.

Technological innovations such as high-efficiency modules, use of trackers and battery storage will drive the growth of this market. Some of the detailed case studies in the next section highlight the key innovations that leading players have adopted in rooftop solar projects and how that is related to the scale of the rooftop project, type of roof, use of trackers, use of high efficiency modules, and the viability of battery storage.

[14] WWF India. SECI meets C&I customers to map competitive RE pricing. January 2020.

Annexure: Project Case Studies

Apollo Tyres by Cleantech Solar (12MWp large scale Rooftop Solar Plant)

Site Name		Apollo Tyres Chennai
Location		Oragadam, Chennai
AC Capacity		12MWp
DC Capacity		-
Year of Commissioning		2019
Installation type (rooftop. Ground mount/ carport etc.)		Rooftop
Project Type		Opex
Net metering		There is no net metering facility available in Tamil Nadu
Grid Interconnection Voltage		Power is evacuated at 11kV
Construction time		5 months
Equipment suppliers	**Module make and specifications**	Canadian, Trina and JA Solar (325 Wp and 330 Wp)

	No. of modules	37,000
	Inverter make and specifications	SMA (60 kWp) ABB (1.7MW)
Plant Performance	**Annual generation capacity**	12MWp
	Plant CUF	16.6%
	Plant Performance ratio	78.1%
Benefit to customer	**CO2 offset**	13,000 metric tonnes per annum

Project Unique Proposition

This state-of-the-art 12MW solar PV project was executed with thorough planning and careful design; it features an optimal electrical design and layout tailored to the customer's electrical network along with walkways, safety lifelines and safety handrails installed over the entire expanse of the system. The project set a new benchmark for standards of quality, performance, and safety in the industry.

Challenges and Solutions

Project Size and Execution

It was challenging to execute a project of this size and expanse at a customer's existing facility with strict health, Safety and Environment (HSE) norms and operating procedures in place, whilst adhering to strict deadlines. To add to the complexity of the project, the cable routing had to be done without disturbing the aesthetics of the facility, which was essential to the customer. Furthermore, working at heights of over 50 feet required strict safety, design, and execution practices.

LAPP India by Amplus (Onsite Solar Plant with Trackers)

Site Name		LAPP-INDIA, Bhopal, Madhya Pradesh
AC Capacity		745.2 kWp
DC Capacity		993.6 kWp
Date of Commissioning		25 Jan 2019
Project type		Opex
Net metering		Available
Grid Interconnection Voltage		415 V
Construction time		90 Days
O&M details		Handed over on 12 Feb 2019
Equipment suppliers	**Installation type (rooftop. Ground mount/ carport etc.)**	Ground Mount – Single Axis Tracker
	Modules make and specifications	Sun Power, 345Wp, Model: SPR-P17-345-COM
	No. of modules	2,880

	Inverters make and specifications	Solar Edge, 82.8KWp, 3 Phase String type, model:SE-82.2K
Plant Performance	**Annual generation capacity**	1721MWh/Year
	Plant CUF	21%
	Plant Performance ratio	77.44%
	Power demand met through this plant	35-40%
Savings	**Cost Savings in last year**	Rs4.45 m
	Projected savings for next 25 years	Rs210 m
	CO_2 offset	31,845 tCO_2
Project Financing	**Funding agency**	Tata Cleantech Capital Limited
	Debt: Equity ratio	Financing has been done on a portfolio basis and an overall loan of Rs 128.23 Crore has been sanctioned for a capacity of about 34.3MWp. The Overall D:E ratio of portfolio was 53.7:46.3
	Loan tenor	Repayment tenor of loan is 14 years starting from Q1 FY 2020 and ending Q4 FY 2033

Project Unique Proposition

Implementing Technologies That Drive Higher Generation Efficiency

This project has set a benchmark for efficient generation. This ground-mounted installation has a single axis tracker along with a combination of technologies to improve performance under space constraints. Amplus' engineering team, based on its research, designed the project with following features to maximise generation efficiency.

It features a single axis tracker that plots the sun's position of sun and rotates using gears and motors to best position solar modules.

The SunPower mono modules used in this project are more efficient in producing electricity than PERC modules.

