Accelerating India's Clean Energy Transition

The future of rooftop PV and other distributed energy markets in India

November 28, 2017

Bloomberg New Energy Finance

Executive summary (1/3)

India is accelerating development of renewable energy projects to provide cheap, reliable and clean energy to its 1.3 billion people. Rooftop solar continues to be the fastest growing sub-sector, and needs to grow faster still to reach the ambitious 40GW target, which presents a $23 billion investment opportunity.

Installation of renewable energy projects will be higher than fossils fuel technologies for the first time in 2017 and in the years thereafter. The country added 12GW of renewable energy plants in FY2017 (April 2016 to March 2017) – a 66% year-on-year growth over FY2016.

Fast growth is not fast enough. Rooftop PV continued to be the fastest renewables sub-segment in India and has clocked a four-year compound annual growth rate of 117%. With a cumulative installed capacity of 1.3GW at the end of FY2017 however, India achieved only 3% of its target capacity addition of 40GW by FY2022.

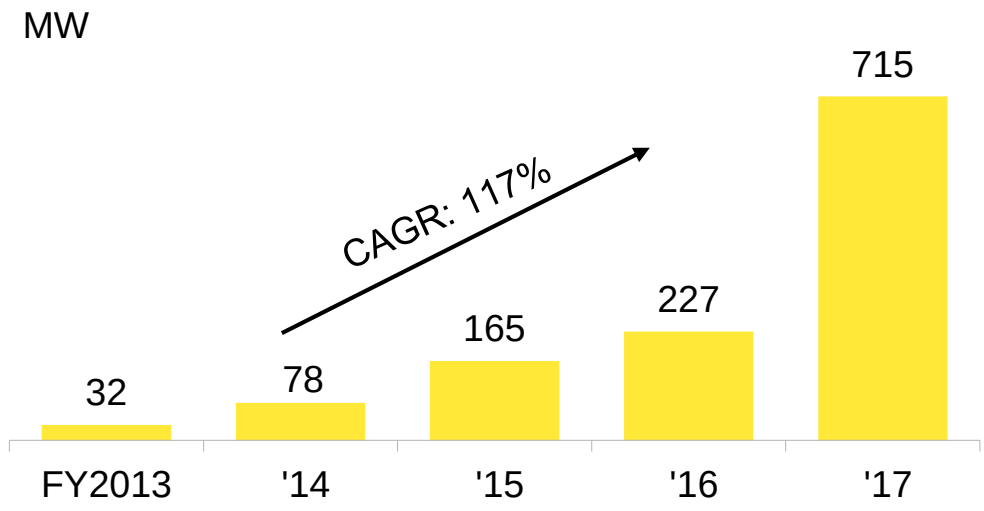
Residential sector PV growth will pickup post-2021. High upfront capital expenditure compared to commercial and industrial (C&I) consumers, lack of financing options, and cheaper grid electricity for residential consumers with low consumption currently make rooftop PV less attractive for residential consumers than their C&I counterparts.

12GW Renewable energy installations in India in FY2017

715MW Rooftop PV installations in India in FY2017

117% Growth rate of rooftop PV in India since April 2013

Annual rooftop PV installations in India



Source: Bloomberg New Energy Finance, industry surveys, Ministry of New and Renewable Energy. Note: India's financial year is from April to March.

Executive summary (2/3)

PV has a big potential to power irrigation and reduce the use of back-up diesel generators. 60GW of small-scale PV can be deployed across various sectors consuming diesel.

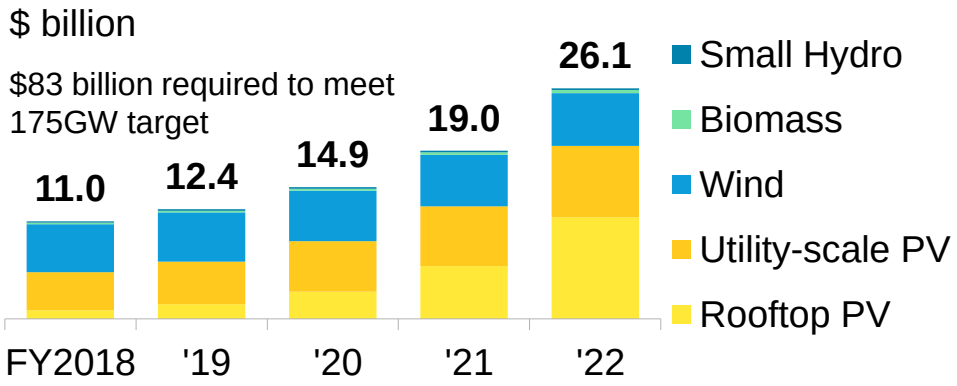
India's ambitious targets have received a shot in the arm from falling capital costs. India would need $83 billion between FY2018-FY2022 to meet its 175GW target. Utility-scale renewable energy aspirations of 135GW will require $19 billion less than our previous estimates.

Average cost of debt for renewable energy projects in India has come down. However at 9-11%, debt is still among the most expensive in Asian countries.

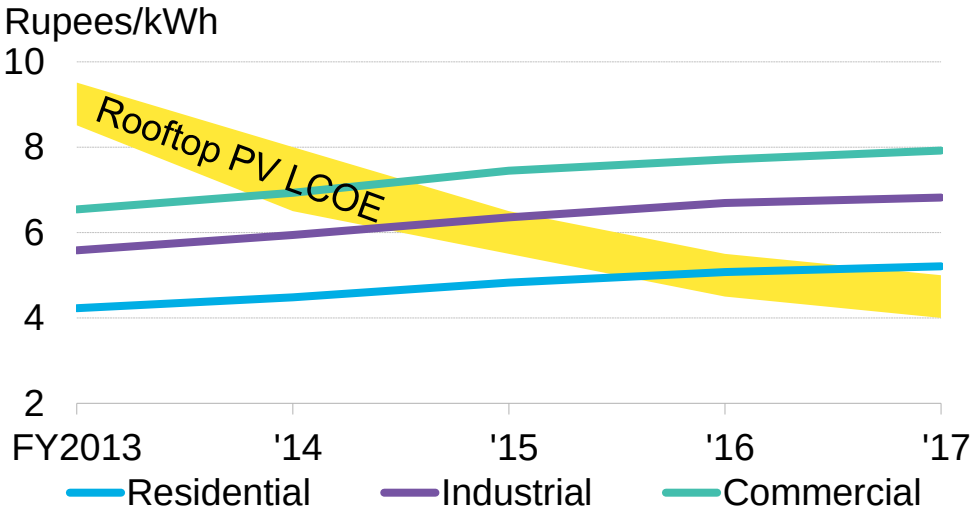
Costs of electricity from rooftop PV has halved in the last five years. Fierce competition in the market and drop in equipment costs have led to cheaper rooftop PV power. In contrast, average retail electricity prices have increased by 22% in the same period.

Government policies and auctions are driving growth but have also increased risks. Auctions have become the preferred mode of adding power generation capacity in India. Plans to hold more auctions across states and technologies provide visibility on future projects. However, concerns are increasing that intense competition is forcing bidders to expose themselves to higher project risks.

Investment required to achieve 175GW renewable energy target by FY2022



Average rooftop PV LCOE and electricity tariffs



Source: Bloomberg New Energy Finance, industry surveys. Note: India's financial year is from April to March.

Executive summary (3/3)

Rooftop PV is showing signs of a maturing market in the corporate segment. C&I customers now set-up larger capacity rooftop PV assets and are also open to signing long-term power purchase agreements indicating growing confidence in this technology. The economics of PV work for C&I customers even without net metering. Net metering is a far more important enabler for residential consumers as they usually draw less power during the day when their PV panels are producing electricity.

Three out of four rooftop PV projects are built under the capex model where customers pay for the system upfront. Renewable energy service company (RESCO) projects, which require the consumer to pay a monthly fee, could not increase their market share due to financing challenges. Some corporates and government institutions that are trying to avoid performance risk and high upfront cost are driving the RESCO market.

Off-grid companies have not been able to match the rapid growth of utility-scale renewables and rooftop solar systems. These companies are innovating on business and financial product offerings to increase sales and enhance consumer engagement. Micro grid operators are connecting more productive loads to their grids while solar home system (SHS) companies are offering financing solutions to their customers, that has increased the appetite for SHS over solar lanterns.

While the **quality and reliability of electric supply by power distribution companies (discoms) in rural areas continues to remain poor,** even a partial achievement of the government's promise to provide 100% electrification and 24x7 power will curb investor appetite for off-grid solutions due to the risk of becoming stranded.

Growth of rooftop solar in India looks inevitable with or without the support of distribution utilities. This presents an opportunity for the discoms to diversify and start their own rooftop solar business rather than lose customers to other competitors.

Discoms can also partner with rooftop PV companies to provide operations and maintenance (O&M) services, billing, lead generation, branding and sales support. Utilities can provide critical insights about customer load patterns and payment history that can help RESCO developers in system sizing and off-taker credibility assessment.

This report is a follow-up to Financing India's Renewable Energy Transition published in November 2016. Bloomberg New Energy Finance was supported by The David and Lucile Packard Foundation. The content and conclusions are those of Bloomberg New Energy Finance alone, based on our own independent analysis.

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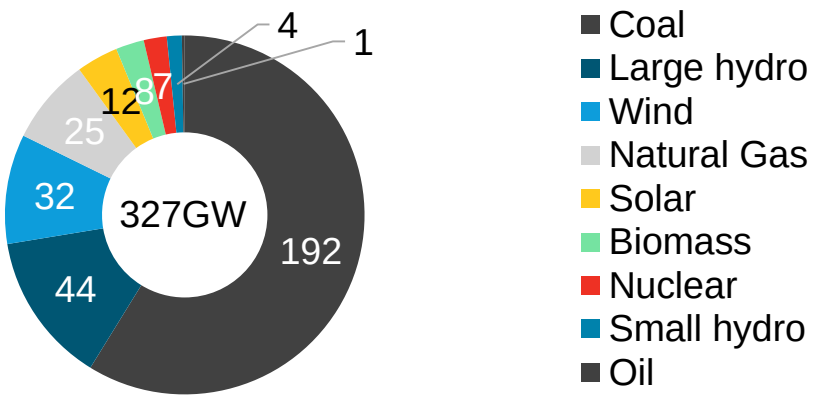
Rooftop PV gathers pace while utility-scale renewables maintain growth

The market today

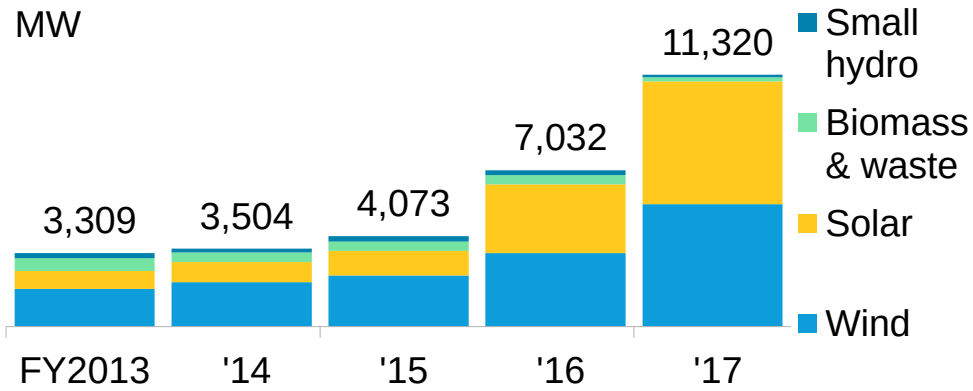
Utility-scale renewables continue to claim a larger share

India's grid-connected power generation capacity in March 2017



Source: Bloomberg New Energy Finance, Ministry of New and Renewable Energy

Annual utility-scale renewable energy installation in India



Source: Bloomberg New Energy Finance, Ministry of New and Renewable Energy.
Note: FY2017 – April 2016 to March 2017. Utility-scale projects are ≥1MW.

