Rooftop Solar in India

Looking back, Looking ahead

Acknowledgments

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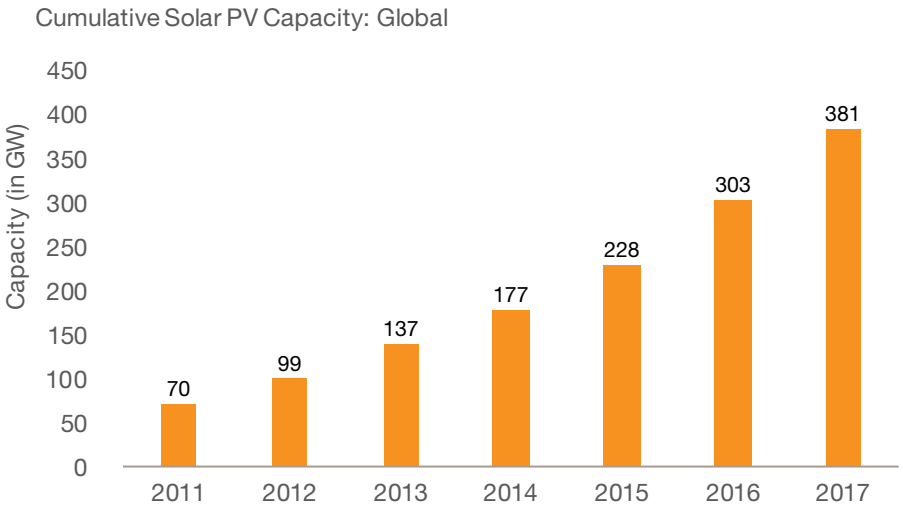
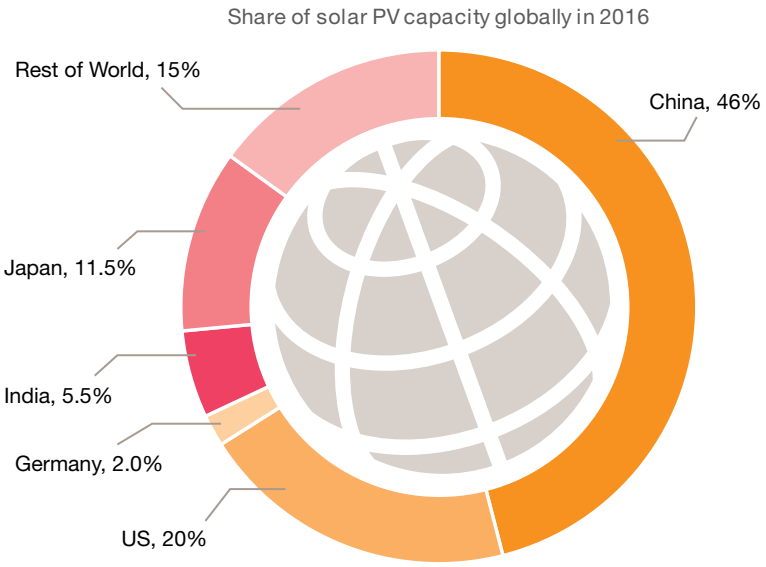
Introduction

Solar photovoltaics (PV) has witnessed exponential growth from 2007 to 2017. During this period, solar PV has evolved from a niche market of small-scale applications to a mainstream electricity source. In the early years, growth was mainly driven by Japan and Germany through programmes like feed-in-tariffs (FiTs) which incentivised wide-scale adoption of solar PV. Germany was the largest solar PV market in the world until 2015, after which China took over. As Germany scaled back on its rooftop solar programme, China and the US became the key drivers boosted by their respective FiT and net metering programmes.

The top five countries contributing 85% of this global addition, in 2016 and 2017, were China, Japan, the US, India and United Kingdom. Other countries like Germany, the Republic of Korea, Australia, the Philippines and Chile followed. While China has been dominating the market, both in terms of manufacturing and installed capacity, other emerging markets are also beginning to contribute significantly to the global growth. In 2016 and 2017, 77 GW and 78 GW solar projects were installed globally respectively, with China alone accounting for around 46%of this capacity, followed by the US, Japan and India.[1]

Global Solar PV capacity



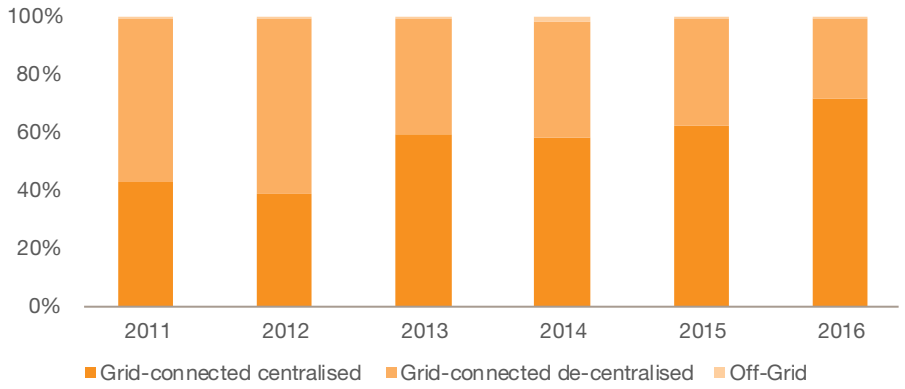


Source: REN21 Global Status Report 2017

1 IHS Markit

While significant capacity has been added in utility scale solar projects, rooftop solar projects have also grown tremendously during this period, powered by various government programmes such as FiTs (as in Germany and China) and net metering (as in the US). In addition, fiscal incentives such as subsidies and tax credits have also helped the rooftop solar industry to grow exponentially throughout the world. Innovative financing mechanisms such as third-party financing (leasing, power purchase agreement), especially in the residential market, have also contributed to the sector growth, particularly where the high initial cost of PV systems was a major barrier to growth.

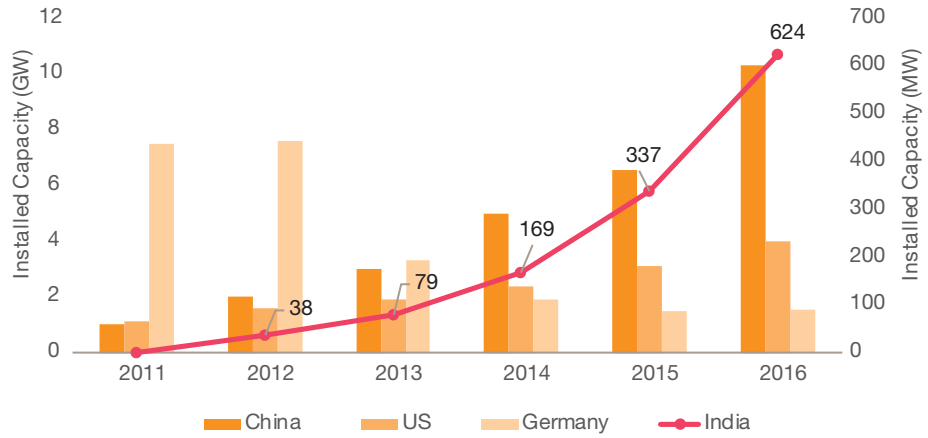
Solar PV technology-wise split



Source: REN21 Global Status Report 2017

Rooftop solar PV has experienced annual growth in most countries, except in countries like Germany, where the market became saturated and hence started to fall. However, the overall growth of rooftop solar across the globe saw an annual increase in capacity and is expected to rise further, thereby improving the ratio of rooftop solar over large utility scale solar in the global solar PV mix. Market forces, including price decline and change in financial incentive and emerging business models, are expected to contribute to this perceived growth. While China and the US are expected to occupy top positions, India is also expected to become a major market in the next few years.

Distributed generation (rooftop) installed capacity



Source: Compiled from various sources, PwC analysis

India has achieved tremendous growth in terms of installed PV capacity, primarily in utility scale installations during 2010 to 2017 through the National Solar Mission (NSM), which aims to achieve 100 GW solar PV installed capacity by 2022. Under this mission, India has set an ambitious target of 40 GW rooftop solar capacity by 2022, which offers significant growth potential for the Indian rooftop solar market. While the growth in the utility scale solar market has been spectacular, with more than 21 GW installed in a period of seven years, rooftop solar growth has not been as impressive, with around 1,219 MW installed capacity achieved as of June 2018 as per official figures released by the Ministry of New and Renewable Energy (MNRE).[2]

The benefits associated with rooftop/ distributed solar PV systems are multi-fold. For a developer, it includes reduced land and interconnection costs and increased profitability due to higher savings contributed by increasing commercial and industrial tariffs. Rooftop Solar PV also supports distribution companies (DISCOM) by reducing the peak demand during the daytime for most countries and decreases transmission and distribution (T&D) losses as the power is consumed at the point of generation. Further, huge commercial benefits are envisaged by reducing investments in the transmission system in the host country with these rooftop systems. Above all, rooftop solar PV reduces the dependence on grid power and diesel generators and, at the same time, offers a long-term reliable source of power for end consumers.

Despite all the underlying benefits, rooftop solar in India has not achieved significant growth. Various international credit lines and concessional funding have also been extended to financial institutions and banks in India to support the large-scale deployment of solar rooftop in the country. Such sources have supported the market growth in recent years by reducing the high cost of financing for smaller projects, thereby reducing the tariffs and making the projects more viable. However, there still exist many challenges in this segment, such as awareness building, lack of capacity, legal and contractual issues, and roof right issues, which need to be addressed at each stakeholder level to help further scale up the deployment.

Currently, India is in the market transformation phase and hence, the need of the hour is to address the issues and challenges hampering this growth. Other developed countries like Germany, China and the US have faced these barriers in the early growth years. Hence, with this study, PwC aims to analyse the rooftop market scenario in developed countries like China, the US and Germany, followed by a detailed analysis of the Indian rooftop solar segment, identifying the challenges and the role of the Clean Technology Fund (CTF) in addressing some of these challenges through concessional funding support. The study also provides a way forward for the need for concessional funding support in the Indian market to support the large-scale deployment of rooftop solar PV along the lines of the growth seen in the utility solar market.

2 https://www.mnre.gov.in/physical-progress-achievements

Global experience

The development of a distributed energy system is one of the most important measures to promote energy production and innovation of energy utilisation patterns of a particular country. India, being at the development stage, there is a need to analyse the experience from international markets such as China, the US and Germany to understand the trends and business models followed to gain the scale achieved.

China

China's solar market has grown tremendously from less than 1 GW in 2010 to 130 GW in 2017, with a growth of around 67% from the previous year. Rooftop solar installations have reached to around 28 GW as on 2017 and are expected to almost double in 2018.

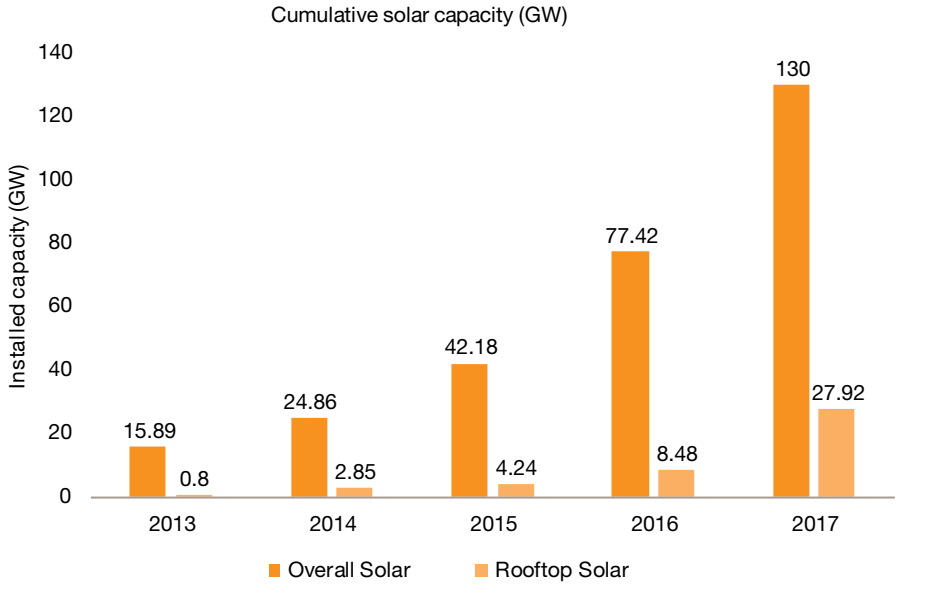
The country added around 53 GW of solar PV installations in 2017 as compared to 34.5 GW addition in 2016.[3] Out of 53 GW installed in 2017, 19.44 GW was achieved through distributed solar PV projects. Rooftop installations grew by almost three times in 2017, comprising 2GW residential solar PV projects.