The SolarEdge micro inverters used in the project have module-level maximum power point tracking (MPPT) while standard inverters of the same capacity have 2-3 MPPTs. This module-level feature intensifies the installation's generation output at all times. Accordingly, plant generation has increased by 8-9%.

Challenges and Solutions

Novelty of the Inverter

While Amplus has experience in installing single axis trackers, the micro inverters were a challenge since because the Amplus team was installing them for the first time. The SolarEdge provided technical support during the execution stage and the project was successfully commissioned.

Integration of a New Inverter System with Amplus Monitoring

Amplus has a cloud-based centralised system for to monitor project performance for its operations team. It was a challenge to integrate the SolarEdge inverter into the system, but the SolarEdge technical team again provided support.

Third Party Ownership of Land for a Ground-Mounted Project

Unusually for a ground a ground-mounted project, the customer did not own the underlying property. The land was leased by M P Audyogik Kendriya Vikas Nigam (AKVN) to LAPP via a tripartite agreement between Amplus, Lapp and AKVN.

Jubilant FoodWorks by SunSource Energy

Site Name	Jubilant Food Works Ltd. (Dominos India)
Location	Greater Noida, Uttar Pradesh
AC Capacity	600 kW
DC Capacity	793 KWp
Year of Commissioning	January 2019
Installation type (rooftop. Ground mount/ carport etc.)	Rooftop
Net metering	Yes
Grid Interconnection Voltage	415 V
Construction time	3 months
O&M details	25 years
Module make and specifications	REC- 325Wp

No. of modules		2440
Inverter make and specifications		Sungrow String Inverter
Plant Performance	**Annual generation capacity**	~1mn kWh
	Plant CUF	17%
	Power demand met through this plant	20%
Benefit to customer	**Cost Savings**	Rs81m for a project lifetime of 25 years From commissioning date till now over Rs4m saved
	CO2 offset	About 20,000t over the project lifetime (25 years)
Project Financing	**Funding agency**	State Bank of India
	Debt: Equity ratio	70:30
	Loan tenor	15 years
	PPA Contract term	25 years
	Project Type	Opex

Project Unique Proposition

Jubilant FoodWorks Ltd is a food service company that has the exclusive rights to develop and operate Domino's Pizza brand in India, Sri Lanka, Bangladesh and Nepal. At present it operates in India and Sri Lanka and has signed a joint venture for operating in Bangladesh. The company also has exclusive rights for developing and operating Dunkin' Donuts restaurants for India.

As Jubilant is a food works company and the plant produce food items that are used at Dominos outlets, the solar power project has been developed as a non-penetrating structure**.** This is to ensure that the rooftop installation does add moisture to the facility because it can damage items such as dough and pizza bases. The plant has to maintain maximum hygiene and quality standards to adhere to the global Dominos guidelines and stringent Food Safety and Standards Authority of India (FSSAI) requirements.

Because the plant is net metered, the client can generate additional revenue by selling excess electricity to the discom, while the discom can have additional power without have to spend on transmission infrastructure. Other benefits to the discom are reduced administrative costs and reduced network congestion.

Challenges and Solutions

Module Mounting Without Shading

Plant aesthetics are important for this facility because it frequently hosts visitors. To ensure an attractive appearance, a short aluminium rail module mounting structure (MMS) and adhesive-based system is installed. Metal–to-metal bonding applications were used where the aluminium structures and other metallic materials were fixed to the metal shed. Low-read-through (LRT) acrylic adhesive with Lord Accelerator 20 Solution ensures no moisture penetration.

Synchronisation With Diesel Generator

When diesel generation is synchronised with solar power during a grid power failure solar power generation can exceed consumption. This means excess solar power flows to the diesel generator (DG set) and can damage it. To ensure a minimum DG load requirement and no power feedback in the DG system, a smart controller was installed.