India installed 11.3GW of utility-scale renewable energy in FY2017 - more than the installations in the last two financial years combined.

At the end of FY2017, the country had 57GW of installed utility-scale renewable energy capacity (excluding large hydro). This represented 17.5% of the total power generation capacity – up from 12.5% in FY2013.

During this four year period, India added 104GW of power generation capacity – more than the size of United Kingdom's total generation fleet at the end of 2016.

India raised its cumulative grid-connected PV installed capacity by 84% to 12.3GW at the end of FY2017, driven by national and state auctions.

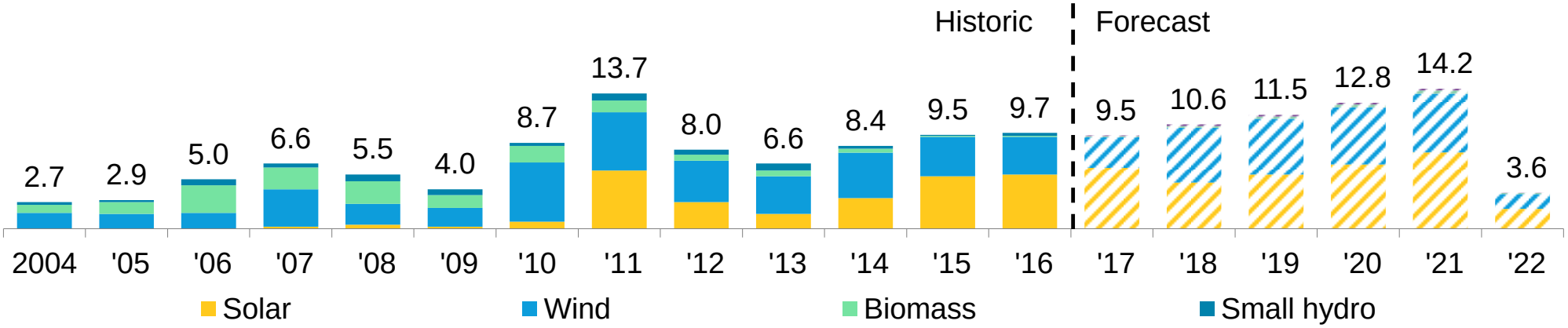
Falling costs of renewable energy led to the cancellation of a few planned coal projects. It also prompted attempts to renegotiate existing power purchase agreements (PPA) of renewable energy projects auctioned and commissioned in the past. Nonetheless, more renewables will be added every year compared to coal power installations from 2017 onwards.

Solar PV will take a dominant role in future capacity mix, growing steadily till 2029, and surging thereafter (see New Energy Outlook 2017) .

Government targets present a $53bn investment opportunity

Historical renewable energy investments in India and estimated future financing requirements

$ billion



Source: Bloomberg New Energy Finance. Note: $1 = 65 rupees.

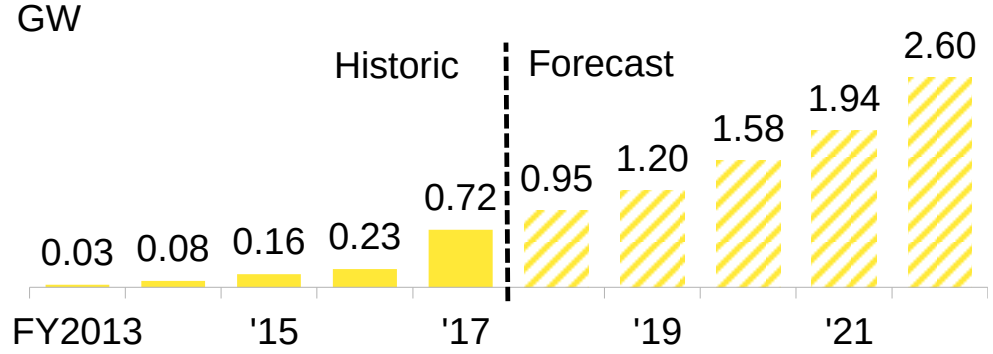
India's renewables sector is a $53 billion investment opportunity. The amount will be needed over 2018-22 in order to achieve India's 135GW of utility-scale renewable energy target. Additional financing will be needed to hit the nation's 40GW target for small-scale solar.

The investment requirement is much lower than previously estimated. Rapidly declining costs of wind and solar projects mean that India's financing requirement for utility-scale projects over the period will be an estimated $19 billion lower than projected just a year ago.

Renewables financing will go public. Project finance in India is typically raised via debt through domestic and international banks and equity from private investors and corporates. Several IPPs are now expected to launch initial public offers in the near future, opening up the market to broader investor participation. Despite a decline in the cost of debt for renewable projects in India in recent times, it still lies between 9-11%, making it one of the highest in Asia. Green bonds worth $2.9 billion were issued in 2017 (till October), up from $1.5 billion in the whole of 2016. This financing mechanism is expected to pick up as more IPPs try to free up equity locked in commissioned projects.

Rooftop PV is rising rapidly to become a multi-GW opportunity

Annual rooftop PV installations in India and forecasts



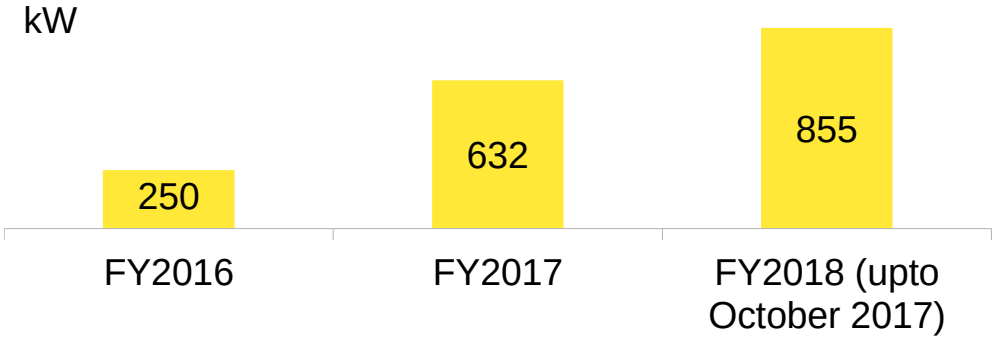
Source: Bloomberg New Energy Finance, industry surveys, Ministry of New and Renewable Energy. Note: India's financial year is from April to March.

Total rooftop PV capacity at the end of FY2017 in India totaled 1.3GW, representing a tenth of the total solar PV installations. **The market is also accelerating – more capacity was added in the last financial year than in the previous four years combined.**

A compound annual growth rate (CAGR) of 117% in annual installations between FY2013 and FY2017 makes rooftop PV the fastest growing renewable energy sub-segment in India. This growth is mainly driven by savings in electricity bills and increasing consumer acceptance along with fierce competition in the market.

We estimate India will reach 9.5GW of rooftop PV capacity by FY2022 – seven times its current total.

Average size of C&I behind-the-meter PV installation by top 20 developers/EPC



Source: Bloomberg New Energy Finance, Ministry of New and Renewable Energy. Note: Based on data reported on Bhuvan portal. EPC is engineering, procurement and construction. India's financial year is from April to March.

Not just the market, but individual projects are also getting bigger. Private sector commercial and industrial consumers have been early adopters of rooftop PV, as they pay the highest tariffs for grid power, and the rates have only been rising. The technology offers a way to lock in energy costs, and savings. Government institutions are now catching-up with solar adoption through mandated auctions.

The average installation size of C&I rooftop PV installations by the 20 largest companies has increased from 250kW in FY2015 to 855kW in FY2018. This has been made possible by better utilization of rooftop space and the willingness of consumers to meet a higher share of demand through on-site sources.

Despite record growth, the rooftop PV targets are unachievable

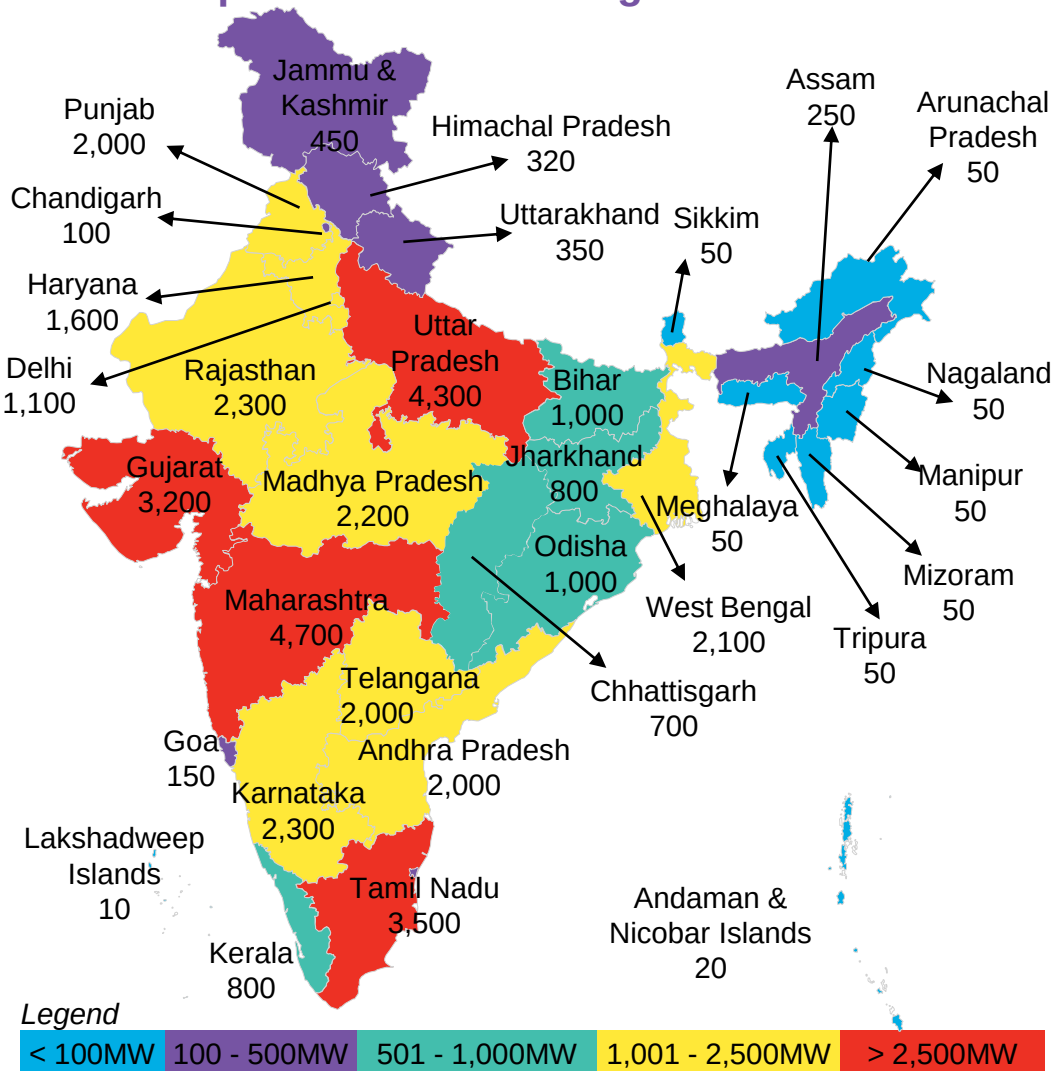
With 1.3GW of rooftop PV installations in India at the end of March 2017, only 3% of the government's targeted 40GW has been achieved so far. **More than half the market is concentrated in just six states.**

In order to achieve the government's target, the pace of new installations needs to double every year between now and 2022. While the year-on-year growth of rooftop PV has been phenomenal over last five years, India will not be able to maintain its current growth rate, even though rooftop PV installations will keep rising.