The major reasons behind this tremendous growth in rooftop solar projects are:

- **Policy support:** The government's plan to phase out subsidies by 2020, which led investors to grab the business opportunity with the available high subsidy
- **Market deregulation:** Distributed generators' model to sell directly to neighbouring industrial and commercial customers
- **Demand:** Availability of multiple customers and low cost of rooftop solar compared to industrial and commercial customers' retail power prices

China has already over-exceeded its target of 105 GW (targeted for 2020) by 24% and thus represents around one-third of the total installed PV capacity globally.

Cumulative solar capacity (GW)

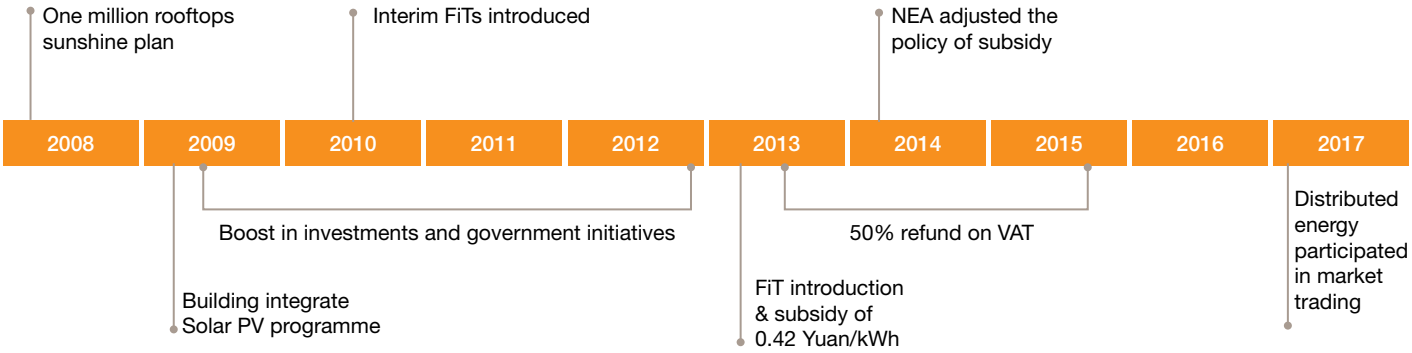


3. https://mercomindia.com/china-2017-solar-report/

Market evolution

The Government of China is aiming to install the solar PV capacity equivalent to conventional power. For this purpose, various subsidy schemes from the Central and provincial governments, depending on the cost of land, labour, financing, etc., have been introduced over the years as the Chinese market shifted from provision of an investment subsidy to FiT from 2009 to 2017.

Market evolution in China



2008

Shandong Province announced the implementation of the **One Million Rooftops Sunshine Plan** in January 2008. The programme was designed to encourage the integration of solar and geothermal power sources into building construction. This regulation was implemented in cities of Yantai and Jinan.

2009

The government initiated the **Integrated Solar PV Programme** that provided upfront subsidies for grid-connected rooftop and building integrated Solar PV (BIPV) systems. The government determined a capital premium for systems with minimum peak capacity of 50kW. However, the subsidy levels declined from 15 CNY/W (2.35 USD/W) in 2009 to 7 CNY/W (1.1 USD/W) in 2012.

2010

The process of implementation of national FiT for solar PV generated electricity came into the picture in 2010 when National Development and Reform Commission (NDRC) set up a special **interim FiT** of 1.15 CNY/kWh (0.17 USD/kWh) for four PV power plants in Ningxia province.

2012

In October, the State Grid Cooperation for China (SGCC) announced **Interim Measure of Distributed Solar Power Generation**, to allow grid connection to small-scale distributed solar power generators with less than 6 MW installed capacity and lower than 10,000 kV. The charges for grid connection were waived off.

2013

In order to develop solar power generation, between 2013–2015, the Government of China proposed to refund 50% Value added Tax (VAT) on self-used solar power.

2013

The National Development and Reform Commission (NDRC) announced an **FiT** by setting the benchmark on grid power tariff at 0.9 RMB/kWh, 0.95 RMB/kWh and 1 RMB/kWh depending on resources and construction costs in different zones across China. It was forecasted that the FiTs would fall by at least 10% each year on projects smaller than 20 GW and by 20% each year on projects larger than 20 GW. The reason behind such a fall in tariffs was to promote technological development and improve efficiency. The FITs in 2017 were around 0.65 RMB/kWh, 0.75 RMB/kWh and 0.85 RMB/kWh compared to 0.8 RMB/kWh, 0.88 RMB/kWh and 0.98 RMB/kWh in 2016.

2017

China's NDRC released FiTs for solar PV projects to be implemented from January 2018. The FiT for distributed projects were decided at 0.37 RMB/kWh (5.8 US cents/kWh) with 11% reduction annually.

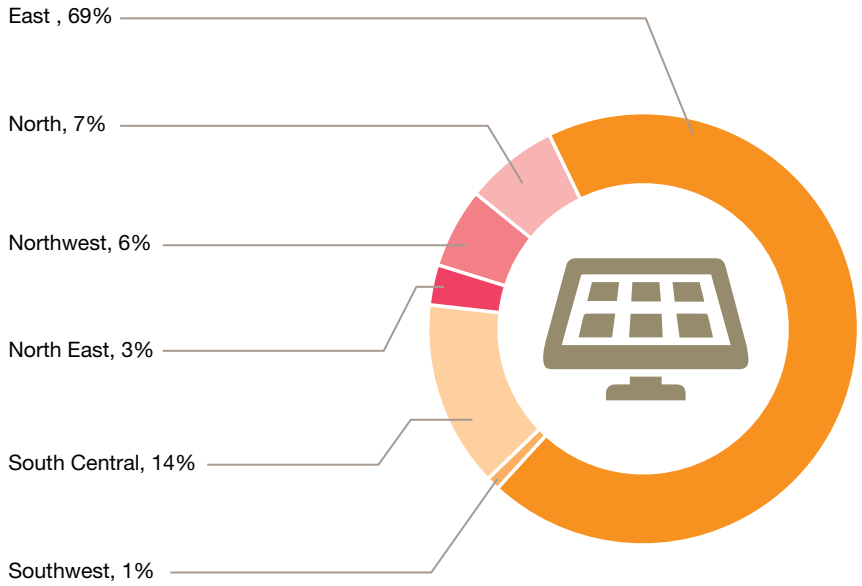
China's Five Year Plans

Development plan	Requirement	Target
11th Five Year Plan on Energy (2006–2010)	Distributed energy technology was outlined as one of the cutting-edge technologies and strategic areas.	–
12th Five Year Plan on Energy (2011–2015)	Develop distributed energy actively on the principle of electricity generation mainly for self-use with surplus sold to grid and achieve coordinated development of centralised and distributed energy.	Apart from other distributed energy project, focus was on 10 GW distributed solar capacity by 2015
13th Five Year Plan on Solar Energy (2016–2020)	Promote distributed solar power in central and east regions, giving priority to the development of distributed solar power, especially those connected to the low-voltage distribution network and consumed nearby.	Distributed solar to reach 60 GW by 2020

Target market

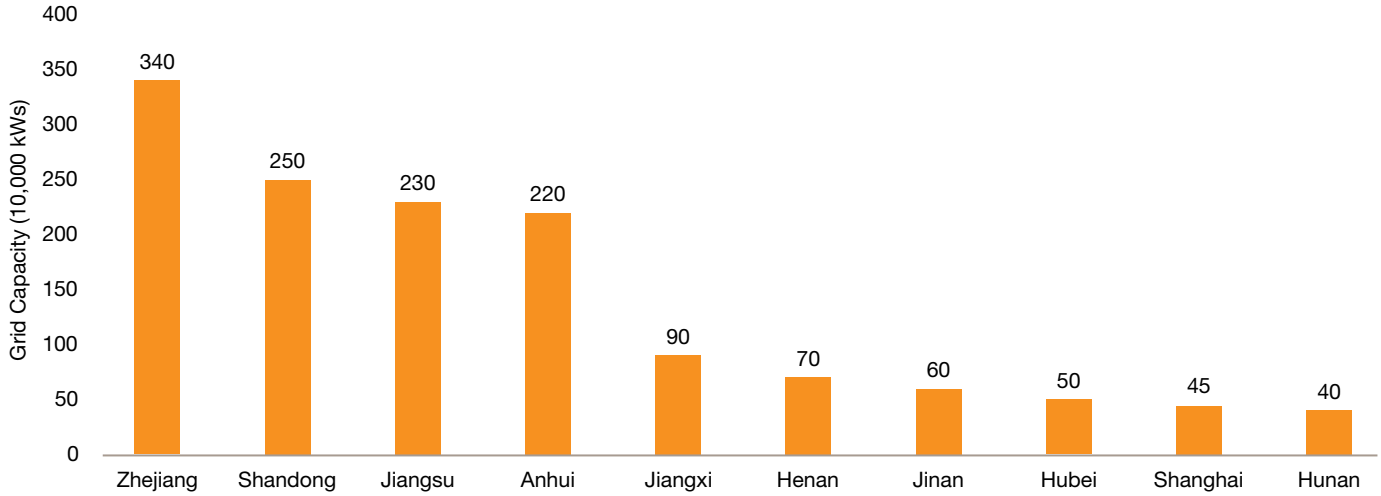
The solar market in China comprises a utility scale market, dominant in western China, and distributed solar market, which is shifting to the central and eastern regions because of the increasing load centre in eastern China. Out of the total installed capacity, 69% comes from the eastern region, followed by 14% from south central, 7% from the north, 6% from the northwest, 3% from the northeast and 1% from the southwest. Power generation is increasing in the central and eastern regions, while the provinces leading the installed capacity are Zhejiang, Shandong, Jiangsu, Anhui and Jiangxi. With the increase in installed capacity of renewable sources in western China, further capacity addition of wind and solar is increasingly becoming a significant issue. Since there were issues with transmission and rising curtailment practices in the western part of China, the investment started flowing in closer to the load centre in the east.

Geographical distribution of PV projects in China



The top 10 provinces of China with distributed solar PV capacity (as of June 2017) are represented below.

Provincial distribution of rooftop solar projects



Business models

The revenue models of solar PV projects are:

All online model

In this model, the owner gets the PV FiT (fixed for 20 years) of 0.65 CYN/kWh, 0.75 CNY/kWh and 0.85 CNY/kWh in addition to the local subsidy (if any). This model is used mainly for utility scale projects.

Revenue = FiT + local subsidy (if any)

Extra online model

This model is popular for distributed solar PV projects. The power generated can be either utilised for personal use or sent to grid.

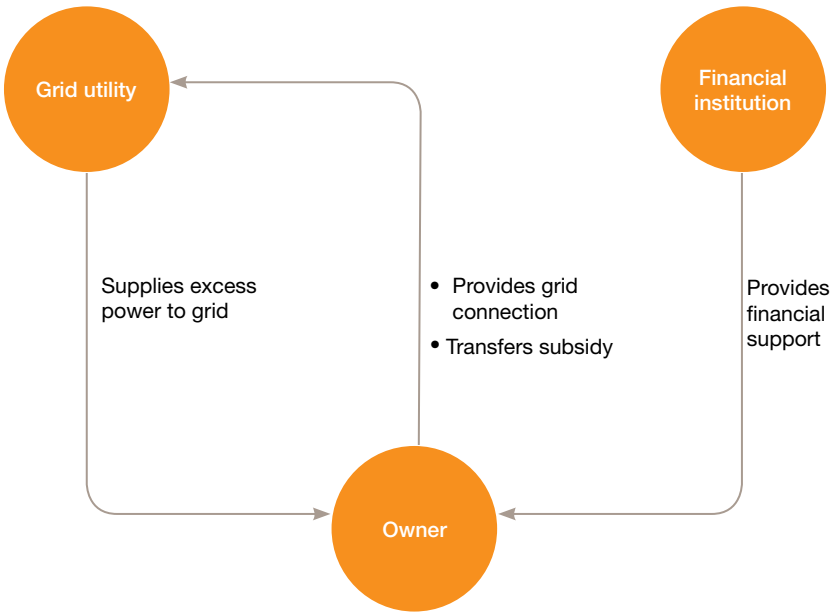
Host-owned model: This model is the simplest business model in which the owner installs the project on their rooftop, consumes the power generated and sells the excess power to the grid utility. The reason for maximum success in this model is that the owner saves on the electricity bill and additionally gets the subsidy. If the power generated is utilised for personal consumption, no revenue is generated; however, the owner will be eligible for a subsidy of 0.37 CNY/kWh along with local subsidy (if any) in addition to savings on the retail electricity bill.