Sumip Composite Pvt Ltd by Harsha Abakus (Curved Roof)

Site Name		Sumip Composite Pvt Ltd
Location		Changodar, Ahmedabad, State-Gujarat, India
AC Capacity		143 kW
DC Capacity		150 kWp
Year of Commissioning		2020
Installation type (rooftop. Ground mount/ carport etc.)		Curved rooftop project
Net metering		Project is installed under an availability- based tariff metering system
Grid Interconnection Voltage		415 Volt
Construction time		75 Days
O&M details		Non-comprehensive O&M for 1 year
Equipment suppliers	**Module make and specifications**	Canadian Poly PERC Modules, 355 Wp
	No. of modules	425

	Inverter make and specifications	SunGrow inverters, (20 kW*3), 33 & 55 kW each
Plant Performance	**Annual generation capacity**	2,25,000 kWh (for first year)
	Plant CUF	18%
	Plant Performance ratio	75.5%
	Power demand met through this plant	35% of the total contract demand
Benefit to Customer	**Cost Savings**	Rs1.5m for first year (considered Rs6.5/ kWh as the industrial tariff & 1,50,000 Units per 100 KWp in first year)
	Projected savings for next 25 years	Rs33.6 m (considered degradation of 0.7% y-o-y from second year onwards, first year degradation is 2.5%)
	CO2 offset	5 million metric tonnes over 25 years
Project Cost	**Module Cost**	55% of project cost
	Inverter Cost	11% of project cost
Project Financing	**Project Type**	Capex
	Debt: Equity ratio	70:30
	Payback period	Less than 4 years

Project Unique Proposition

This is one of the first C&I rooftop solar installations Gujarat with solar capacity above 100% of its sanctioned load. In Sept 2019, the Gujarat government relaxed the state's solar policy to allow MSMEs to install solar projects that exceeded 100% of their sanctioned load or contract demand. Before this, the Gujarat Solar Policy (2015) allowed C&I clients to install only 50% of their sanctioned load.

This is the third rooftop solar PV project for Sumip Composite. Over two Harsha Abakus has cumulatively installed 350 kWp of rooftop solar plant on Sumpip Composite's premises at Ahmedabad and Viramgam in Gujarat.

Surplus generation from such plants also helps discoms fulfil their renewables purchase obligation and avoid having to buy renewable energy certificates. It reduces transmission and distribution losses since generation and consumption points are on the same premises. It reduces the capacity requirement for discoms

and can at times substitute for energy procurement from expensive generators and power exchanges as well as helping discoms to manage peak-hour demand.

Challenges and Solutions

Roof Access and a Labour Crunch

Key challenges included the height of the metal roof, which is almost 55 metres from ground level, access to the roof for installation, the slope of the metal roof, high temperatures, and the COVID-19 pandemic. Roof access is via a walkway–type ladder. Safety lines and harnesses were used for the installation work around the roof, ruling out falls and ensuring workers' safety.

A non-penetrative, clamp-type module mounting structure (MMS) was used on the curved roof. The project's biggest challenge was COVID-19. Because of the pandemic, all work was halted. When the lockdown 3.0 was lifted, Harsha Abakus managed to get local skilled workers for the curved-roof installation and completed the project.

Big Basket Warehouse by U-Solar (Solar+Storage Solution)

Site Name		Big Basket Warehouse
Location		Kataria Chowk, Gurgaon, Haryana
AC Capacity		116 kW
DC Capacity		144 kW
Net metering		Not applicable; micro-grid connection
Construction time		3 months
O&M details		Monthly O&M contract including module cleaning by U-Solar Clean Energy
Date of Commissioning		December 2019
Installation type **(rooftop. Ground mount/ carport etc.)**		Rooftop solar + battery storage
Equipment suppliers	**Module make and specifications**	Monocrystalline 330Wp by Adani
	No. of modules	434
	Inverter make and specifications	Delta, 1x69 kW + 1x50 kW
	Battery Capacity	281 kWh
	Battery Technology	Lithium ion
	Battery make and specifications	Narada
Plant Performance	**Annual generation capacity**	~ 2, 01, 600 kWh
	Plant CUF	15% (standard); specific yield of 3.5 kWh/kW
	Plant Performance ratio	75.54%
Benefit to customer	**Cost Savings in last year**	Rs 0.9m
	Projected savings for next 25 years	Rs111.5 m (projected)
	CO2 offset	196 tonnes of CO2/ every year
	Power demand met through this plant	~ 85% of total load provided by solar + battery
	Project type	Opex
	PPA Tariff	Rs12.5/kWh

Project Financing	**Funding agency**	U-Solar Clean Energy Solutions Ltd.
	Payback period	7 years

Project Unique Proposition

This facility is not connected to the grid and uses large amounts of diesel fuel, causing environmental damage as well as incurring high energy costs. U-Solar's solution was to synchronise the diesel generator to the solar rooftop power plant and storage system to create a micro-grid.