The rooftop market is still facing two main bottlenecks which, if removed, could accelerate growth:

- Most of the market growth so far has been driven by industrial and commercial self-consumption, not net metering. A simplified process to apply for the scheme could boost residential PV uptake.
- Most PV so far has been fully self-funded. Improved access to debt for rooftop developers or customers would accelerate the market.

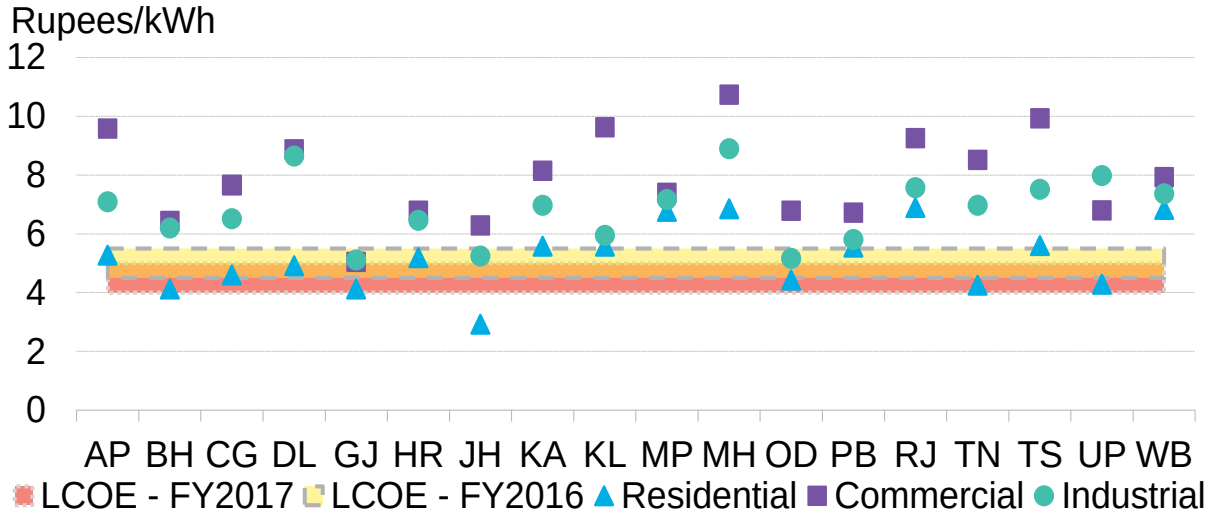
Rooftop PV installation targets for March 2022



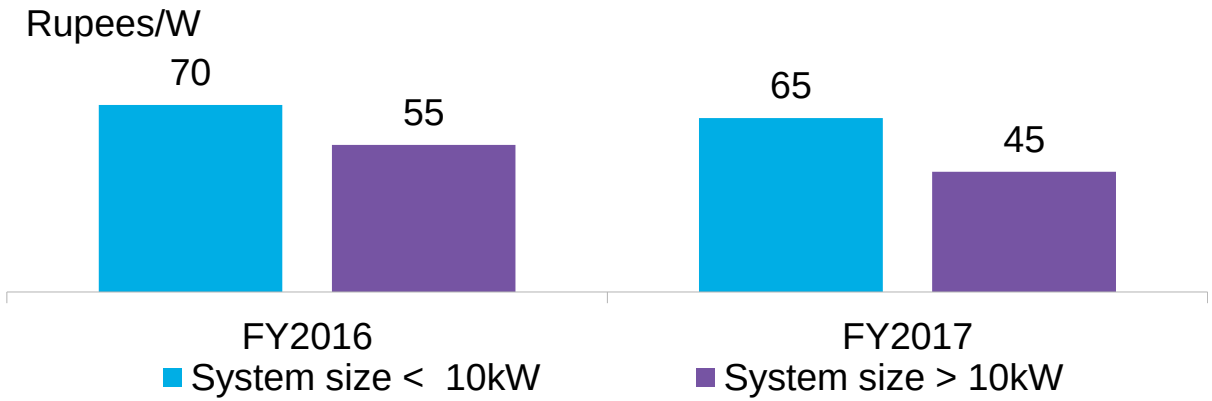
Source: Bloomberg New Energy Finance, Ministry of New and Renewable Energy

Rooftop PV costs are lower than grid tariffs for C&I consumers

Retail electricity tariffs and rooftop PV LCOE in FY2017



Capital cost of rooftop PV projects in India



Rooftop PV is now cheaper than commercial and industrial grid tariffs in all major states in India. This is a result of rising tariffs and falling solar costs.

Equipment cost declines in just the last year have also brought socket parity for high consumption residential customers having system sizes greater than 5KW in at least 10 states.

Retail electricity tariffs will continue to rise at least in the short term due to regulator driven tariff hikes to help ailing electricity distribution utilities recover their cost of electric supply.

Costs of solar electricity are further expected to come down globally because of efficiency gains in technology and manufacturing.

For commercial customers, payback periods are already average 5-7 years. A drop in equipment cost and rising grid tariffs will further lower the payback periods for C&I consumers.

Source: Bloomberg New Energy Finance, industry surveys. Note: AP – Andhra Pradesh, BH – Bihar, CG – Chhattisgarh, DL – Delhi, GJ – Gujarat, HR – Haryana, JH – Jharkhand, KA – Karnataka, KL – Kerala, MP – Madhya Pradesh, MH – Maharashtra, OD – Odisha, PB – Punjab, RJ – Rajasthan, TN – Tamil Nadu, TS – Telangana, UP – Uttar Pradesh, WB – West Bengal. India's financial year is from April to March.

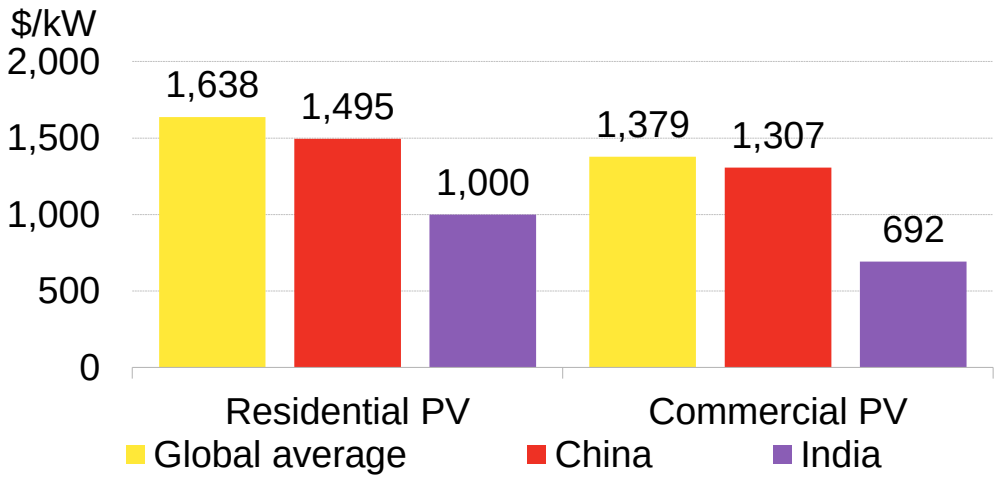
Indian rooftop PV costs are among the lowest in the world

The LCOE of rooftop PV in India for both residential ($0.077/kWh) and commercial ($0.062/kWh) consumers is one of the lowest in the world and comparable only to some of the sunniest parts in Australia and U.S.

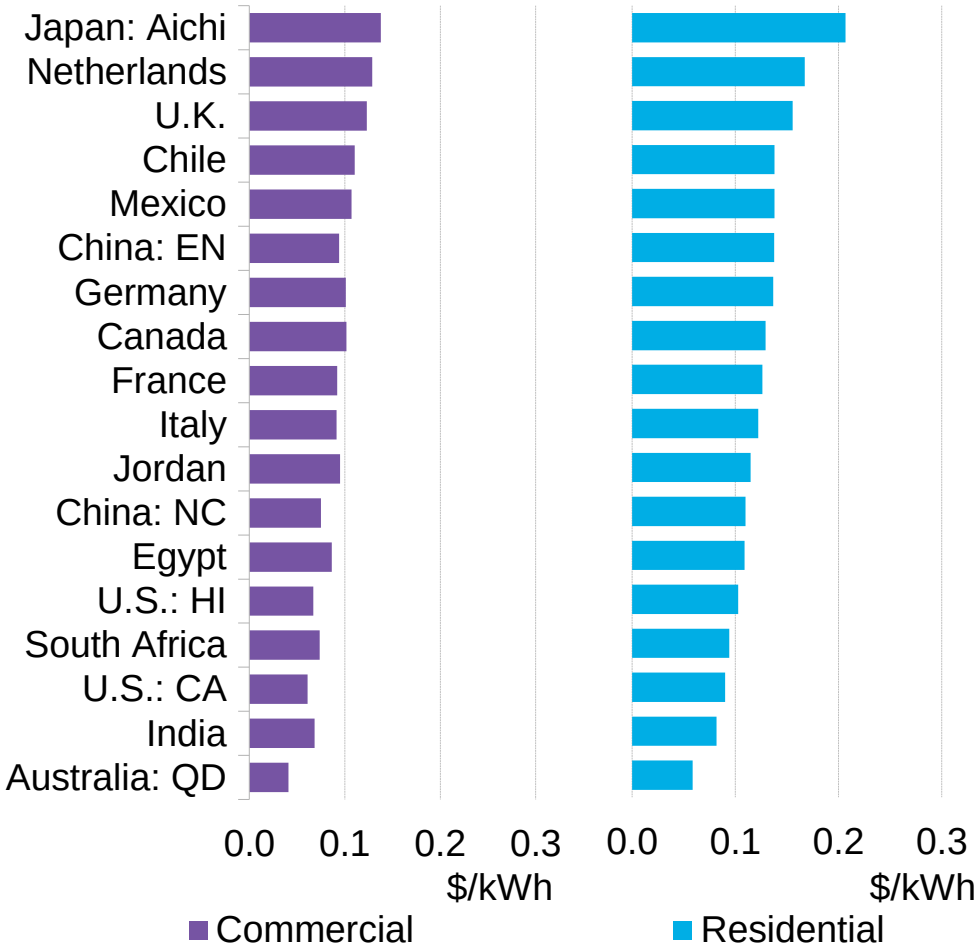
The low price is driven by capital expenditures that are 39-50% lower than the global average. All components, including equipment, EPC, labor and soft costs are cheaper in India.

The capital costs are even lower than China, from where India imports most of its PV equipment.

Capital cost of residential and commercial rooftop PV in 2017



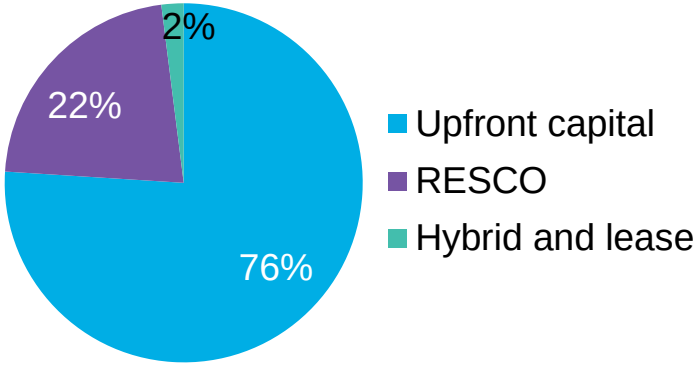
Global rooftop PV subsidized levelized cost of electricity (LCOE) in 2017



Source: Bloomberg New Energy Finance, industry surveys. Note: QD – Queensland, CA – California, HI – Hawaii, NC – North Central, EN - Eastern. $1 = 65 rupees.

Upfront capital dominates the rooftop PV market

Rooftop PV share of installations in FY2017



Source: Bloomberg New Energy Finance. Note: RESCO means renewable energy service company and implies a PPA with the energy consumer. See appendix for details about different business models. India's financial year is from April to March.