Self-use price = Basic price + local subsidy (if any) + 0.37 CNY/kWh

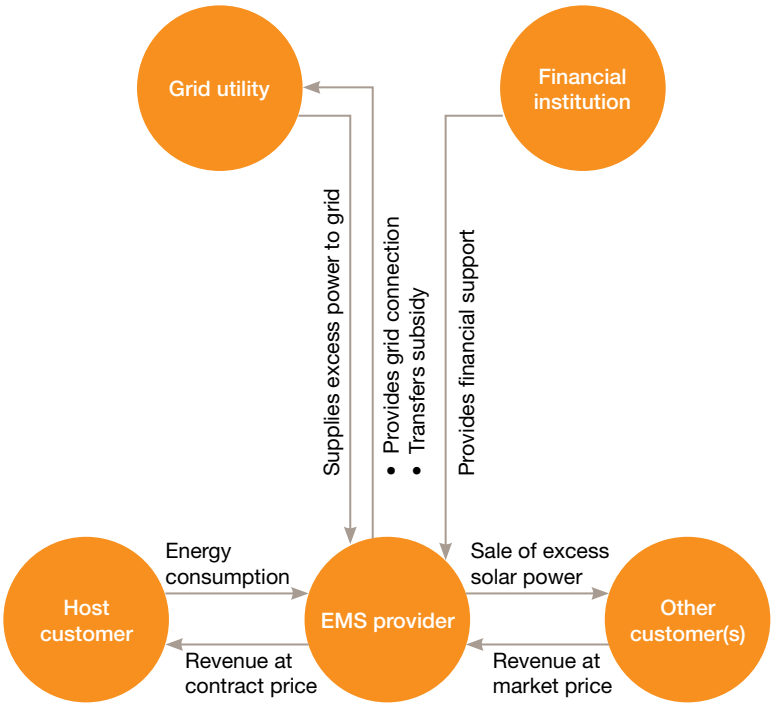
Energy management service (EMS) model: This model is similar to the US third-party ownership model and is further composed of a lease model and power purchase agreement (PPA) model. The PPA model is, however, preferred over the lease model as the owner eliminates the need to deal with grid connection and power sales.

- **PPA model:** In this model, the EMS provider owns and installs the solar panel on the rooftop of the host customer and the customer in turn gets solar power supply at a rate that is 80–90% lower than the market retail price. The revenue for the customer is the savings made from the electricity bill. The sources of revenue for the EMS provider are the revenue generated from sale of solar power to the customer, government subsidy and sale of excess solar power to the grid.

Host-owned model



PPA model

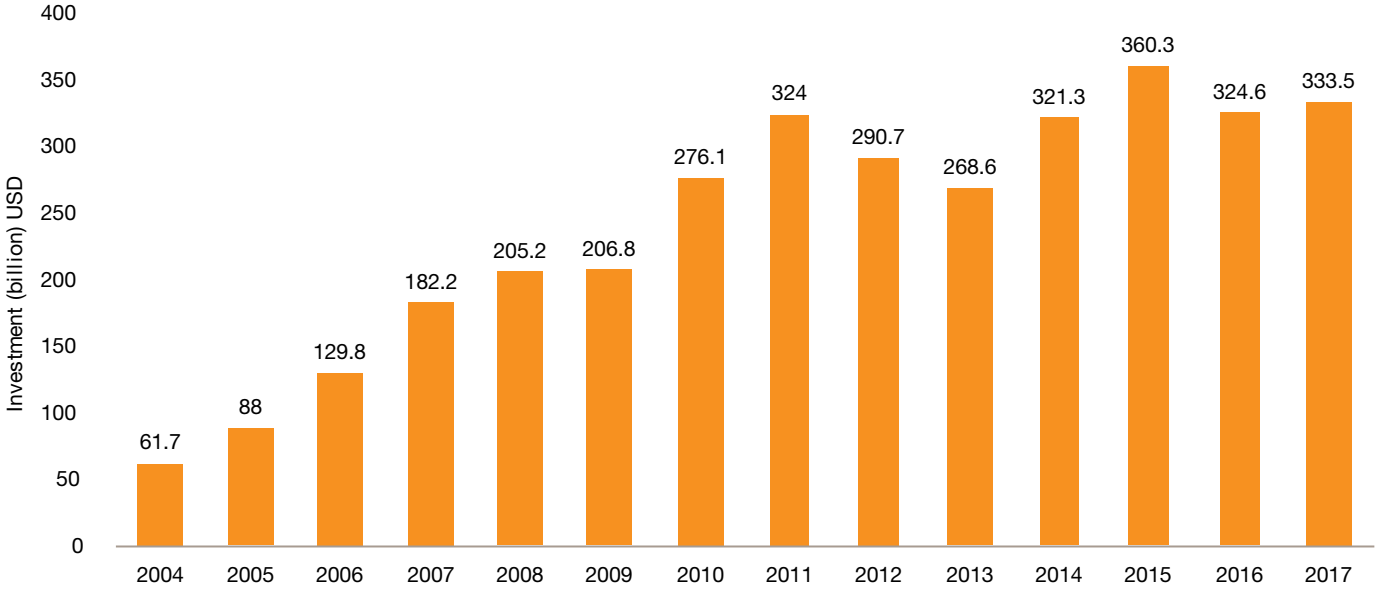


- **Lease model:** In this model, the customer leases the PV system from the EMS provider and pays monthly fixed payments for a fixed duration of lease until the system is transferred to the host customer. The revenue for the host customer, during the lease tenure, is the saving on the electricity bill, sale of excess electricity to the grid and government subsidy.

Financing instruments

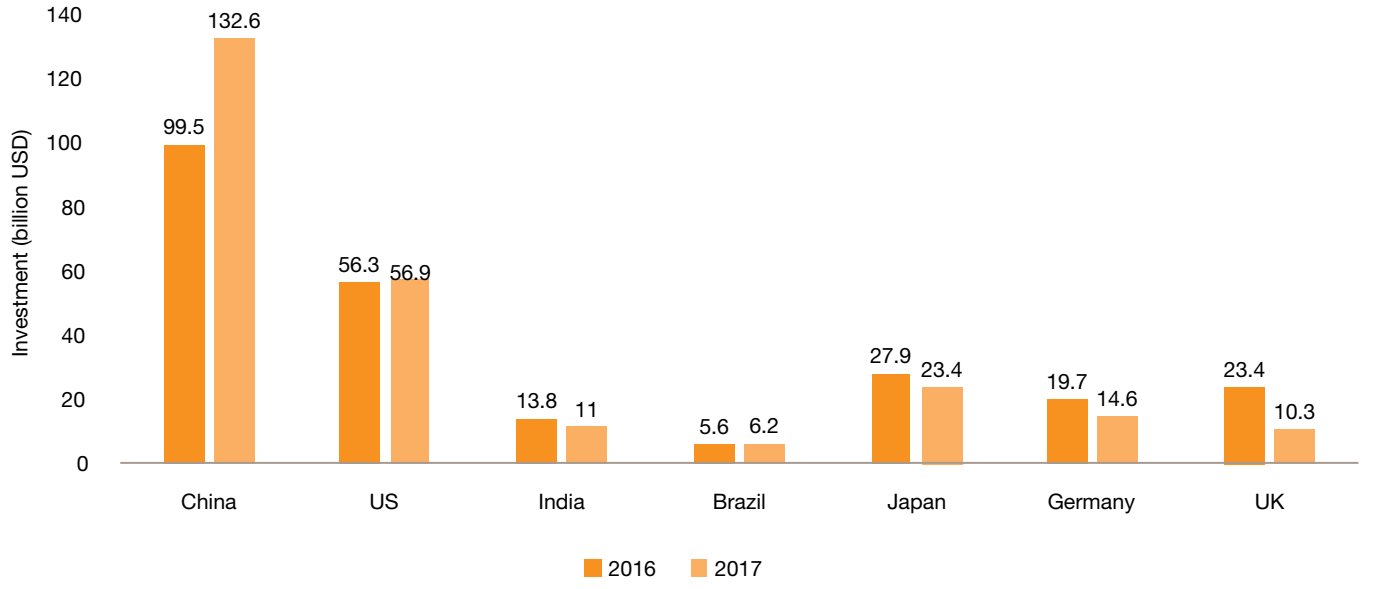
A global investment of approximately 333.5 billion USD[4] was made in 2017 for the development of renewable energy and cutting-edge power technologies, out of which approximately 168 billion USD was used for development of solar projects.

Global clean energy investment



China recorded the maximum investment with around 40% of the total global investment. The reason for the growth of the solar market in China was the increased installation of solar panels in industrial parks where companies planned to reduce their energy costs and meet their electricity demand through solar energy.

Country-wise clean energy investment



4 Bloomberg New Energy Finance

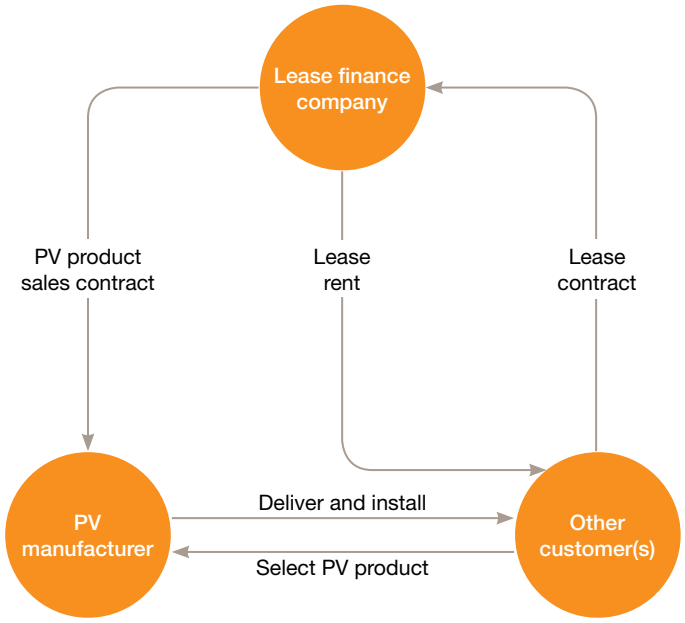
Currently, corporate collateralised loans are the most common form of financing solar and wind projects in China. Apart from this, in order to meet the solar targets and provide low-cost, yield cos, leasing, and crowd and community funding are promising financing models.

The various modes of financing prevalent in the market include:

Conventional bank loans: The loans provided by the China Development Bank (CDB) and/or other commercial banks are the main source of finance for the rooftop solar sector in China. The loans are provided for a short term (1–5 years) based on a borrower's credit risk.

Loan financing platforms: Initially, there were some constraints on bank loans for distributed solar PV (DSPV) projects, particularly for non-state-owned enterprises. The National Energy Administration (NEA) and the CDB jointly established a local financing platform where the CDB provided a line of credit to medium- and small-sized companies who do not get bank loans due to low credit rating. The government proposed a bank loan for a period of five years at a lower interest rate for the rural, residential and agricultural sector to promote deployment.

Lease financing



Lease financing: In this type of financing arrangement, the project developer selects the PV product, the financing company purchases the required PV product and leases it out to project developer.

Key challenges

Some of the challenges faced by the country can be grouped under the following categories:

Commercial

The residential market in the country is highly fragmented and hence customer acquisition is quite expensive, especially considering the small size and high cost of distributed systems. Additionally, due to low grid electricity prices, the customers do not see a huge incentive in installing rooftop solar systems without FiT support.

Regulatory/legal

Another major challenge faced by the country is the ownership structure of residential complexes. Large cities with high income households have limited rooftop solar space for installation and with multi-family apartment complexes and rented houses, the ownership rights become a major hindrance to deployment. Further, installation in the country is majorly focused towards the highly industrialised eastern provinces, while western and southern provinces have been lagging behind their targets.

Technical

In the absence of an official industrial standard for residential PV systems coupled with low level of technical awareness and low price expectations of customers, equipment quality tends to be a challenge during project design and installation.

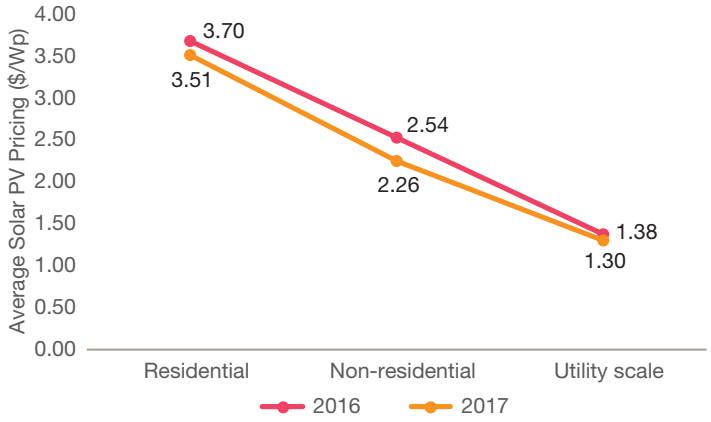
However, despite the above challenges, China has been able to achieve one of the largest rooftop capacity additions across the globe and the lessons from its experience could be quite relevant for the Indian market.

US

The US installed around 4.5 GW of solar PV during the first half of 2017, reaching a cumulative capacity of 45.4 GW.[5] Growth of solar installations has been mainly because of falling solar PV prices. It can be observed that solar PV pricing has fallen from 8 USD/Wp in 2005 to much lower (see Figure 15).