This innovation has reduced Big Basket Kataria's use of the diesel generator to 8 hours a day from 24. It now largely relies solar generation during the day and its 281 KW battery at night. The micro-grid solution is ideal for facilities that have high diesel dependence. The system is configured to ensure that the solar power is used as a primary source, the battery as the secondary source, and the diesel generator as a backup.

Challenges and Solutions

Lack of Grid Access as Well as High Dependence on Diesel Genset

Diesel costs Rs55/litre (USD 0.73) producing electricity at a cost of Rs25/kWh. The project's power purchase agreement (PPA) supplies electricity at Rs12.5/kWh. The warehouse is in a remote location without grid access, ruling out a grid-tie connection. A solar + battery storage system solves both problems. It utilises solar power during the day and stores excess solar power. However, the diesel generator is still operated at 30% load because of synchronisation.

The micro-grid plant at Kataria Chowk, Haryana, addresses operational, technical, cost issues as well as reducing environmental harm.

World's Largest Solar Rooftop Installation on a Cricket Stadium, at Brabourne, Mumbai by Tata Power Solar

Site Name		Stadium Roof of the Brabourne Stadium
Location		Cricket Club of India Ltd, Churchgate, Mumbai
AC Capacity		700 kW
DC Capacity		820.8 kW
Net metering		Yes. With Discom: Brihanmumbai Suburban Electric Supply (BSES)
Construction time		4 Months
O&M details		2 Years O&M with generation guarantee
Date of Commissioning		15th August 2018
Installation type		Roof top
Equipment suppliers	**Module make and specifications**	Make: JA Solar, Rating: 360 Wp Mono crystalline
	No. of modules	2280

	Inverter make and specifications	Delta RPI-M50A 50kW X 14 nos.
Plant Performance	**Annual generation capacity**	1.12 million units per annum
	Plant CUF	16%
	Plant Performance ratio	84.4%
	Project Type	Capex
Benefit to Customer	**Cost Savings in last year**	25% saving on annual power costs
	CO2 offset	Offset 840 tonnes of carbon annually
Project Cost		Module: Rs20 m, Inverter: Rs2.5 m

Project Unique Proposition

The environmental impact of large-scale sporting events is a serious concern and organizations across the world have taken concrete steps towards mitigating such harms through sustainability initiatives such as using renewable energy. The solar rooftop project at Brabourne stadium generates over 1.12 million units of electricity per year, cutting its power consumption costs by 25%. The customer, Cricket Club of India (CCI), now avoids the emission of over 840 tonnes of carbon dioxide annually. This landmark project was completed within a record period of 100 days.

Challenges and Solutions

Cable Laying

A total 3.6 km of AC cable was laid, routing from the AC distribution panel box to the low-tension (LT) room (8 run x 400 Sqmm): This job was conducted with extreme safety precautions because there was minimum space available on the site.

Module Lifting

Due to insufficient space available for lifting the equipment at site, all solar modules were moved manually to the installation area.

Cable Crossing Between Two Ends of the Stadium

Cable crossing was a concern. A cross-over bridge was constructed with proper design with approval from the client.

Termination of Evacuation Cable to Customer LT Panel

Shutting down the main LT panel was not possible in daytime due to the CCI Club's routine activities. To ensure minimum disruption for CCI Club, all cable-related work was done after midnight.

About JMK Research & Analytics

JMK Research & Analytics provides research and advisory services to Indian and International clients across Renewables, Electric mobility, and the Battery storage market. www.jmkresearch.com

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The Institute for Energy Economics and Financial Analysis (IEEFA) examines issues related to energy markets, trends and policies. The Institute's mission is to accelerate the transition to a diverse, sustainable and profitable energy economy. www.ieefa.org

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