The upfront capital payment model ('capex') made up three quarters of the market in 2017, whereas the RESCO model accounted for 22%. Newer models like leasing and hybrid investments held only 2% market share.

Large corporates with the ability to make upfront investments had previously preferred capex model but are now increasingly opting for RESCO projects to reduce performance risks. At the same time, small and medium enterprises who earlier opted for RESCO to avoid a large upfront bill are now favoring capex projects to avoid signing long-term contracts.

A major influencer for capex model has been the accelerated depreciation benefit which allowed an investor to claim 80% asset depreciation in the first year of installation. This benefit was capped at 40% from April 1, 2017, reducing the attractiveness of the model.

The tilt towards the RESCO model is driven by an increase in the number of companies offering projects under this model, government procurement, acceptance by large C&I consumers of long term contracts and lower performance risks. Lack of financing for RESCO companies however continues to be a dampener.

RESCO adoption has been limited to C&I and government clients so far. Residential consumers are generally deemed too risky by the developers, but a few are testing the market now.

Many companies in the C&I rooftop PV sector are offering storage and energy management solutions. This is a client retention strategy as increased services offer more opportunities for continued customer engagement.

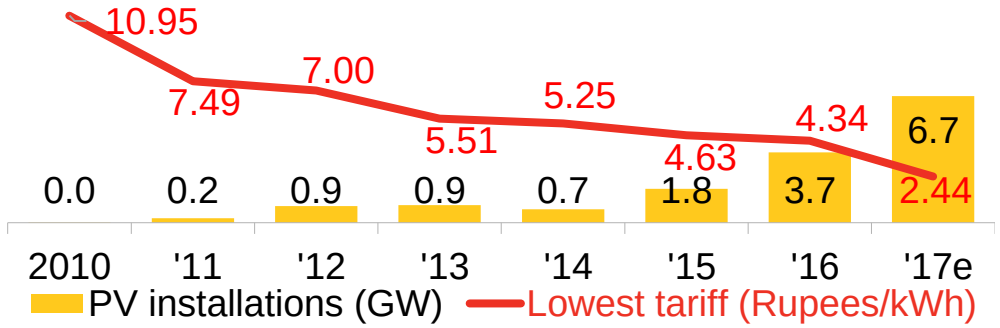
The hybrid model is used to avoid regulatory hurdles in states which allow only consumers - not developers - to avail net metering. In this model, the consumer has a small equity investment, and the developer/third party investor funds the rest. Leasing of rooftops has been difficult so far because of issues around roof access and future construction risks.

Auctions, economics and competition are driving the renewables market

Drivers of growth in the market

India's renewables auctions were the most competitive in the world

Utility-scale PV auction prices and installations

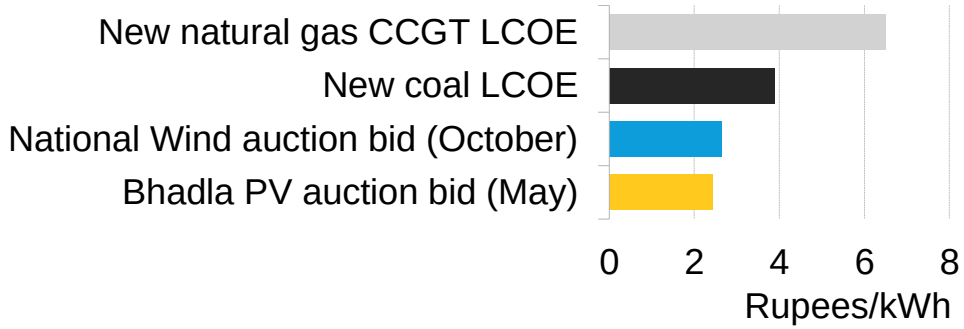


Source: Bloomberg New Energy Finance, Ministry of New and Renewable Energy

World's lowest solar and wind tariffs were discovered at the time of bidding in 2017, on a levelized basis**.** Prices of utility-scale solar projects dropped to 2,440 rupees ($38)/MWh and onshore-wind to 2,640 rupees ($40.5)/MWh in 2017. The low prices are particularly impressive when considering that the tariffs in Indian solar and wind auctions are fixed in nominal terms, and do not escalate with inflation, as is common elsewhere.

The aggressive bidding was a result of land-grab strategies. The desire to secure future project pipelines led to aggressive bidding and reduced profit margins across the supply chain. Intense competition forces bidders to expose themselves to project risks without comprehensive hedging and financial buffers. Future cost reductions will partly depend on whether the supply chain can innovate and is able to operate in an environment of tighter profit margins.

Auctions prices and BNEF assessed LCOEs (2017)



Source: Bloomberg New Energy Finance

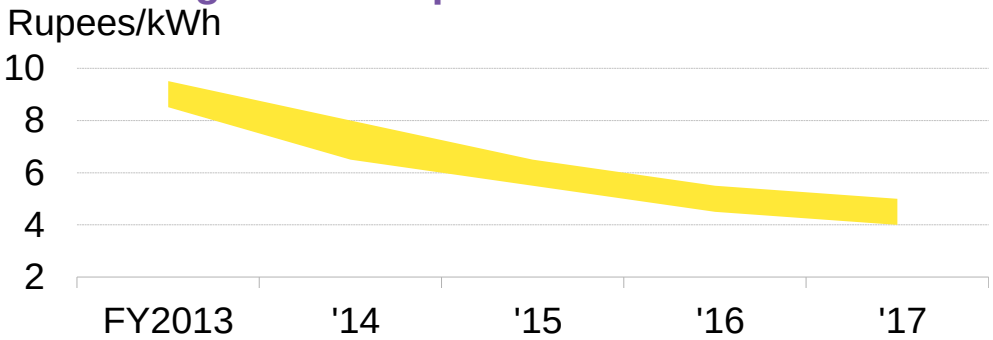
Utility-scale renewables are now significantly cheaper than fossil based power generation. They make it challenging for other forms of electricity production.

The auctions so far are just the beginning. India awarded 17.3GW of utility-scale PV and 2.5GW of wind projects under various tariff-based auctions till October 2017. The government plans to auction at least another 20GW each of solar and wind projects to achieve its renewable targets and to spur domestic manufacturing.

India's target of installing 175GW of renewables by 2022 is the major driver for current and future growth. While the country may not be able to achieve this target, it looks likely to meet its UNFCCC Intended Nationally Determined Contribution commitment of sourcing 40% electricity from non-fossil fuel energy sources by 2030.

The small-scale PV market is highly competitive

LCOE range of rooftop PV in India



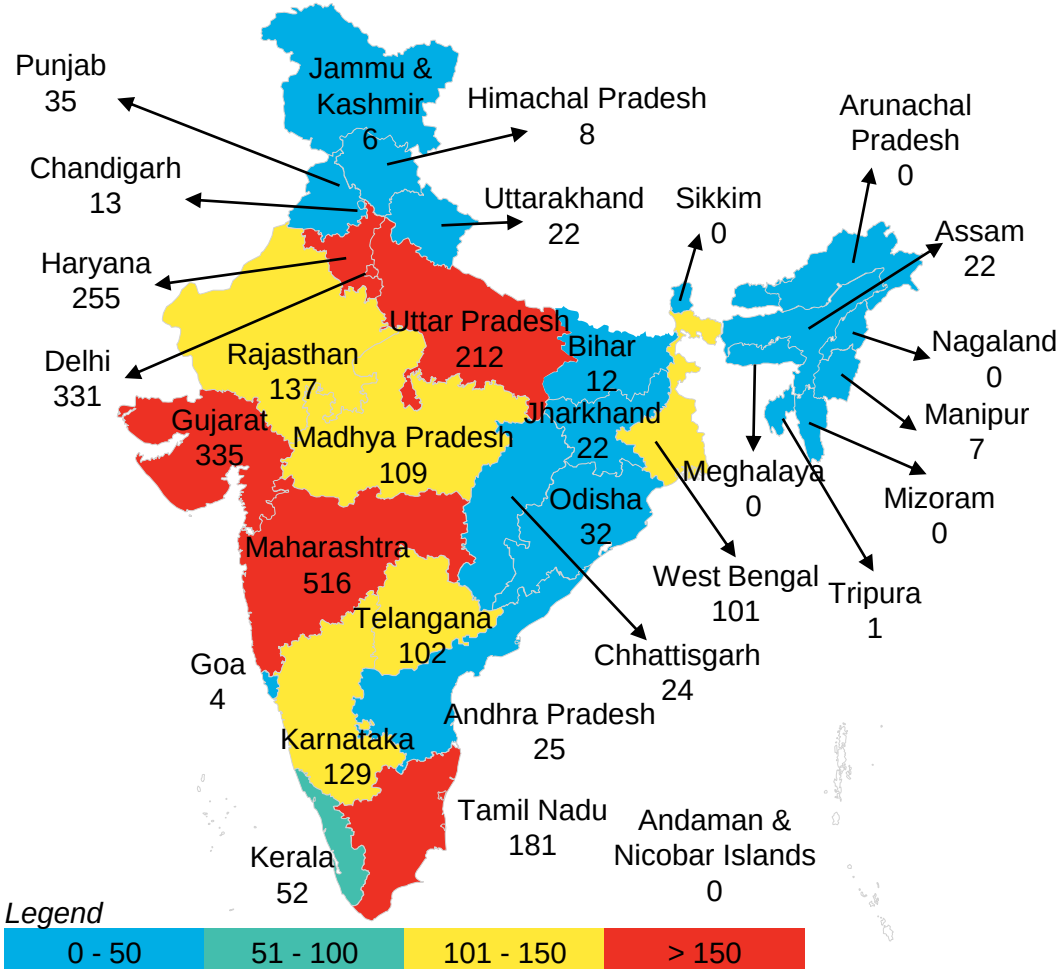
Source: Bloomberg New Energy Finance, industry surveys. Note: India's financial year is from April to March.

The LCOE of rooftop PV dropped by 11% in FY2017 over FY2016 and averages between 4-5 rupees/kWh. The two most important reasons behind the decline in LCOE in the recent years are increased competition in the market and the decline in capital costs. Lower costs have increased affordability of PV systems for the consumers.

We estimate that more than 5,000 companies are active in the small-scale solar segment in the country. Out of those, 2,713 were registered with the MNRE as authorized channel partners till October 2017.

Some companies are engaging in aggressive price wars to win orders and are often agreeing to risky contract terms such as fixing long-term tariffs at up to 30% discount to grid electricity prices and offering warranties by themselves for equipment that was purchased from others.

Number of government channel partner companies



Source: Bloomberg New Energy Finance, Ministry of New and Renewable Energy (MNRE). Note: A channel partner was a company accredited by the MNRE to engage in solar PV business activities. Ministry discontinued this program from November 23, 2017.