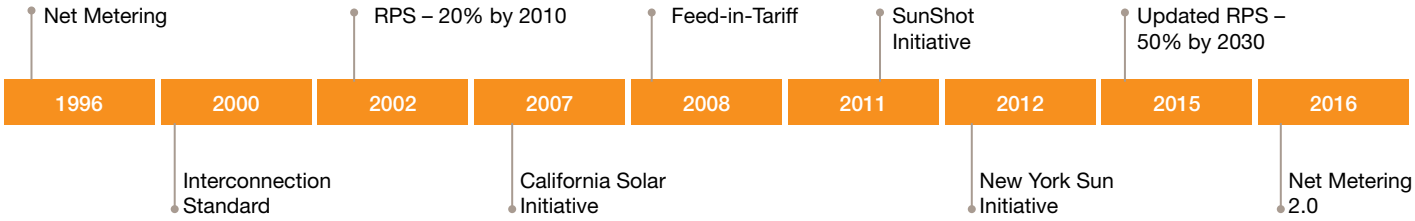
The system installation costs in the residential sector are the highest due to the small size of installations, complex supply chain logistics, taxes, overhead costs as well as margins. On the other hand, utility installations, larger in size, have lower costs as compared to rooftop projects.

Average solar PV pricing



Market evolution

Some of the major incentives/programmes to promote solar PV in the US are represented below:



1996

California's **Net Metering** law was announced in 1996 and was applicable to all utilities except Los Angeles Department of Water and Power (LADWP). Under this law, net excess generation (NEG) from the rooftop system is carried forward to the customer's next bill. Under this law, any NEG remaining at the end of each 12-month period was granted to the customer's utility. Customers had an option of rolling over any remaining NEG from month-to-month indefinitely, or they could receive financial compensation from their utility for the remaining NEG. In addition, customers also benefited from the Renewable Energy Credits (RECs) associated with the electricity produced and used on-site.

2002

The California Renewables Portfolio Standard, 2002, requires its large utilities to buy 20% of supplies from renewables by 2017.

2007

Solar California Initiative (CSI) or Self-Generation Incentive Program (SGIP) planned a capacity addition of around 3000 MW in California. The CSI is a key component of the Go Solar California campaign. The CSI programme had a total budget of 2.167 billion USD between 2007 and 2016 and a goal to install approximately 1,940 MW of new solar generation capacity. The initiative paid customers either all at once for smaller systems or over the course of five years for larger systems.

2008

The California Public Utilities Commission announced an FiT programme in 2008, authorizing the purchase of 480 MW of renewable generating capacity from renewable facilities smaller than 1.5 MW. These FiTs provided a simple mechanism for small renewable generators to sell power to the utility at predetermined terms and conditions, without engaging in contract negotiations.

2011

The US Department of Energy (DOE) launched the **SunShot Initiative** with the goal of making solar energy fully cost competitive with traditional energy sources before the end of the decade. Through SunShot, the DOE supports efforts by private companies, universities, and national laboratories to drive down the cost of solar electricity to 0.06 USD/kWh by 2020, making solar energy affordable.

2012

The New York Sun (NY-Sun) Initiative was launched in 2012 to increase solar electric installations in the state. In April 2014, a commitment of nearly 1 billion USD was made to NY-Sun for expanding deployment of solar capacity throughout the state and transform New York's solar industry into a sustainable, subsidy-free sector. NY-Sun is also expanding the use of solar through New York State. As of March 2016, a total of 568 MW of solar electric had been installed across the state, with New York State Energy Research and Development Authority (NYSERDA) funding, powering more than 94,000 homes. The substantial growth is attributed to a decline in solar electric component prices and growth in the number of installer businesses marketing solar electric to customers.

5 https://www.nrel.gov/docs/fy18osti/70406.pdf

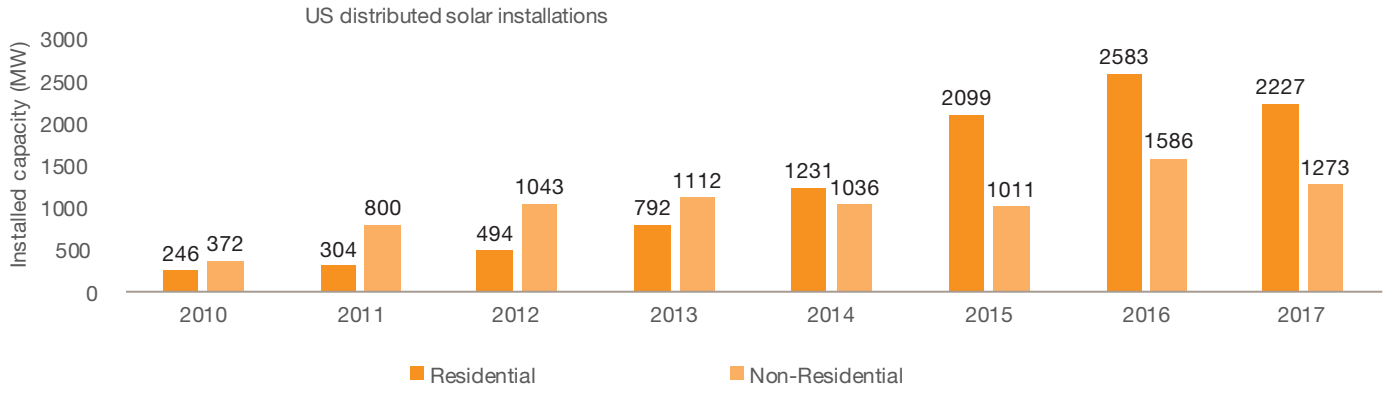
Target market

In 2016, the US witnessed a record 2.6 GW of residential distributed solar systems. Residential customers have been the major drivers of distributed solar generation in the country. The deployment had been the fastest in the states where net metering had been quite active.

The residential market boomed at around 70% growth in 2015, which slowed down to 23% growth in 2016, on account of both seasonal factors and the inevitable levelling-off of demand. The major reason for the slowdown, despite stable policies and solar reaching almost grid parity, was the customer acquisition challenges faced by solar providers. Another factor affecting the overall slowdown in the solar installations was the addition of taxes on the imported solar cells and modules that affected bulk procurement and hence increased the project cost.

The non-residential market, on the other hand, remained flat over the past couple of years until 2016. The major contributor to the sudden growth observed in 2016 was the new state-level policies which included the extension of the net metering programme capacity limits. The growth in the distributed solar market for both residential and non-residential customers is represented below:

US distributed solar installations



Business models

Until 2006, the US solar market was mainly driven by utility scale projects; however, by 2015, the residential solar PV grew to capture about one-third of the total installed capacity in the country. The major contributors to growth included the fall in hardware costs, including the panel and inverter cost decline by over 60% on a per watt basis since 2010.

Considering the solar system cost on a per watt basis, the average residential solar prices ranged at around 3.70 USD during 2014–2015. Approximately two-thirds of this per watt cost includes the cost of installation, while the remaining one-third constitutes sales as well as general and administrative costs. Given the average household income of 53,657 USD of Americans in 2014, rooftop solar systems fell beyond the reach of most people. Hence, a model similar to the one in the auto market was considered. The residential solar providers created third-party owned financing models to attract customers. With 'no money down' contracts and low initial rates, households faced fewer barriers to accessing what companies believe to be residential solar's long-term value proposition. They became providers of 'solar-as-a-service': selling, installing, financing and maintaining the solar system for customers. The new residential solar business model influenced households as well. Solar leasing and loan products allowed a higher number of Americans to become 'prosumers' of electricity—producing, consuming, and reselling electricity to the grid.

Four primary financial contracts were used:

1. Loans

Under this model, the solar provider (engineering procurement construction [EPC] contractor) grants a loan to homeowners, thus allowing them to purchase the solar system and make interest payments to the EPC contractor until the loan maturity tenure. The debt product can, however, involve an annual escalator.

2. Property Assessed Clean Energy (PACE)

PACE finance is similar to the home equity loan wherein PACE customers receive solar installations, while municipalities structure municipal bonds to repay the capex on the installations, so that the customers are not burdened with upfront cash payments. PACE households then repay the bonds, which are secured by the home, via annual tax assessments over approximately 15 years. Unlike other forms of financing, PACE has one major constraint: it is limited to municipalities with programmes in place.

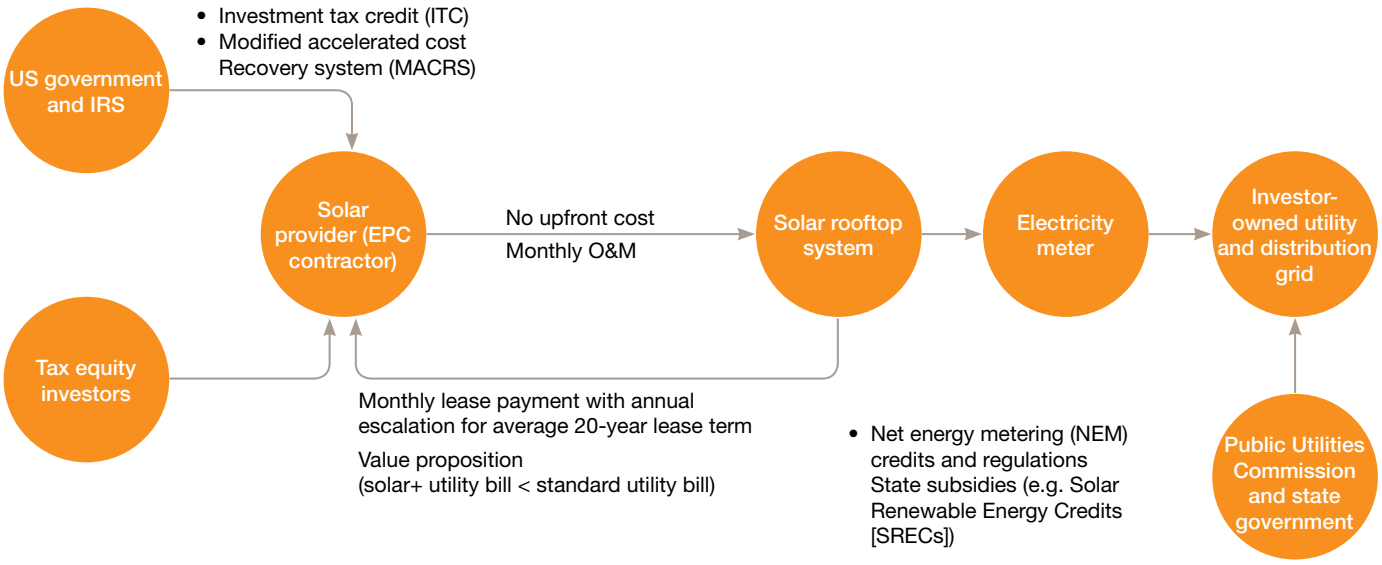
3. Lease

Under this model, the EPC contractor enters into a standard 20-year lease agreement with the customer and, in turn, provides the solar panels and complete system. The household thus agrees to a fixed USD/kWh payment which is less than the previous utility bill. The differential in the utility bill using solar and without solar makes the value proposition for the household with the added incentive of no upfront payment.

4. PPA

This model is quite similar to the leasing model with the difference that PPA holders enter into a contract to buy the solar system's power at a predetermined USD/kWh rate.

Typical business model for US solar residential systems – lease/PPA



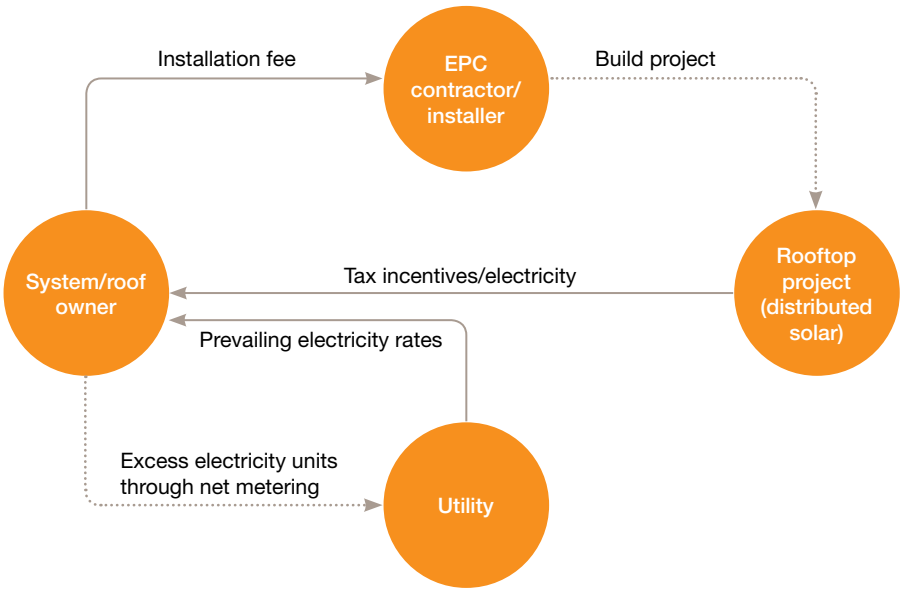
In the lease model, three primary incentives and cash flows are:

- **Lease payments** from household (rooftop system beneficiary) to the solar installer/provider,
- **State credits** for the electricity produced, and
- **Federal government tax credits** (ITC and MACRs) and investors in them:
  - Investment tax credit (ITC): ITC involves a 30% reduction in the income tax payable by the individual or firm seeking the credit until 2019 and then a gradual step down to 10% by 2023.
  - Modified accelerated cost recovery system (MACRS): It is a form of federal subsidy allowing the companies to depreciate rooftop solar assets over five years and deduct up to 85% of the cost.