Rooftop PV auctions pick up pace in the states

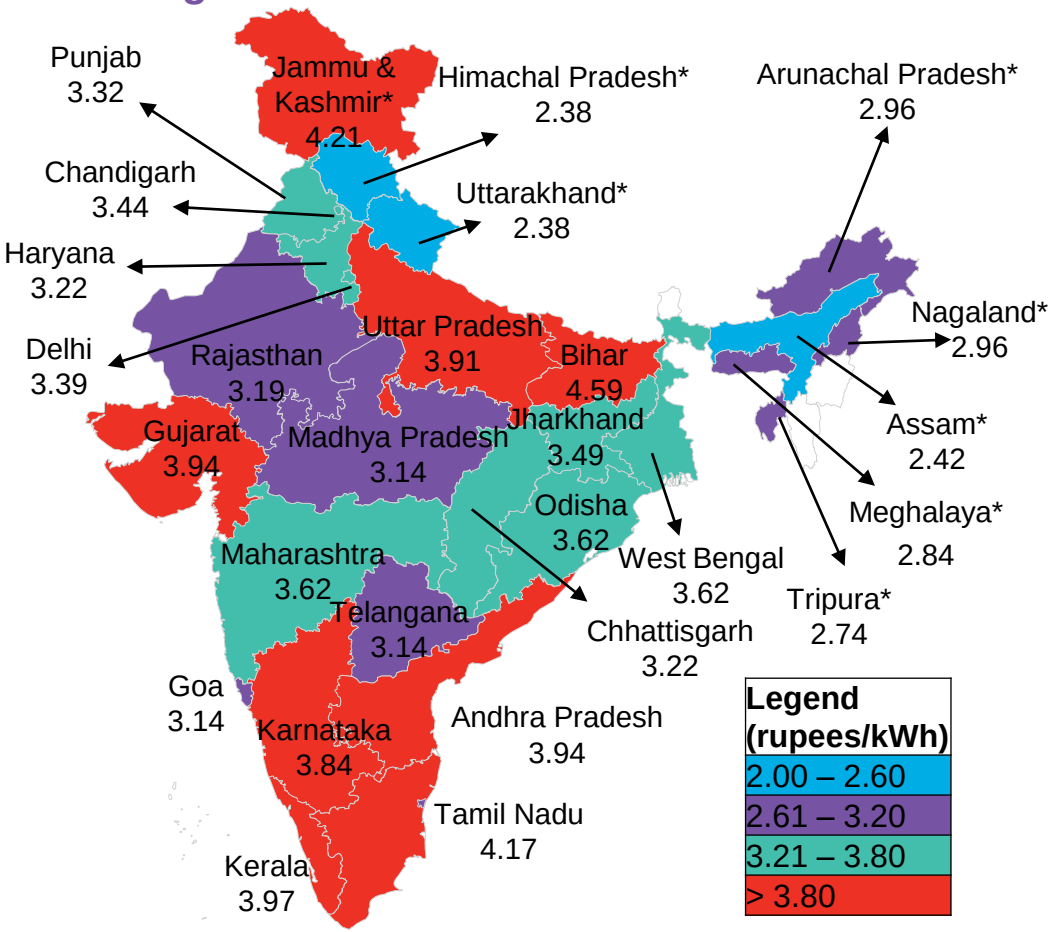
More than 1GW rooftop PV projects were auctioned by various government bodies in the first nine months of 2017 due to a strong policy push by national and local governments. About 70% of these projects were under the RESCO model.

Government institutions prefer signing PPAs under RESCO model as it helps them avoid making upfront investments while receiving the benefits of rooftop PV. Developers also prefer government-owned off-takers as they offer PPA tenors covering the project lifetime, carry lower default risk and are less likely to break away from the signed contracts.

Usually rooftop PV companies have operations in just one or two states but **national level auctions conducted by the Solar Energy Corporation of India (for government buildings), Indian Railways and others have made it easier for many existing rooftop PV companies to expand their presence in multiple states**. This has also opened up opportunities for smaller companies and new entrepreneurs to compete, unlike the utility-scale segment which is dominated by deep-pocketed investors.

Rising competition, upper limits on project capex set by the government for rooftop PV auctions and subsidy of 18,750 rupees/kW(peak) in most states are factors which have helped bring down the tariffs in government tenders.

Auctioned tariffs for rooftop PV on government buildings in FY2017



*Source: Bloomberg New Energy Finance, Solar Energy Corporation of India. Note: * indicates special category state. The developers are eligible to avail a maximum subsidy of 18,750 rupees/kWp (45,000 rupees/kWp in case of special category states) depending upon commissioning in specified amount of time.*

Net metering has teething problems, but issues are clearing up

Net metering helps full utilization of rooftop PV: It lets consumers maximize their rooftop installations – even if they cannot use all the power they generate – by allowing any surplus electricity to be offset against metered supply. Some of this generated rooftop solar power would be lost in the absence of such a mechanism.

Regulations lack clarity: Most states have notified net metering regulations which are mandatory. However, a few states like Andhra Pradesh, Odisha**,** Tamil Nadu and West Bengal do not have regulations but instead have guidelines which are legally non-binding. Lack of clarity about grid connectivity in these states hinders installation of net-metered rooftop PV systems. On the other hand, some states like Madhya Pradesh have been active in addressing these issues, setting a precedent for others.

Limits on PV system sizes and transformer loading curtails installation: Barring a few exceptions, most states permit rooftop solar installations between 1kW and 1MW as eligible for net metering. Most states put maximum limits on power fed back to the grid. This is generally around 30% of the rated transformer capacity. However, Uttar Pradesh has allowed higher capacity projects (5MW) to be connected on a case-to-case basis. Similarly, states like Karnataka allow transformer injection limits up to 80% of the rated capacity thus providing flexibility on project sizes.

Limits based on annual consumption and PV output curtails generation: Some states have put a limit on injection of PV electricity to 90% of power imported by the consumer from the grid.

Rollover of energy credits makes grid connectivity more attractive: Across most states, an energy bill (for import and export) is generated on a monthly basis and financial settlement (if any) is done at the end of financial year. Generally, states allow surplus electricity generated in a month to be carried over to the next month as energy credits. This lets consumers bank higher generation in a month for use in lean periods and lower their power bills.

Other incentives: Most states have exempted banking charges (*facility to inject excess energy in the grid which can be claimed later for a fee*), wheeling charges (*using the discom assets to transfer power from point of generation to point of use*), cross-subsidy charges, electricity duty and other surcharges, thereby incentivizing rooftop projects.

Our view: Effective implementation of net metering can further propel growth of rooftop PV. Standardization of regulations, timely & automated application approvals and better co-ordination among discoms and consumers are critical for a seamless net metering roll-out.

Corporates, households and solar-diesel hybrids are still untapped markets

Future potential for growth

Corporate purchases will continue to drive renewables growth

Power consumers in India with >1MW connected load have the flexibility to choose from a range of on-site or off-site power purchase options depending on their needs and internal strategy.

However, direct procurement by signing power purchase agreements with RESCOs for on-site and off-site power is becoming an important means of consuming renewable electricity by corporates. It lowers their bills and helps in meeting internal/external renewable purchase mandates. **We estimate more than 2.3GW of cumulative renewable corporate power purchase agreements** to have already been signed in India by the first half of 2017.

Several Indian companies like Tata Motors, Infosys and Dalmia Cement have committed to use 100% renewable electricity to power their operations. Corporates are expected to continue exploring both capex and RESCO models for on-site and off-site procurement depending on energy requirements, capital availability, risk appetite and tax incentives.

Corporates have different options for renewable purchases

	CAPEX (On-site)	CAPEX (Off-site)	RESCO (On-site)	RESCO (Off-site)
Parties involved	• Corporate • Project EPC partner • Discom (for net metering)	• Corporate • Project EPC partner • Discom (for gross metering)	• Corporate • Project developer • Third-party investor (if any) • Discom	• Corporate • Project developer • Third party investor (if any) • Discom
Benefits	• Less reliance on grid • Potential for cost savings • Tax benefits	• Installation of higher size systems • Potential for cost savings • Tax benefits	• Hedge against increasing retail electricity prices • Potential for cost savings • No upfront costs	• Hedge against increasing retail electricity prices • Potential for cost savings • No upfront costs • Higher system size
Drawbacks	• Constrained by roof-size • Installation/O&M costs • Property value/taxes	• Project development risk • Operating/ performance risk • Tax complexity	• Long-term PPA • Complexity – financial, energy market, contracts, credit risks	• Long-term PPA • Complexity – financial, energy market, contracts, credit risks
Examples	• Maruti Suzuki, Ultratech Cement, TCS, Honeywell	• Infosys, Sun Pharma, Hatsun Agro	• Apollo Tyres, Bangalore Airport, NIT Surathkal	• Delhi Metro, Wipro, Bharti Airtel

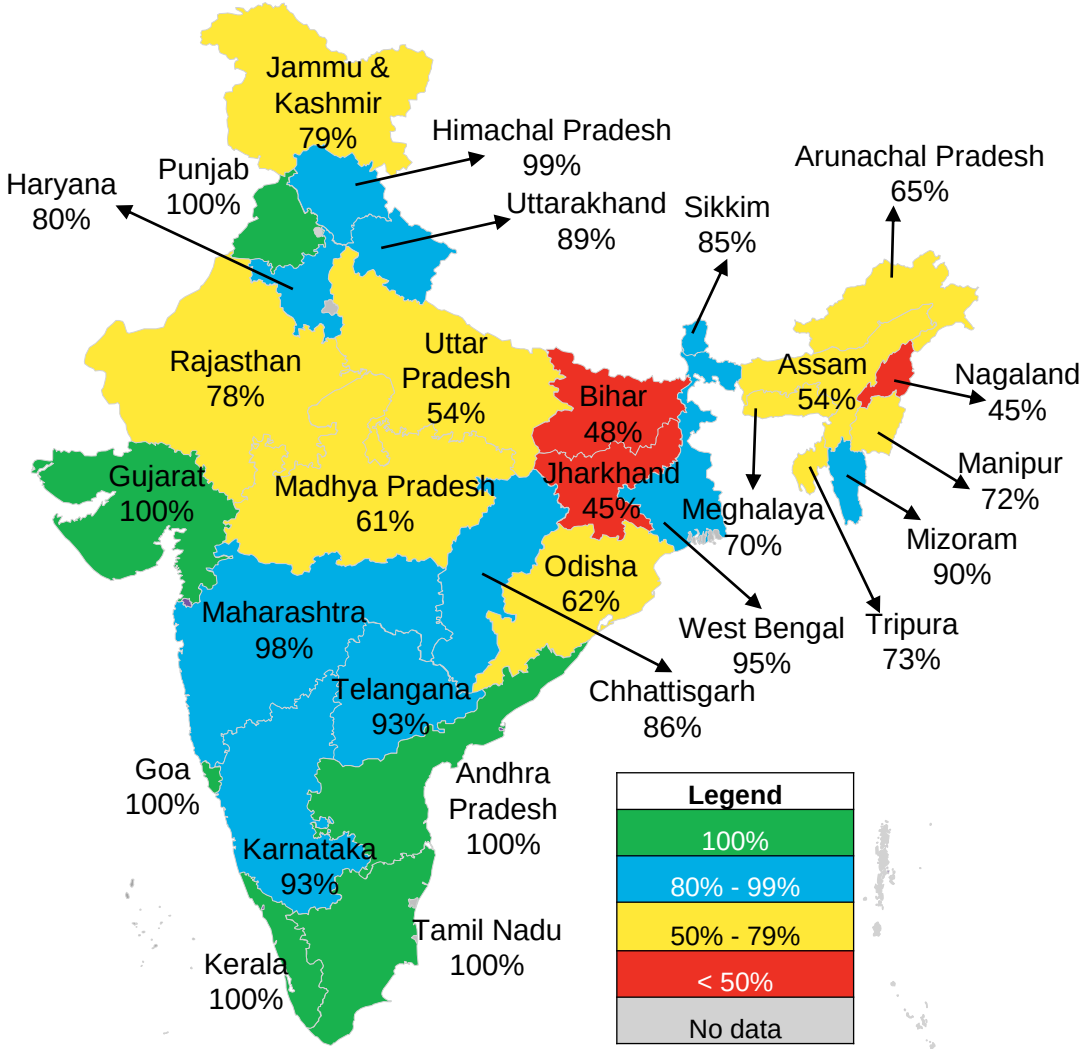
Next wave of growth will come from the residential sector

India's residential solar market has remained largely untapped, for several reasons:

- **Low electricity tariff:** The electricity prices for residential consumers are cross-subsidized by industrial and commercial users and are therefore low. Small-scale PV is far less competitive in private homes.
- **Higher system cost:** The average capital cost of residential PV systems in FY2017 were 44% higher than commercial and industrial PV, mainly due to higher soft costs and absence of economies of scale.
- **Lack of awareness:** Residential consumers still lack awareness about rooftop policies and incentives, cost savings, equipment quality, O&M care and other industry innovation and best practices.
- **Challenges in net metering:** Consumers often require multiple approvals to avail net metering leading to delays in implementation of grid-connectivity.
- **High customer acquisition cost:** The costs associated with acquisition of residential customers leave very little margins for rooftop PV companies due to smaller ticket sizes. Therefore, many major companies have completely avoided catering to residential PV market segment so far.
- **Lack of access to finance:** Lack of dedicated financial products from banks and inhibition of consumers to put their residences as bank collateral limits the financing options for consumers to avail rooftop PV.
- **Government policies can drive growth:** Central government updated the 'Model Building Bye Laws' which mandate the installation of rooftop PV on both old and new buildings exceeding a size and power consumption threshold. Effective implementation of the bye laws and 'Energy Efficiency Building Code' that suggest rooftop PV installation, can lead to a sustained growth of the residential PV market.
- **Our long term view:** Residential installations will increase their share in rooftop PV markets, driven by socket parity and a quest for more reliable power supply. Rural areas, which face higher grid supply disruptions, are better suited for reliable self generation with small-scale PV rather than their urban-counterparts.
- **Net metering is a far more important enabler for residential small-scale solar than for business:** The latter consume power throughout the day, when the sun shines. Homeowners are usually drawing less power when their PV panels produce, making self-consumption much harder.

Energy access has improved, but 24x7 power-for-all seems far away

Share of rural household electrified (October 2017)



Source: Bloomberg New Energy Finance, GARV portal

The Indian government aims to provide round-the-clock power to all its citizens by 2018. In September 2017, a new electrification scheme was launched with an aim to connect all the villages to the electricity grid by December 31, 2017 and provide electricity connection to all of its rural and urban households by the end of 2018. The scheme aims to electrify 0.5 million households through off-grid option.

In order to achieve its revised household electrification targets, India would need to electrify 3.3 million households every month, up from 0.3 million electrified in October 2017.

Even after a dramatic improvement in village electrification levels in the last three and half years, the quality and reliability of electricity supply in rural parts of the country remain poor. This provides an opportunity for renewable energy sources, either with battery storage or in combination with diesel generators, to provide reliability in power supply.

If the government fulfills its promises of 100% electrification and 24x7 power, then this would jeopardize the off-grid businesses. Even 50% achievement of both will alarm investors.

Solar-powered agriculture starts to bear fruit

Around 8 million irrigation pumps that are currently powered by diesel could be economically replaced by solar-powered versions. Another 12 million pumps are powered by heavily subsidized grid electricity.

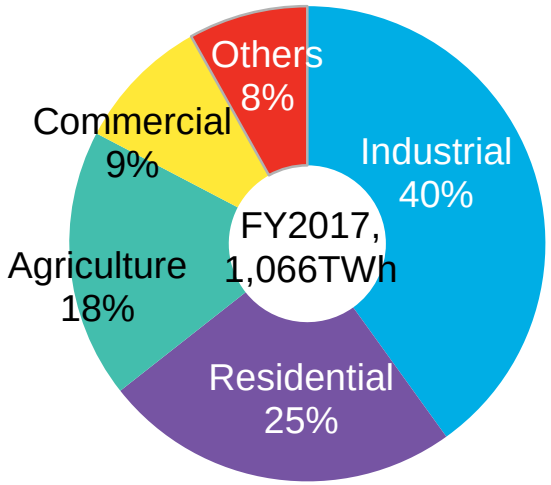
Only 48% of farmed land in India is irrigated at the moment. **We estimate that up to 11.6 million additional irrigation pumps could be deployed** if all agriculture land is watered.

Diesel-powered pumps burn an estimated $2 billion of fuel per year. The government supports solar pumps with subsidy programs offering up to 90% of capex, which directly cut its fuel subsidy expenses and India's oil import bill.

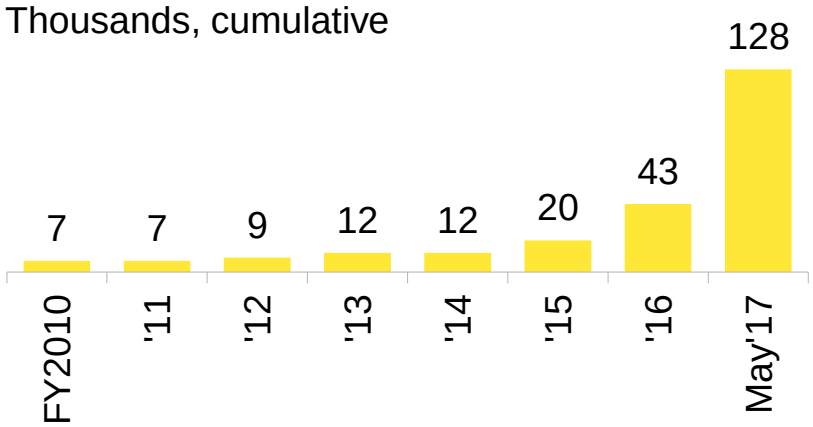
Only 0.13 million solar pumps were in use by May 2017, despite an ambitious target of selling 1 million solar pumps by 2021, favorable economics and a recent surge in uptake. Reliance on government-driven distribution and sales programs has meant that private manufacturers or the financiers do not advertize the product, keeping farmers' awareness of the technology low and retail demand in check.

The sector has seen rapid growth in the last two years, despite a lengthy process to deliver subsidies and challenges in the sales process. Allowing retailers to advertize more aggressively and streamlining the process of securing financing could let the sector grow even faster.

Electricity consumption in India



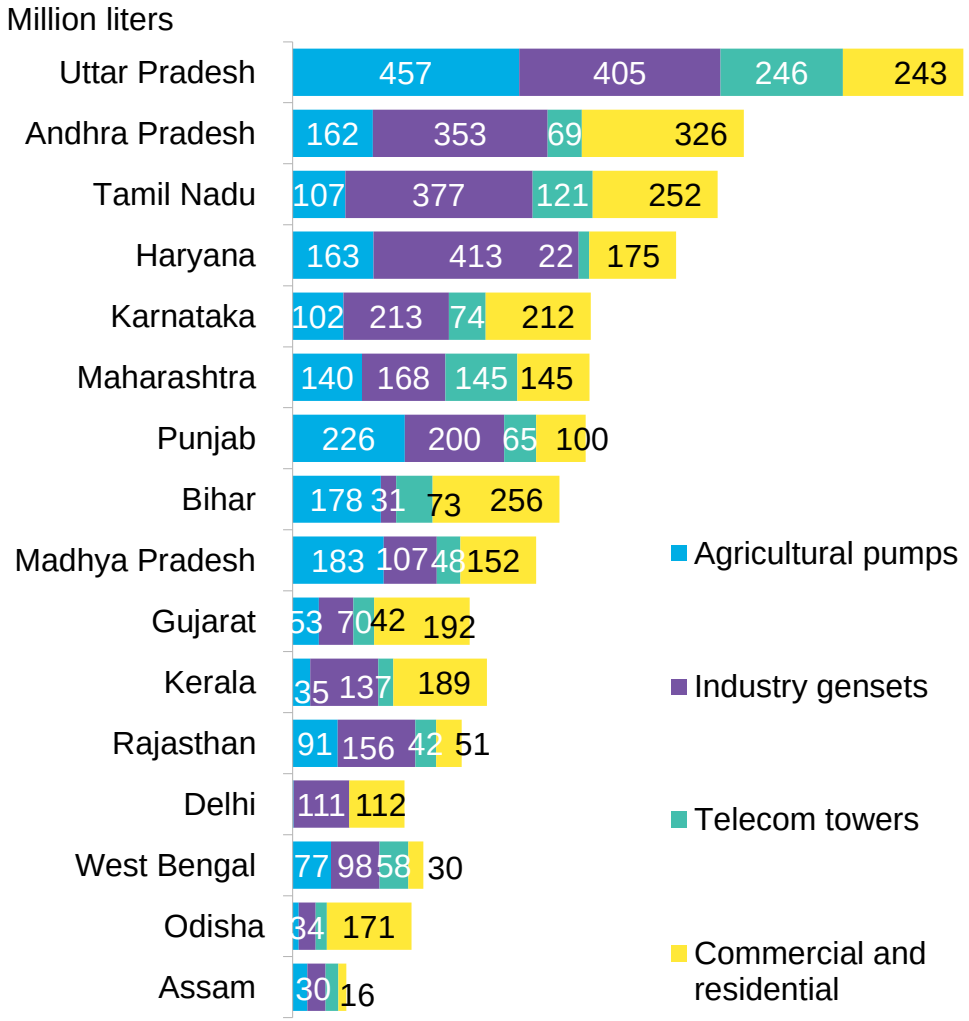
Solar irrigation pumps installed in India



Source: Bloomberg New Energy Finance, Central Electricity Authority, Ministry of New and Renewable Energy. India's financial year is from April to March.

Solar PV can reduce use of back-up diesel generators

Diesel consumption for power use in FY2014



Source: Bloomberg New Energy Finance, Ministry of Petroleum and Natural Gas.
Note: India's financial year is from April to March.

Despite improving grid reliability, many commercial and industrial facilities in India still rely on back-up diesel generators to a varying extent. This is common in industrial facilities outside the cities, and also commercial users within the city such as fuel stations, banks or telecom towers.

Large C&I facilities and the residential sector spent an estimated $7 billion consuming diesel fired back-up electricity in 2014.

Irrespective of back-up power needs, their relatively high electricity tariffs have made them active in India's booming small-scale solar sector already.

A mix of grid power and on-site solar-diesel-storage systems are the most economical way to ensure power reliability for most facilities, as this configuration will reduce the running hours of diesel generators.

Just a handful of C&I rooftop projects are currently configured to operate as an islanded micro-grid during a power outage despite the favorable economics compared to back-up diesel generators. As system integration becomes more readily available, we anticipate this market will grow significantly in future.

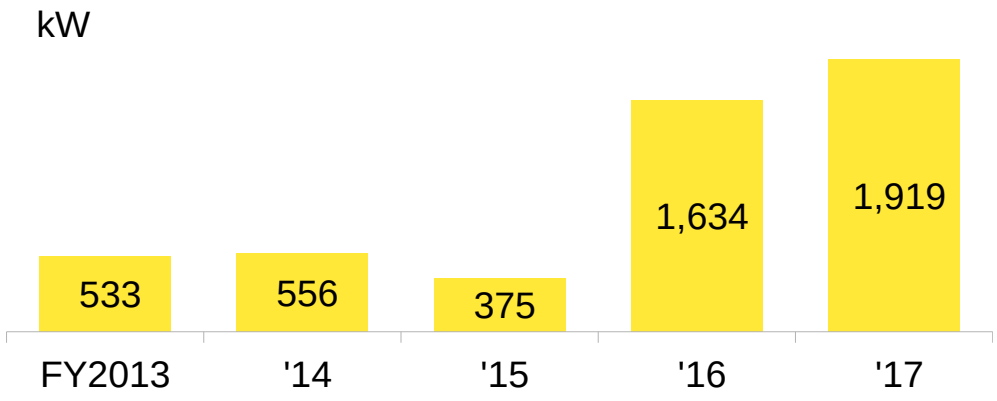
Based on space and self-consumption constraints, we estimate that the sectors using back-up diesel could host 60GW of PV.

India’s clean energy boom is slow to reach rural areas

Market trends for micro-grids and portable solar kits

Innovation in grid utilization is essential for growth of micro-grids

Annual rural micro-grid installations in India



Source: Bloomberg New Energy Finance. Note: Based on data from 17 companies.

India has reached only 1% of its micro-grid target. Unlike the utility-scale and rooftop targets, micro-grid growth is relatively stagnant.

The rising micro-grid tide is not lifting all boats. Our survey of 17 micro-grid companies found that 1.9MW micro-grid projects were installed in FY2017, up from 1.6MW built a year ago. Nine companies reported an uptick in installations in FY2017, whereas four reported a decline in installations and the other four reported no installations in the year compared to FY2016.