Based on system ownership, the three types of business models prevalent are:

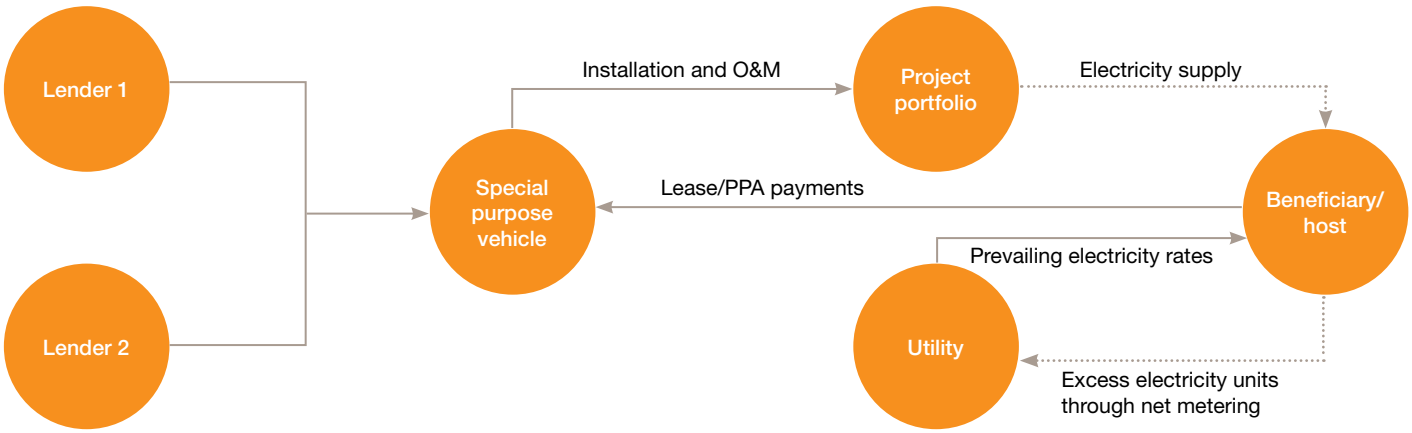
- **Host-owned model:** This is the most common ownership model followed for rooftop solar projects. In this model, the rooftop solar system is owned by the roof owner and the electricity produced from the system is mainly used by the owner, and the excess electricity produced is sent back to the grid for which the owner receives the credit. This model, however, has certain disadvantages, including high upfront and maintenance cost, risk of poor performance depending on the quality used by the EPC contractor and transaction cost associated with grid interconnection.

Host-owned model



Thus, to overcome this disadvantage of huge upfront capital investment by the customer and ownership for the operation and maintenance of the system, various other business models are preferred for residential distributed solar.

- **Third-party ownership:** In this model, a third party owns the system on the customer premises/roof and offers the benefits of solar generation to the customer through a 10–25 year lease or PPA arrangement. In this PPA arrangement, the customer agrees to pay a fixed per unit charge for the electricity used. Hence, the amount paid varies monthly as a function of power generation. The main advantage of this system is that the third party can pool in multiple projects (PPAs/ leases) to attract a larger project portfolio and offer competitive returns. This model has been quite prevalent in the US market as the solar leases and PPAs available have favourable interconnection and net metering policies; legal and regulatory clarity for third-party solar ownership models and local financial incentives have also favoured growth in the US.
- **Community ownership:** In this model, multiple customers own a single rooftop PV system and share the benefits of solar generation. This model helps multiple consumers gain the benefit of PV installation, especially customers who face challenges of roof ownership rights (e.g. tenants) or customers with high rise buildings (roof ownership access/building constraints of shadow free area).



Financing instruments

The initial cost of a solar PV system acts as a barrier for deployment. In order to overcome this barrier, the following financing mechanisms are practiced in the US.

Financing through government/utilities

The government and utilities can play a significant role in the advancement of rooftop solar PV. Quite a few municipalities in the US have initiated programmes to allow for affordability of rooftop PV projects through provision of financial incentives such as low interest loans, rebates, subsidies or the creation of alternative ownership structures like shareholding structures in solar farms. Some of these initiatives are outlined below:

PACE programmes

As mentioned earlier, PACE acts as a municipal financing mechanism through which property owners receive 100% financing in the form of loans for their renewable energy projects through the municipality. This loan is repaid through property tax bills. Municipalities collect this funding from local people through the issuance of green bonds.

Municipal bond-PPA model (the Morris model)

As per this model, bonds with low interest rates are issued by the government in order to raise funds. The proceeds are then handed over to a project developer in exchange for an attractive lease purchase agreement. The developer can then sell the electricity through a PPA to the DISCOM.

Third-party ownership model

The developer finances, owns and operates the cost of the rooftop under two main categories:

Solar leasing model

The building owner pays monthly instalments to the third-party rooftop owner ('developer') as he leases the system through a long-term contract, while the cost of the system is borne by the developer. The building owner consumes electricity at a price that is at times lower than what he would pay to the utility. This model has been predominant in the development of the US solar market.

Solar power purchase model (PPA):

In this model, the consumers buy generated electricity from a third-party developer through a price decided in the contract per kWh, typically for 10–20 years. The developer installs, owns and operates the system. Any excess electricity can be sold to the utility. This results in the reduction or elimination of the upfront cost of the system, allowing those with less income to afford rooftop systems.

Utility-sponsored model

In this model, the utilities find a source of finance on behalf of their customers through:

On bill financing:

This is an instrument through which renewable energy projects are paid for by utility customers on their monthly electricity bills. Utilities take advantage of the fact that they can obtain lower interest loans than consumers, and in turn make available the finance they have obtained through to commercial, residential and community projects in the form of a loan. This loan is in turn repaid to the utility as a line item on the monthly electricity bill.

Utility-owned distributed solar:

The utility installs, owns and operates the rooftop systems. These systems can be installed on leased commercial and public properties within the utility's service territory. This model saves on the transaction cost of payments through utility bills.

Volume purchasing

Rooftop owners interested in solar panels can get together in educational workshops as a group and the high upfront costs can be overcome through bulk purchase of systems. This model also decreases cost when combined with government incentives. Also, system owners can offer discounts as they save on marketing costs.

Key challenges

Some of the challenges faced by the country during its growth phase were:

Lack of state support

In a federal system like the US, states hold the power to regulate renewable energy growth. The lack of mandatory RPSs in several states with a large rooftop PV potential has impeded the growth of the industry.

Third-party arrangements

Several states have specified that third-party arrangements are not considered as utilities by their state regulatory agencies and are therefore not subject to regulation. Most net metering rules did not address this issue, which led to the creation of contracting ambiguities. Further, third-party ownership is not allowed in several states, thus creating barriers to leasing models.

Influence of traditional energy sources

The coal industry and power utilities, whose revenues were threatened by captive solar power, are formidable and had a significant influence in slowing down the growth of distributed solar.

Ownership of RECs

RECs are the environmental (non power) attributes of renewable generation. RECs allow these attributes to be unbundled or sold separately from the associated energy commodity. REC ownership has emerged as a critical policy and economic issue for distributed generation system owners, utilities and regulators, especially in the wake of the widespread state adoption of RPSs in recent years.

Soft costs

Activities such as permitting, financing and customer acquisition drive up 'soft costs' to the point where non-hardware costs make up an unreasonable portion of total costs in the US, especially for rooftop systems. The DOE reported that soft costs make up more than half the price of installed solar power, with residential solar bearing the largest burden of these expenses. The soft costs associated with customer acquisition are higher than those of large-scale projects due to the distributed nature and small size of the projects.

Real estate barriers

Almost one-third of all American houses are rented, and an average family shifts its home 11 times, which becomes a challenge in justifying the 25-year investment in solar PV. Rented homes and multiple tenant homes have little incentive to adopt rooftop solar projects.

Outdated regulations

Several states follow outdated grid codes and regulations which were drafted when there were no safe provisions to feed power safely back to the grid. In the absence of RPSs, these regulations are interpreted arbitrarily by utilities with an inherent conflict of interest due to the loss of revenue from the distributed solar projects. Often, this leads to rejection, lengthy delays and arbitrary high costs for applications by investors.

Other considerations

Many districts and states have historical preservation guidelines which require many neighbourhoods to install solar panels in ways that cannot be seen from streets. This reduces the available roof space.

However, these challenges were managed by the country to reach GW scale installation in distributed generation.

The US solar market which grew by a record high level of around 15 GW in 2016, fell to around 10 GW in 2017 and is further expected to remain stagnant with the major contribution from the increased (30%) tax on imported solar panels. The impact of this move is expected to be seen during the period 2018–22. The forecasts conducted estimate a dip of 13% in the overall solar deployment in the country. Although the major impact of increased duties on imported modules is expected to be on large-scale utility installations, residential and non-residential deployment shall also be affected by this increased system cost.

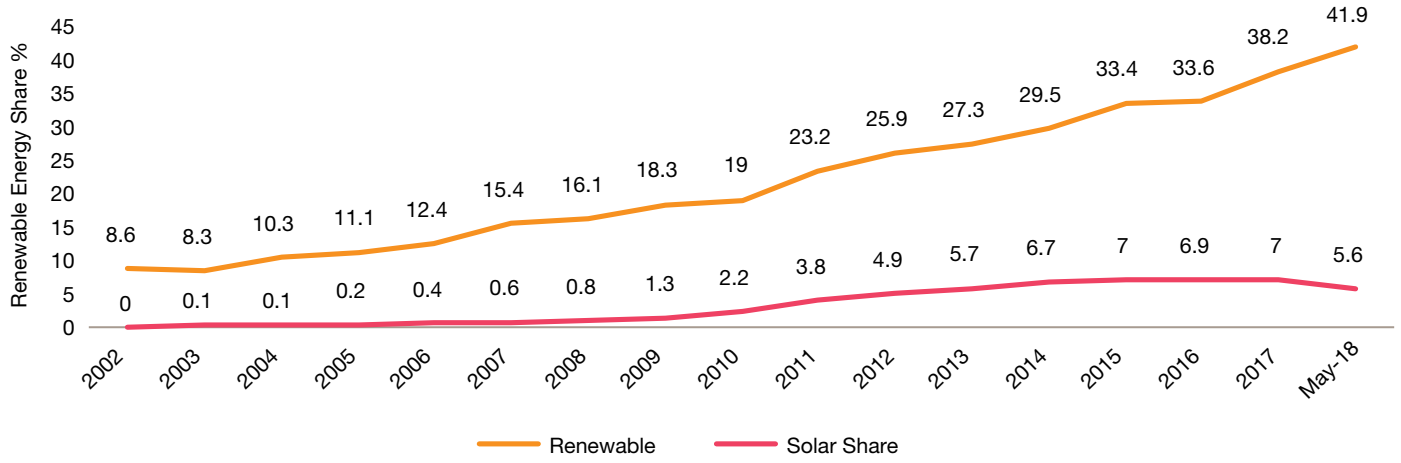
Germany

Over the past 10 years, Germany's renewable energy sector has grown more than threefold and the country is now an undisputable leader in renewables in Europe and globally. The current energy mix comprises around 50% of renewable energy capacity, with small-scale PV at this time representing around 15% and expected to grow further due to the decrease in solar prices.

In 2010, legislative support was passed that aimed to lower greenhouse gas (GHG) emissions to 80–95% by 2050 (relative to 1990). To achieve this, the Energiewende (the transitional move by Germany towards low-carbon, reliable, affordable and environmentally sound energy supply) programme was started for complete elimination of electricity generation through nuclear and petroleum fuels. The targets were established to switch to 35% renewable energy by 2020, 40% by 2025 and 60% by 2050.