The growth in the sector has been driven by philanthropic and corporate social responsibility initiatives. Regulatory uncertainty is still a major bottleneck in scaling-up the business. Stranded asset risk because of grid extension, revenue collection challenges and uncertain project returns are the main concerns for investors.

Micro-grids deployed for rural electrification are often oversized to meet anticipated demand increases. However, this means that many micro-grids are not running at full capacity.

In the absence of an anchor load such as a telecom tower, ramping up the utilization and revenues from micro-grids can be a slow process and takes a few years. Companies are responding to under-utilization of systems by connecting more productive loads to grids like rice hullers, cold storage and water purification units. Micro-grid operators have also started to build modular and containerized grids that offer ease of expansion.

Taking advantage of growing digital payments penetration in rural India, many micro-grid operators now offer smart metering and online payment options, allowing them to streamline operations and revenue collection.

Micro-grid operators are also providing their customers with financing options to buy electrical appliances and other commercial equipment. This serves three objectives - increasing micro-grid utilization, higher customer engagement and boosting economic activity in the rural areas.

Micro-grid installations may pick up due to government policy

In a draft notification, the government has stated a target to install 10,000 micro-grids across the country by 2021, totaling a capacity of 500MW. Some states have released micro-grid policies and regulations in the last two years to promote installations.

Uttar Pradesh was the first state to introduce a detailed micro-grid policy and regulation in early 2016. Bihar announced a 100MW target of micro-grid capacity by 2022 in its 2017 state renewable energy policy. The two states represent 52% of India's total un-electrified population.

The extension of the distribution grid to a micro-grid area is not necessarily bad for micro-grid companies. **Possible options to interconnect with the discom's grid and sell excess power to the grid at the feed-in tariff can help companies to increase the asset utilization and revenues** while continuing to serve their customers.

Uttar Pradesh offers capital subsidies of 30% of project cost for micro-grid operators. But developers have not been keen to take advantage of such subsidies due to strict pre-conditions imposed. Subsidized projects require 10 years of mandatory operations and maintenance, and minimum six (commercial) or eight (residential) hours of daily electricity supply. The site selection is done by the state nodal agency and it also fixes the tariffs for customer with connected load of up to 100W.

Efforts aimed at rural electrification have led to a significant increase in access to electricity over the last three years. However, **quality and reliability of electric supply by discoms in rural areas continues to remain poor** and thus several micro-grid operators function concurrently with the discom network.

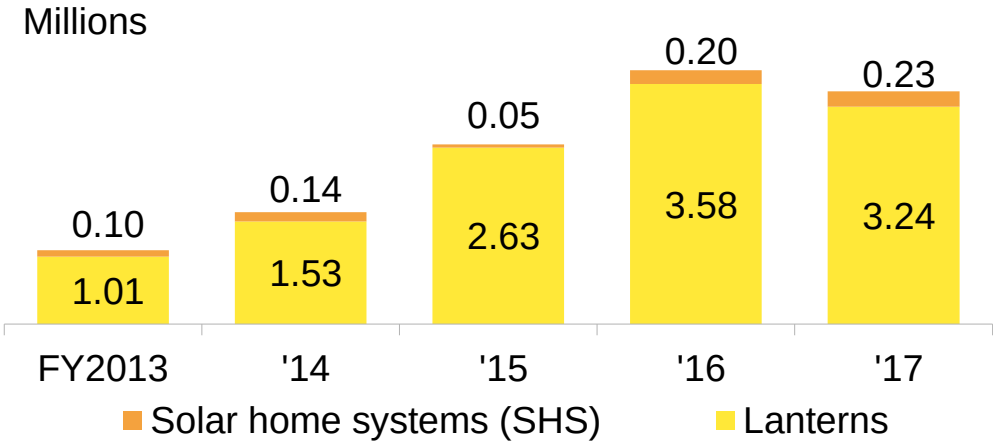
Possible options available to micro-grid companies upon grid arrival

Options / State	UP	BH	MP	OD	AS
Continue to operate maintaining the status-quo.	✔	✔		✔	
Sell entire electricity to discom at feed-in tariff	✔	✔	✔	✔	✔
Transfer ownership of asset/ distribution network to the discom	✔	✔	✔	✔	✔
Engage with discom as distribution franchise	✔	✔	✔	✔	✔
Allow parallel operation with grid and sell excess electricity to the discom at feed-in-tariff	✔	✔		✔	

Source: Bloomberg New Energy Finance. Note: UP – Uttar Pradesh, BH – Bihar, MP – Madhya Pradesh, OD – Odisha, AS – Assam. Regulations in Assam and Odisha are currently in draft stages.

Portable solar product sales have declined this year

Total number of portable solar product sales



Source: Bloomberg New Energy Finance. Based on data from 13 companies. Note: India's financial year is from April to March.

After steadily growing till FY2016, solar lantern sales declined for the first time in FY2017. Total lantern sales were 9% lower in FY2017 over FY2016. Sales for SHS products increased by 12%.

Whether the drop is temporary or an indicator of things to come is not clear. Several micro-finance institutions - an important distribution channel - had temporarily reduced off-grid sales in late 2016 and early 2017 as they were restructuring themselves as payment banks.

Where loans are available via banks and microfinance institutions, customers are opting for larger sized systems. That has been a major driver of growth for off-grid market.

Mobile charging and lighting solutions are in highest demand, followed by fans and televisions. Other products like domestic water pumps, air coolers and refrigerators are also sought by well off villagers.

Many products are used by customers connected to the grid. Frequent power outages and extended blackouts have made lanterns and SHS the preferred mode of lighting in many rural areas during evening hours. These products are also very popular for substituting kerosene lamps in completely off-grid areas.

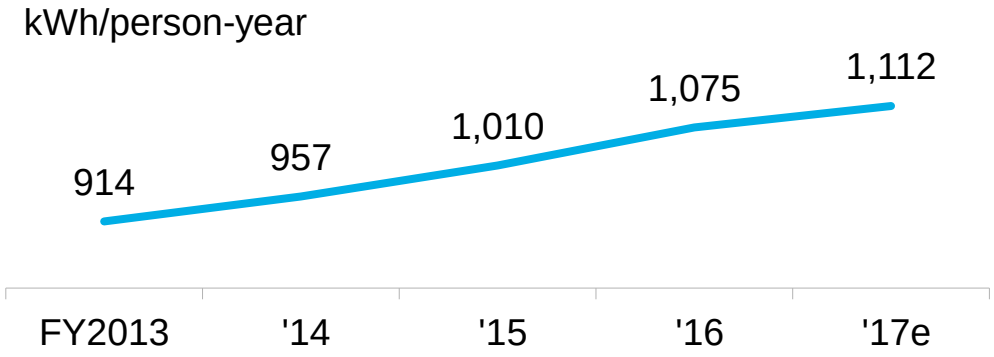
Online sales of off-grid products are starting to pick up with a few companies reporting tripling of sales through e-commerce websites despite occasional delivery problems.

Multiple solar home system companies are now offering pay-as-you-go, rent-to-own and other financing solutions to the customers. That has also increased the appetite for SHS over lanterns. SHS companies have been able to up-sell and cross-sell household appliances like TVs and fans to grow revenues.

Several companies are taking their experience of doing business in India to other markets in Africa that also offers potential for solar lanterns business.

Rural electricity use is increasing with rising economic activity

India's per capita electricity consumption



Source: Bloomberg New Energy Finance, Central Electricity Authority. Note: India's financial year is from April to March

India's per-capita on-grid electricity consumption increased by 22% from 914 kWh/person-year in FY2013 to an estimated 1,112 kWh/person-year in FY2017. This consumption has risen due to increased activity in the industrial sector, higher adoption of electrical appliances by the residential electricity users and addition of more consumers to the grid.

Similar trends are observed in off-grid markets where electricity demand is increasing as the economy grows and people demand higher quality of goods and services.

Off-grid power consumers who earlier used lanterns with mobile chargers are now moving to solar home systems (SHS) which can support fans and TV sets.

Similar upward transition is observed for existing SHS users who are now demanding larger capacity systems which can power more or larger appliances.

Clear trends of up-sell and cross-sell of domestic appliances like TV sets and fans by SHS companies and productive load-use equipment like rice hullers, air coolers and refrigerators by micro-grid companies have been observed. Off-grid companies are diversifying their business activities to increase revenue and maintain higher customer engagement to be able to retain them upon grid arrival.

Micro-grids and other small-scale PV systems deployed by for-profit companies, corporate social responsibility mandates, government initiatives and other philanthropic activities have helped in powering schools, primary health centers and community centers.

Sustaining the small solar boom

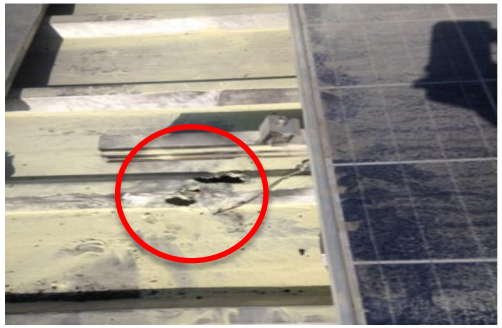
Industry best practices, strategies for power distribution companies

Poor quality of installations may pose serious challenges in future

Incorrect polarity can cause fires

Improper inverter layout can cause shading

Ruptured cables can melt the roof



Poorly designed earthing pit can get damaged

Improperly sized glands can let water in

Corrosion of bolts may lead to rupture

Rooftop service providers can make several quality compromises which are often overlooked by consumers focused on procuring the cheapest PV systems.

Use of sub-standard equipment or poor installation practices can potentially lead to lower system output and system or roof damage.

System performance degradation issues may not arise immediately but after a few years. At that time, seeking service may be difficult if a comprehensive long-term agreement is not in place.

Established rooftop PV companies usually have in-house installation teams which help them control quality.

Government ministries and research institutions have released best practices guides for rooftop PV design, and quality. However, consumer awareness about these is poor.

Source: Bloomberg New Energy Finance, study on quality consciousness of solar industry across India by Cleantech Solar. Note: Best practices manual prepared by Gujarat Energy Research and Management Institute for Ministry of New and Renewable Energy can be accessed here.

Developer strategies to minimize risk of early contract termination

The biggest risk RESCO developers face is the enforceability of power purchase agreements. As rooftop PV costs decline further, C&I and residential consumers may want to exit or re-negotiate the contracts if other competing companies offer cheaper electricity in the future.

- **Assessing off-taker credibility:** Developers usually engage in a two-stage credit check. A soft check before the initial sales pitch, and a thorough assessment of company balance sheets before investment approval.
- **Flexibility in PPA offering:** Allowing flexibility in the choice of PPA – fixed PPA, escalating PPA (tariff increases every year either at a fixed percentage or relative to increase with grid retail tariff), or de-escalating PPA **–** helps in customer acquisition.
- **De-escalating PPA helps in early recovery of capex**, thus enabling a developer to offer cheaper tariffs after a few years – lowering the risk of clients walking away from the contracts.
- **Other important steps** which the developers must take are clear legal provisions in the PPAs, and greater customer-engagement through additional services like energy management and bundling PV with energy storage.

Typical clauses in a rooftop PPA

Clause	Description
Right of way	Clear terms for un-inhibited access to site during installation and for O&M must be specified.
Deemed generation	100% power generated by the PV system must be paid for by the consumer, irrespective of actual consumption and grid export (if any).
Force majeure	All events covered under the force majeure clause like acts of God and other external factors must be clearly specified.
Buyback	Year-wise equipment buyback schedules for termination of the PPA should be mentioned.
Performance guarantee	Clear terms for system performance, minimum generation and de-rating must be present.
Operations & maintenance	Schedules, requirements and additional payments for O&M activities must be specified.
Insurance	A comprehensive insurance coverage for the PV system must be availed and, clear terms of co-insurance and payments must be specified.
Auxiliary power requirement	Terms for supply and payment (if any) for auxiliary power requirement during installation and O&M services must be present.
Liability & indemnity	Clear terms of indemnity against claims from third parties for losses, damage, costs, legal actions must be specified.
Change in ownership	PPA should have clear agreeable terms about change in ownership of either party
Grid interconnection	Clearly defined responsibilities around grid interconnection must be established in the PPA.