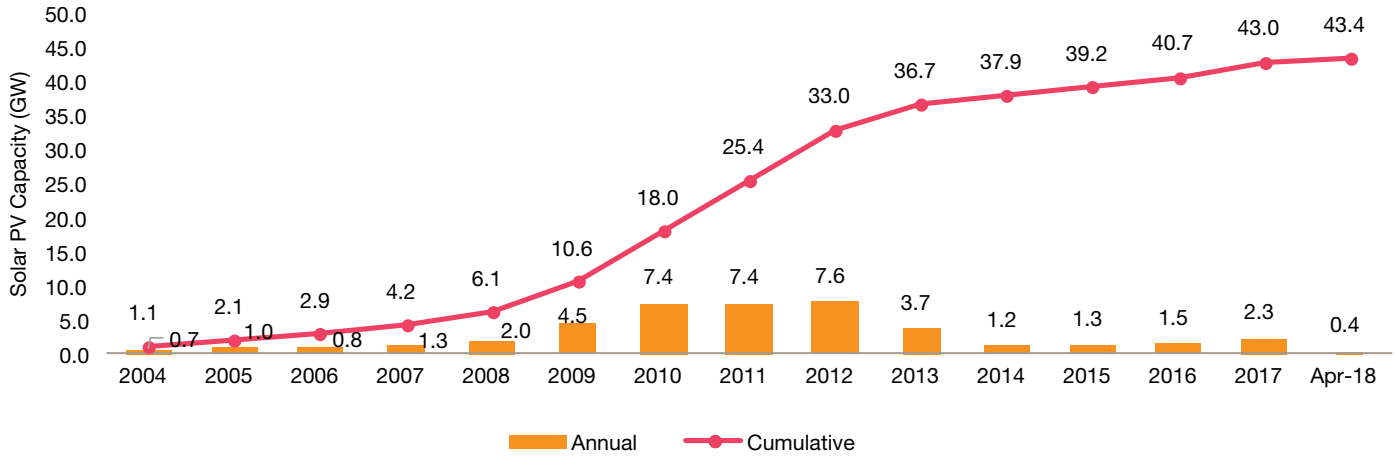
Solar power in Germany consists mainly of PV and constituted 7% of the net electricity generated in December 2017. The country is one of the largest generators of solar PV power in the world, with around 43.4 GW installed capacity as on April 2018. Renewable energy accounted for 39% of net electricity consumption in 2017. A study shows that on sunny weekdays, PV power in the country can cover 35% of the short-term electricity demand that can rise to 50% on weekends and holidays.

Annual share of solar and renewable energy



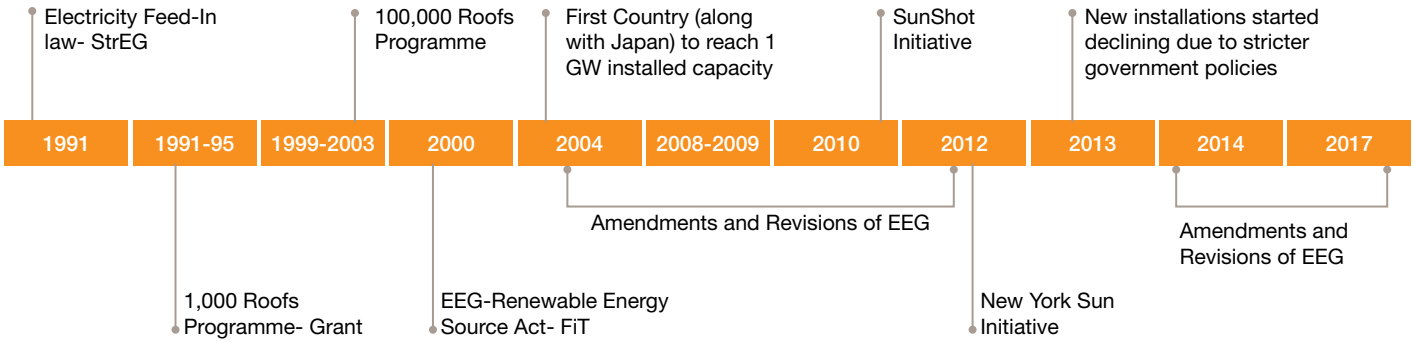
Germany's solar power growth curve has been quite volatile. Solar PV growth accelerated in 2010 until 2012, mainly due to a rapid fall in solar PV module prices. The annual installed capacity reached a record high of 7.6 GW in 2012, but the growth fell to 1.2 GW in 2014 due to the subsidy degression that significantly affected solar growth in the country.

Solar installed capacity



Market evolution

Market evolution in Germany



1991

The **Electricity Feed-in Law (Stromeinseisungsgesetz [StrEG])** introduced the first FiT in Germany. However, the initial FiT rates fixed were 90% of the retail electricity rates (~8.45–8.84 EUR cent/kWh). This rate was not low enough to attract huge deployment; however, additional incentives in terms of rebates equal to 70% of system cost and low-interest financing attracted modest market growth during the decade. Hence, by the end of 1999, 67 MW of PV was installed. In 1991, the Electricity Feed-in Law ensured grid access to the electricity generated through renewable energy. It also obliged utilities operating in the public grid to buy the electricity generated from renewables at higher FiTs. The entire burden was borne by the electricity supplier and its customers. Solar and wind power plants received the highest remuneration, followed by small hydro power, biomass and biogas plants. In 1996, due to liberalisation of power markets and phasing out of cold levy, the premium prices stared to decline. Since, the law had put a burden on utilities, the law was amended in 1998 by introducing a 'double cap', thus limiting the amount of renewable energy. Regional and preliminary electricity suppliers were thus bound to purchase maximum of 5% of renewable energy of their total energy supply, thus leading to a cap of total 10%.

1991-95

The 1,000 Roofs Programme supported the installation or extension of PV systems larger than 1 kW. The programme offered reasonable project financing terms like loans with an interest rate of 4.5% below market conditions, repayment period of 10 years and two years of deferred payments. The projects were financed up to 100% of the cost with a maximum limit of 5,00,000 EUR. For installations smaller than 5 kW, the loans were limited to 6,750 EUR/kW and for installations larger than 5 kW, the loans were limited to 3,375 EUR/kW.

1999–2003

The **100,000 Roofs Programme** was launched in 1999, as an extension of the 1,000 Roofs Programme and aimed to stimulate the installation of 100,000 grid-connected PV systems totalling to 300 MWp within six years. The programme supported the installation of PV systems larger than 1 kW and for this, loans were offered at an interest rate of 4.5% with a repayment period of 10 years and 2 years of deferred payments. The programme was launched with various incentives, some of which were reduced interest rate of up to 0% for PV systems, waiver of last instalment of up to 12.5%of the investment, etc. The programme corresponded to a subsidy of around 35% of the project cost.

While the programme stimulated the market in 1999, only 8.9 MWp (~3,522 PV systems) was financed as compared to the planned capacity addition of 18MWp. It was realised that a subsidy of 35% was not attractive enough to attract demand and at the same time, banks showed little interest in promoting this programme.

2000

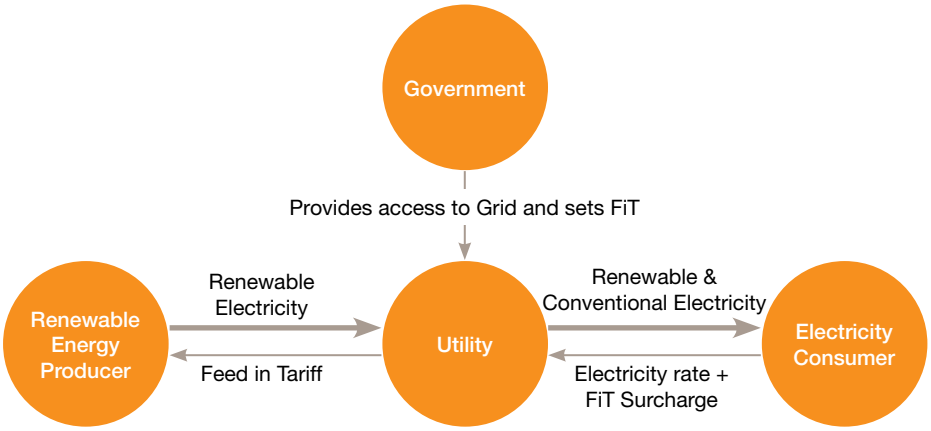
A key programme under Energiewende, **the Renewable Energy Sources Act (EEG)** governs the promotion of renewable energy to achieve its target of 60% clean energy by 2050. The EEG was passed as a legislation in 2009 and has subsequently undergone multiple revisions in 2012, 2014 and 2017. The EEG was a tremendous success in achieving its goals for renewable energy penetration in the country and stipulated FiTs that provided clarity to investors and at the same time provided a mechanism to apportion costs to electricity users, in order to ensure stability in payment mechanisms.

The law is the basis for Germany's Energiewende and specifies two things:

- Priority dispatch for renewable power
- Floor price for electricity generated from renewable sources

Under the EEG, owners of solar arrays are guaranteed access to the grid. The standard contract for FiTs signed with the utility ranged to an easy-to-understand two-page document. The FiTs are guaranteed for 20 years, which is unusually long for PPAs.

EEG model



The law introduced national rates that approximated the generation cost of PV systems and was found more effective than the incentive/subsidy linkages offered. This generation cost method was beneficial as it helped to set a target internal rate of return (IRR) which decreased the risk and provided investors with a high level of certainty. In Germany, the target IRR proposed was 5–7%. The first EEG established a rate of 0.99DM/kWh (~0.51 EUR cent/kWh) for solar PV starting in 2001. With this law, combined with the 100,000 Roofs Programme, a cumulative capacity of ~435 MW was installed by 2003.

Thus, the resulting *high level of investment security and lack of red tape* are assumed to be the major reasons for the success of EEG in bringing down the cost of renewables. Without the EEG, renewable energy projects in Germany would have had to find a buyer for that electricity as most utilities would have rejected the offer due to conflict with the third-party investments in their existing assets. The EEG thus opened up the power market to newcomers who believed they could make solar work.

2003

The EEG rates were revised to 46–62 EUR cents/kWh in 2003 which accelerated the market growth, with cumulative capacity expanding to 5,979 MW by the end of 2008 (average annual capacity addition of ~ 1,100 MW). The revised EEG also supported the PV market growth by removing the 1,000-MW programme cap as well as the cap on system size. This amendment in EEG thus created the first uncapped PV market in the world. The annual degression was set at 5% for all systems, except for free-standing systems which decreased annually at around 6.5% starting in 2006.

2009

The final amendment in EEG in 2009 removed FiT rates for integrated PV; however, a *'self-consumption' incentive with a fixed tariff 0f 25.01 EUR cents/kWh* was introduced.

EEG timeline

Renewable Energy Sources Act, 2010

FiT was introduced for rooftop solar and utility-scale PV projects, leading to an increase in the solar capacity. The key features of EEG 2010 are listed below:

- Providing priority access to renewable energy in the power grid
- Obligation of grid operators to purchase the electricity produced from renewable energy
- Fixed price ('tariff') for every kilowatt hour of energy produced from renewable energy for 20 years
- All different types of renewable sources are considered and tariffs are differentiated by source and size of the plant

EEG 2010 rooftop solar FiT

Capacity	FIT (Eur Cents/KWh)
Up to 30 kW	39.14*
Up to 100 kW	37.23*
Up to 1 MW	35.23*

- Degression of 10–9% /annum on tariff
- Additional reduction of 5% per month on FiT, applicable if the installed capacity exceeds the corridor of 2.5–3.5 GW

Renewable Energy Sources Act, 2012

It preserves the EEG 2010 framework and adds the option for generators to sell the power into the wholesale energy market. It has set a target of 35% renewables by 2020 (already achieved in 2018).

- *Market premium payment:* Encourages direct sale of electricity in the spot market through a market premium payment.
- *Market premium = (FIT – [average monthly wholesale price – management premium])*
- *Management premium* is the additional cost for generators to participate in the whole sale market.

Management premium cost

Year	Management premium
2012	1.2
2013	1.00
2014	0.85
2015	0.70

- Larger management premium means higher market premium.
- Market premium will be zero if wholesale electricity prices are high enough.

Renewable Energy Sources Act, 2014

This act requires operators of a new plant to market their electricity themselves in return for market premium from the grid operator to compensate for the difference between the fixed EEG payment and average spot price for electricity.

Renewable Energy Sources Act, 2017

EEG 2017 specifies a fixed expansion corridor for renewable energy as a share of gross electricity consumption, attempting to both support and restrict the growth in PV capacity.

- For systems above a certain nominal power (ca. 10 kW), self-consumed PV energy is subjected to an EEG levy.
- New PV systems up to 100 kWp receive a fixed feed-in tariff.
- New PV systems between 100 and 750 kWp must sell their energy by direct marketing.

- New PV systems over 750 kWp are required to partake in calls for tender and may not be used for self-production. The last licensing round of the Federal Network Agency in September 2017 set a mean value of 4.91 EUR cents/kWh.
- Numerous other regulations exist regarding potential areas for installations, the capability of remote power control and power reduction, among others.

Target market

In 2000, the Government of Germany launched a massive ratepayer-subsidised campaign aimed at generating affordable electricity using solar energy. Since the costs of solar equipment were high compared to retail electricity prices at that time, the German government has set higher FiTs when compared to the retail electricity price to attract investment in the solar industry. As the flow of investments for solar PV installations started increasing, the PV equipment costs started to decrease.