Involving distribution companies in the growth of rooftop solar (1/2)

Most power distribution companies (discoms) in India are owned by the government and carried cumulative losses of $67 billion at the end of March 2015.

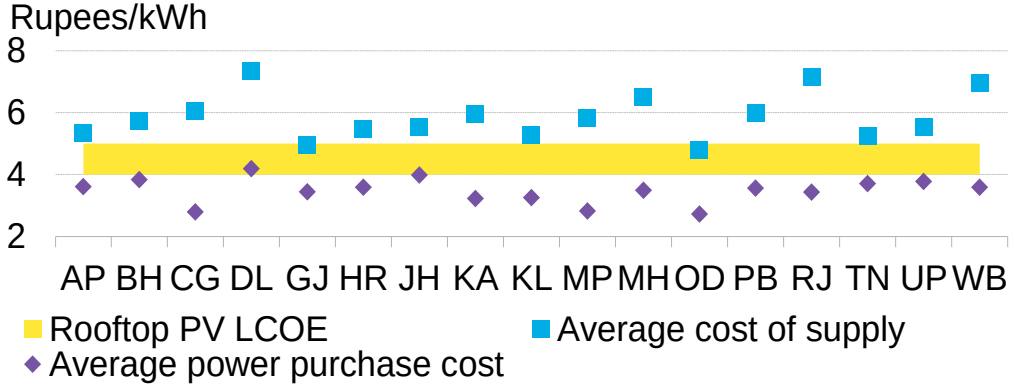
Adoption of rooftop solar is increasing amongst the highest tariff paying consumers of the discoms as they try to reduce their energy bills. This can lead to loss of revenues from the most sought after customers of the discoms. A similar situation in the U.S. led to the scaling back of net metering incentives by several power utilities.

Indian conditions are different from the U.S. as the PV system sizes are restricted by availability of rooftop spaces. Thus, net metering regulations will have limited impact on the revenues of discoms. Most C&I rooftop systems are also built primarily for self consumption and not for grid-export. Rapidly declining costs of energy storage will further reduce the need for net metering regulations in future.

Growth of rooftop solar in India looks inevitable with or without the support of utilities. **Rise of rooftop solar presents an opportunity for the discoms to diversify their business** and offer new services that help them retain existing customers and meet regulatory requirements.

India could therefore learn from countries like Philippines that face similar power sector issues. One local power utility in Philippines, Meralco, saw its revenues dip due to rise of

Average cost of supply, cost of non-renewable power purchase and rooftop PV LCOE in FY2017



Source: Bloomberg New Energy Finance, Central Electricity Authority. Note: Average power purchase cost is the cost of power paid to the generators. Average cost of supply is the average per unit cost of electricity supply incurred to the discom after accounting for transmission, distribution and commercial losses.

unlicensed rooftop PV and responded by starting its own rooftop solar business rather than lose customers. Some initiatives that Indian discoms can take are:

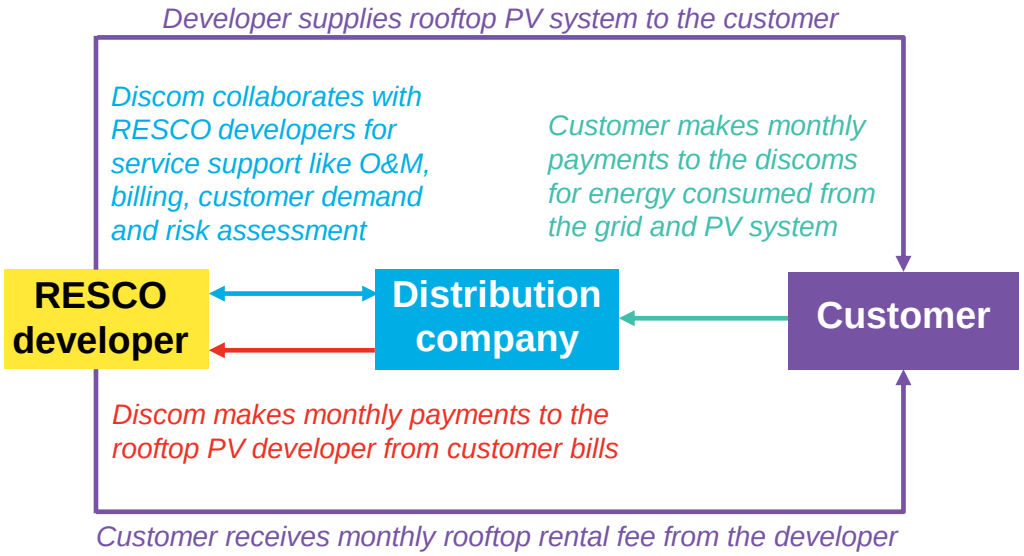
- **Meet their solar purchase obligations and avoid their own installations by directly procuring power from rooftops.** LCOE from rooftop PV in many cases is already lower than average cost of supply by the utilities and in a few years it can become cheaper than their average power purchase costs. Discoms promoting higher injection from rooftop PV systems can benefit from lower purchase costs with minimum distribution losses,

Involving distribution companies in the growth of rooftop solar (2/2)

which will in turn also reduce their financial losses.

- **Utilities can start their own EPC offerings to avoid losing customers to third party installers.** The utilities would be in a position of strength compared to other market players due to availability of better customer data to target potential consumers and leverage long-standing existing relationship with consumers. Discoms can either start operations in their own region of operation (which would require regulatory approvals) or outside their regions through subsidiaries.
- **Discoms can partner with rooftop PV companies for service provision.** They can leverage their existing workforce and infrastructure to provide O&M services, billing, lead generation, branding and sales support to the rooftop PV companies. Utilities can provide critical insights about customer load patterns and payment history which can help RESCO developers in system sizing and off-taker credibility assessment.
- **Discoms can defer investments in building last mile connectivity.** Working with micro-grid companies on a franchise model can help discoms meet rural supply responsibilities while avoiding costs of building and maintaining distribution infrastructure.
- **Discoms can be the drivers for growth of rooftop leasing model.** Discoms can help in kick-starting the government's plans to promote leasing of rooftops by partnering with RESCO developers. While developers installs rooftop PV systems on customer roofs, discoms can act as a customer aggregator and provide service support in activities like O&M, billing, customer demand and risk assessment. The role of discom as a single point of contact for the customer can help in the model's uptake as it avoids the hassles of dealing with multiple parties.

Discom – developer partnership for roof leasing



Source: Bloomberg New Energy Finance

Customer acquisition is becoming expensive for small PV companies

While the equipment costs have come down significantly over recent years, soft costs associated with a project like customer acquisition costs and labor costs have not come down at the same rate.

Acquiring both C&I and residential rooftop PV customers usually takes a couple of months but can range anywhere between two weeks to as much as a year. It also requires multiple follow-ups and site-visits by sales and technical teams adding to the soft costs.

Many back-office associated tasks to handle sales, advertising, tender applications, purchasing, logistics, warehousing, office space rentals and human resources, are often overlooked by aspiring market entrants and are often learned through experience.

Companies try to work on several nearby sites at once to benefit from site density economics, as on-site teams can quickly move from one location to the other once their task is complete, minimizing logistics and downtime.

Future market growth in rooftop PV space will be accompanied by increased competition and **it will become extremely important for companies to automate tasks and keep non-equipment costs in check** to be able to make decent profit margins.

Customer acquisition schemes adopted by rooftop PV companies

Advertisement	Networking	Miscellaneous
Newspapers, magazines,	Harnessing pre-existing customer relationships	Word-of-mouth, cold-calling
Radio, online, events	Creating new relations – expos, tradeshows	Database subscriptions
Billboards, roadshows	Social media	Door-to-door campaigns
Local television	Emails, newsletters	Online sales

There is no definite customer acquisition strategy used by project developers and product sellers. Their approaches depend on demographics, company's previous experiences and internal capabilities.

Established EPC companies and subsidiaries of big-brand conglomerates try to leverage existing client relationships and brand image. New market entrants mainly focus on cost competitiveness, customization, innovation in system designs and remote monitoring.

Appendices

A.1 Business models in rooftop PV in India

	Self ownership		Third party ownership			Other models
	Capex (on-site consumption)	**Capex (grid export)**	**Rooftop leasing**	**PV system leasing**	**Solar power purchase agreement**	**Hybrid ownership**
Description	PV system is owned by the rooftop owner and electricity is generated for self consumption only.	PV system is owned by the rooftop owner and electricity is generated for self consumption. Surplus electricity is sold to the grid through net metering. Alternatively system can be built for total grid export under gross metering.	A developer leases the roof from the property owner and pays a rooftop lease/rental. Electricity generated is sold to the grid at the feed-in-tariff determined by the regulator. System is owned by developer.	Rooftop owner signs a lease agreement with the lessor to make monthly payments over an agreed period of time. System continues to be owned by the developer. Major benefit is no upfront capital requirement to the consumer.	Rooftop owner signs a PPA with a third party developer and enters in to a net metering arrangement with the discom. The ownership of the system lies with the developer. Major benefit is no upfront capital requirement to the consumer.	Rooftop owner puts a small equity investment while the developer puts the rest/arranges debt from the bank/other investors. Such systems have joint ownership to avoid regulatory hurdles in net metering.
Financing	The owner pays for the system upfront and may or may not arrange debt from the banks or other financial institutions.	The owner pays for the system upfront and may or may not arrange debt from the banks or other financial institutions.	The developer puts in the equity investment in the project and arranges debt from the bank/other investors.	The developer puts in the equity investment in the project and arranges debt from the bank/other investors.	The developer puts in the equity investment in the project and arranges debt from the banks/other investors.	Rooftop owner and the developer put an equity investment and arrange debt from bank/other investors.
Performance risk	Performance risk lies with the consumer.	Performance risk lies with the consumer.	Performance risk lies with the developer.	Performance risk lies with the developer.	Performance risk lies with the developer.	Performance risk lies with the developer
Operations and maintenance	Responsibility of the consumer (if no O&M contract)	Responsibility of the consumer (if no O&M contract)	Responsibility of the developer	Responsibility of the developer	Responsibility of the developer	Responsibility of the developer
Accelerated depreciation benefits	Benefits are claimed by the rooftop owner.	Benefits are claimed by the rooftop owner.	Benefits are claimed by the third party investor/developer.	Benefits are claimed by the third party investor/developer.	Benefits are claimed by the third party investor/developer.	Benefits are claimed by the rooftop owner.

A.2 Suitability of different sectors for on-site solar generation

	Segments	Load profile	Land availability	Cost of outages	Energy density	Typical configuration
Typically off-grid or remote	Agriculture					Diesel pumps
	Banks					DG + UPS
	Fuel stations					DG
	Telecom towers					DG + Battery
Typically grid-connected	Industry					DG + UPS
	Shopping malls					DG + UPS
	Corporate parks (SEZ)					DG + UPS
	Offices					DG + UPS
	Hotels					DG + UPS
	Hospitals					DG + UPS
	Residential- low-rise					Battery
	Residential towers					DG

Legend	Low favorability to solar	Medium favorability to solar	High favorability to solar

Note: Favorability of solar generation is based on BNEF judgment.

We would like to thank the following companies (1/2)

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JAKSON™ EMPOWERING PEOPLE
Lume Solar Energy Pvt. Ltd.
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We would like to thank the following companies (2/2)

… and Sterling & Wilson, Tata Power Solar and Tara Urja.

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