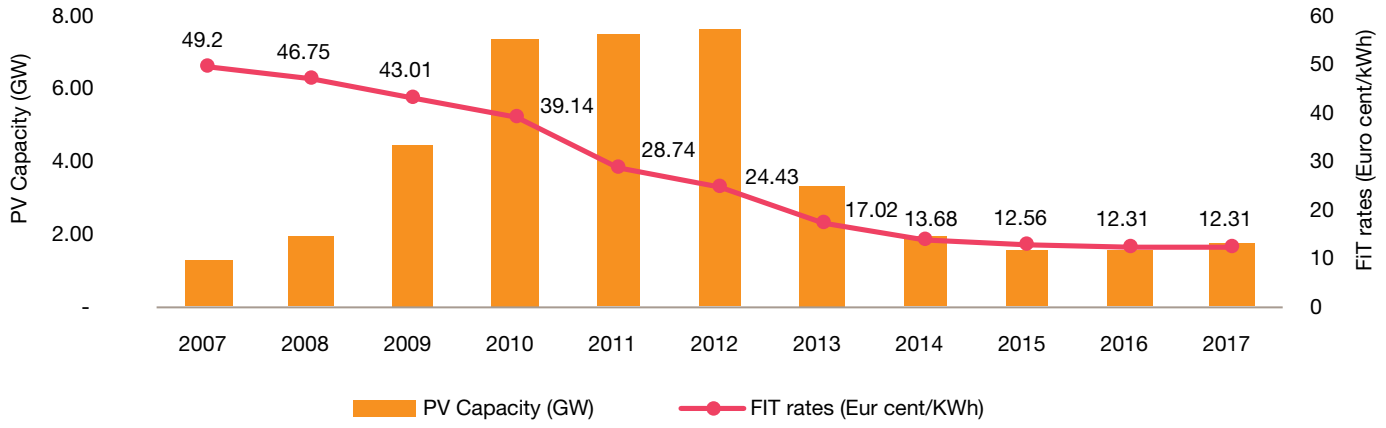
FiT Programme for solar PV projects

The FiT programme for rooftop solar and utility projects was an important catalyst for propelling solar market growth in Germany. The rates where fixed under EEG 2009 and were subsequently modified under EEG 2012, 2014 and 2017. Under EEG 2017, FiT for projects above 700 KW was replaced by an auction-based mechanism as proposed under EEG 2014.

FiTs were designed by the German government to meet the pre-planned capacity addition targets. However, similar to most of the subsidy schemes, they were phased out slowly over time, offering a lower price per kWh. This led to a significant fall in FiT for the residential segment from 49.2 EUR cents/kWh in 2007 to 12.32 EUR cents/kWh in 2017.

Under net metering, which was introduced through an amendment to EEG in 2009, customers received energy credits in their electricity bills, i.e. the excess electricity generated from the solar systems was fed back into the grid and was settled at the retail electricity rate. However, in 2013, customers received a reduced FiT rate of 17.02 EUR cents/kWh, while the retail electricity rate was 25 EUR cents/kWh. This led to a significant fall in new solar installations in the country.

FiT trend in Germany



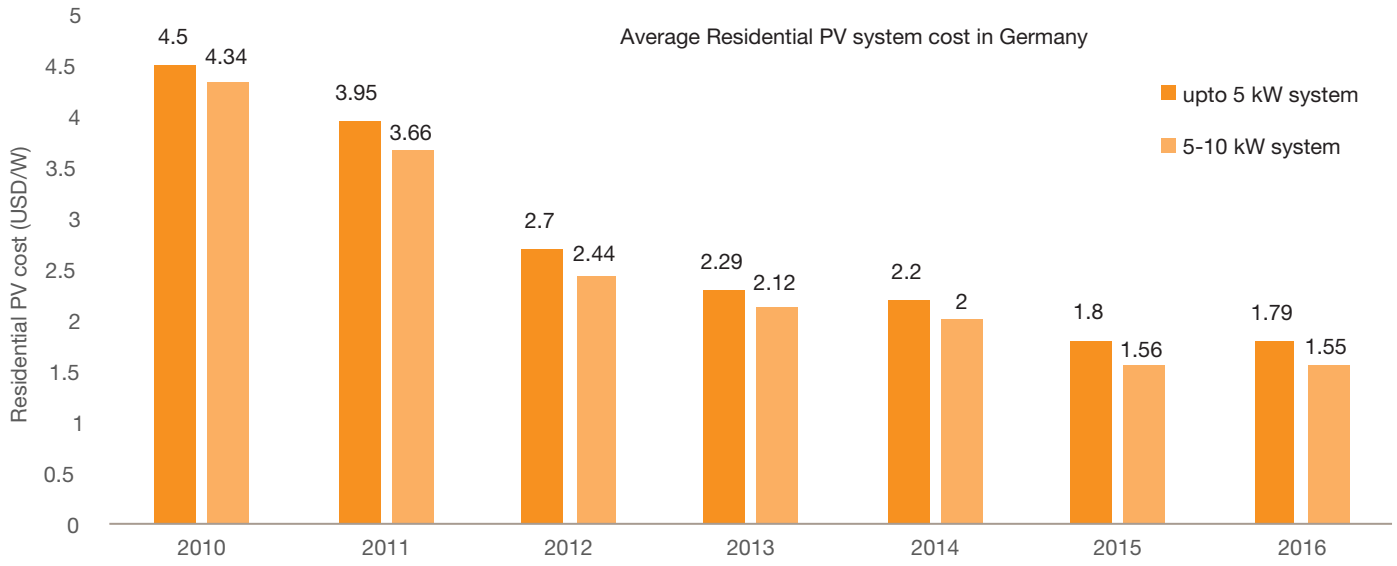
Digression[6]

EEG 2017 has an annual target of 2,500 MW per annum for solar power. A digression rate of 0.5% may be considered every month.[7] It can be increased to 2.8% if the actual development surpasses the digression rate. In case the development of solar power is not able to meet the targets, then the digression rate is reduced and in extreme cases, the tariff rate will even be increased by up to 3%.

Residential sector

The cost of electricity from residential rooftop solar PV is falling rapidly. In just over six years, the costs have fallen by almost 64% in German cities. The cost levels had also varied for small solar systems with the capacity of less than 5 kW and for solar systems with the size range of 5–10 kW. The differential between the two capacity categories, increased from 4% in 2010 to around 13% in 2016, thus increasing the viability of larger systems of 5–10kW against small-scale solar systems of less than 5 kW. The trend of average residential solar system costs over the period of six years starting from 2010 for both small and large-scale rooftop solar system is shown below (Figure 25).

Residential PV system cost in Germany



6 For most technologies, the tariff levels will decrease over regular periods of time. New plants will receive the tariff level applicable on the day they are put into operation. This tariff level will apply for the entire payment period, i.e. the life of the project. For some technologies, the percentages by which the tariff levels will decrease are set by law and are not subject to change. For other technologies, the percentage by which the tariff levels will decrease depends on the amount of newly installed capacity.

7 Section 49, EEG, 2017

Market premium model or self-consumption model

The market premium model or self-consumption model allowed the owners of rooftop solar PV systems to consume the electricity generated from their system directly instead of injecting it into the grid.

Additionally, with the decrease in FiT rates, the small and large renewable energy generating companies started selling their electricity output directly to the market. In return for the electricity supplied, the producers got spot prices plus the market premium instead of FiT rates.

Market premium = FiT – spot market price

Market premium is calculated monthly as the difference in nominal FiT and technology-specific volume weighted average the spot market price in that month. The solar volume weighted average price is slightly higher in the afternoon than the plain average spot price in the afternoon. In general, all the producers generating energy from similar sources receive a price corresponding to the nominal FiT. Depending on the individual producer-specific feed in profile, he will receive a price that is higher or lower than the group average.

The main objectives of this model are:

- The renewable energy generators should familiarise themselves with wholesale market workings in terms of volume and price forecasting, exchange trading, etc., so that they can integrate with conventional generation easily.
- It provides an incentive to control the dispatching of renewable energy at peak loads only.

FiT

The FiT programme for rooftop solar and utility projects is the most important catalyst for propelling Germany as one of the largest solar markets in the world. The rates were fixed by EEG 2009 and subsequently modified under EEG 2012, 2014 and 2017. Under EEG 2017, FiT for projects above 700 kW was replaced by an auction mechanism as proposed under EEG 2014.

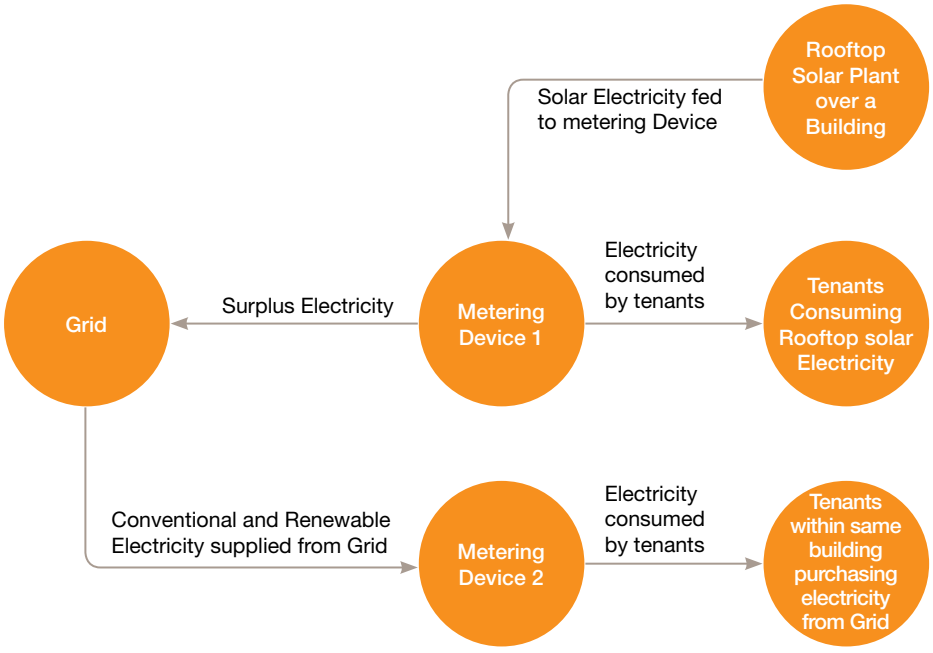
Landlord – tenant electricity supply

In this case, the electricity is generated by installation of rooftop solar plants on a residential building and the electricity generated is passed on to consumers (tenants) living in the building or in nearby residential buildings. The electricity generated is also supplied to run the ancillary facilities located in close proximity to this building. Thus, consumers get electricity from the rooftop project installed and not through the public grid. In case there is surplus electricity, it is fed to the public grid.

By using this model, the tenants will be exempt from the wide range of charges such as FiT, electricity tax, surcharge and fees that they would have to pay if electricity is purchased from the public grid. The landlords also receive credit funding for each unit of electricity supplied to their tenants; thus, it is a win-win situation for both landlords and tenants.

To increase the use of this model, the government proposed to pay a premium to the landlords for supplying electricity to their tenants. The premium is set somewhere between 2.2 US cents/kWh to 3.8 US cents/kWh and is calculated on the basis of the size of the solar installation and the national PV expansion rate. To ensure that the costs for the new funding system will be kept low, the volume of solar electricity that can be added per year for which landlords can receive a premium was proposed to be capped at 500 MW.

Landlord model



Financing instruments

Modes of financing

Key mechanisms	Players involved	Description	Financing mechanism
Market premium surcharge	Plant operator, grid operator	The plant operator sells his electricity directly, i.e. to a third party, by a supply agreement or at the stock market, and claims the so-called market premium from the grid operator.	Premium surcharge is financed through a tax and thus is finally borne by the consumers.
Loans	Multilateral institutions, retail banks, consumers	More than 50% of new capacities for electricity production from renewables in Germany are financed by KfW.	KfW provides refinance loans to retail banks, who in turn provide loans to consumers. It banks on the retail banks to cover any margins for credit risk and handling issues.
Subsidy	Multilateral institutions, plant operators	Provided by KfW	30 million EUR in 2017
Leasing of rooftop system	Utility/or a company	Utility or private company invests in plant to be leased	Bank loan or equity
Crowd investing	Crowdfunding platform, plant operator		• Investors become shareholders • In most cases, subordinated loans (a mezzanine instrument with no collateral requirement)

Key challenges

Some of the challenges faced by the country in the deployment of distributed generation are:

- It was a challenge to obtain bank credit in the case of rooftop systems. To cover this financing gap, crowd investing came up as an alternative instrument where subordinated loans are used and no collateral is required. This has become quite popular in recent years.
- The individual plants were too small to efficiently and directly market energy. Further, the roll-out faced inexperience of many small generators with trading/energy exchange. For these reasons, independent power traders had to operate as intermediaries between generating companies and the market. Network operators are required to sell the electricity fed in by small generators on the electricity spot market.
- The exemption of residential PV systems deriving commercial revenue through FiT from the requirement to obtain planning permission does not cover the possible change of use of non-commercial buildings. PV systems not registered as a trade and not in possession of a licence or an exemption from building authorities thus violate, in part, both the trade law and the building code.
- The FiT scheme, while successful in creating a huge demand and driving down prices worldwide, has been challenged as a drain on public finance. The levy (reallocation charge) on conventional power to finance FiT has led to a surge in power prices for all households. Poor households without PV rooftop will be negatively impacted by the increased power cost. Exceptions for trade-sensitive and energy-sensitive industries from FiT levy imply that the burden was passed on to ordinary households.
- As the grid system in Germany was already strong, it was able to absorb a large amount of renewable energy with minimal modification. However, large-scale changes will be required going forward to achieve the goals of Energiewende. Germany expects to invest 18 billion EUR over the next 5–8 years to update and expand the grid infrastructure, both for transmission lines and distribution grids, as well as for smart metering and technologies to support advanced strategies such as virtual power plants. This will be funded through grid fees, which all German utility customers (commercial and industrial included) pay for on their utility bill, further increasing the risks of public pressure to scale back the programme.

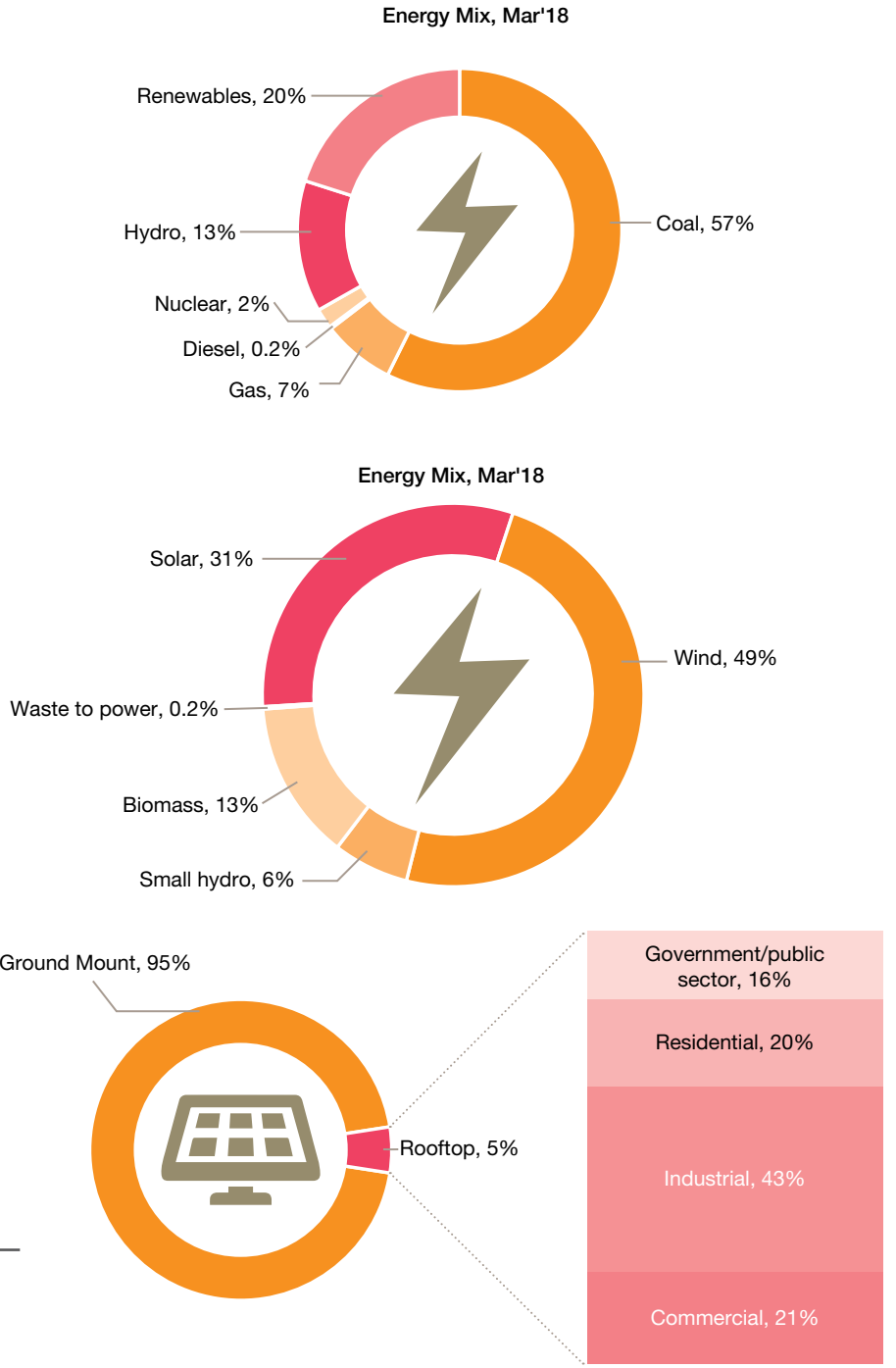
Thus, the learnings from countries which have successfully deployed rooftop solar PV shall be useful in the Indian context based on the Indian market scenario. Although the challenges faced by each country are quite different and specific to it, some of the challenges on the regulatory and technical front can be considered to avoid certain challenges that India would face with the large-scale deployment of rooftop solar PV.

India

India is a growing economy with total installed power capacity of 343.8[8] GW (as on June 2018). This installed capacity is dominated by energy from fossil fuels, followed by the share from renewable sources, nuclear, hydro, diesel and gas. Of the total installed capacity, renewable energy accounts for 69GW[9] (as of June 2018) which is approximately 20% of the total installed capacity. The energy from renewable sources has grown at a CAGR of 15% from FY14 to FY18, while the contribution of conventional energy sources is decreasing at around 4% Y-o-Y. The renewable energy sector is expected to grow further in the coming years because of a shift in the government's focus to meet the demand from renewable energy rather than from conventional energy sources. Currently, wind is the major contributor to renewable energy sources; however, solar is expected to overtake wind by 2020.

Power generated from solar projects has a share of 32% (~23 GW) of the total renewable energy capacity in India and the installed capacity has grown from a mere 10 MW in 2010 to 23,022 MW in 2018 (as of June 2018). The capacity addition of rooftop solar has yet not seen significant growth, contributing only around 6% to the total solar energy mix. However, with the availability of better project financing rates and decline in module/system costs, rooftop solar is expected to make huge additions in coming years and thereby achieve the target of 40GW by 2022.

Energy mix



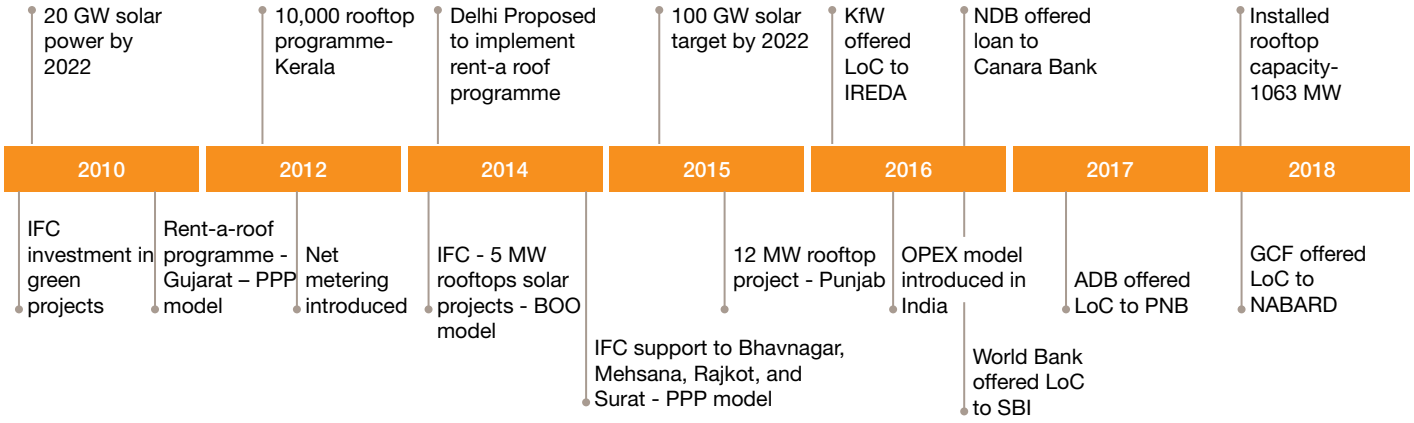
8 http://www.cea.nic.in/reports/monthly/installedcapacity/2018/installed_capacity-06.pdf

9 https://www.mnre.gov.in/physical-progress-achievements

Market evolution

The development of rooftop solar projects in India began with the introduction of rooftop solar targets in Gujarat in 2009. Gujarat was one of the first states in India to announce a solar policy and develop Gandhinagar (the capital city) as a 'solar city'. Though Karnataka, in parallel, also launched the 25,000 roofs programme for 5–10 kW rooftop systems, major success was seen only in the Gujarat programme. Various other programmes/schemes that led to the growth of rooftop sector are summarised below:

Market evolution trend



2010

In order to promote solar power, the **Jawaharlal Nehru National Solar Mission (JNNSM)** was launched in 2010 by Government of India. The government set a target of 20 GW solar energy by 2022. The target of this mission was to create conditions for boosting solar installation in the country.

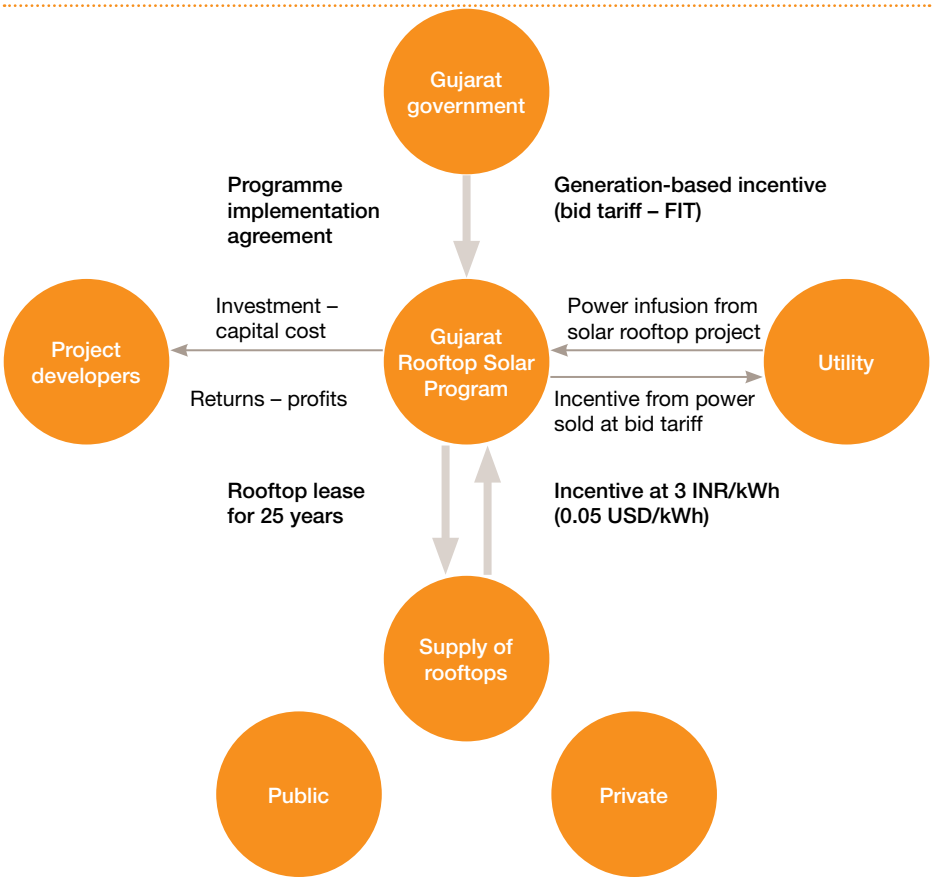
Later during the year, Gujarat initiated the **'rent-a-roof' programme**. Under this programme, supported by IFC, private and government companies started to lease rooftop space on residential rooftops and government buildings. The operators received FiT of 11.21 INR (0.18 USD) for a 25-year concession. The project was installed under the public private partnership (PPP) model (the first of its kind in rooftop solar). The model attracted private clients, with Azure and SunEdison building a portfolio of 2.5 MW each of rooftop projects with a 25-year concession to install solar PV panels on government and residential buildings.

The programme started attracting investments and in 2014, a similar model was implemented in Vadodara for setting up a 5-MW rooftop solar project based on the PPP model. The project was awarded to Madhav Solar Pvt Ltd for a 25-year concessional loan and attracted investment of 8 million USD.

These two cases gave a push to the PPP model for implementation in rooftop solar PV. The model was well received by other states of India like Odisha. The Gujarat Energy Research and Management Institute (GERMI) extended support to the Government of Odisha for implementing a similar model.

The framework of the PPP model developed to support rooftop deployment is illustrated below:

Gujarat PPP framework



2012

Net metering was introduced in India in 2012 to facilitate the connection of small renewable energy systems with the grid in order to provide an impetus to residential rooftop installations. Under the net metering scheme, the excess power generated from the rooftop solar system is fed into the grid and the system owner is credited against the units fed. The major benefit of net metering was for customers, who would be required to pay only the differential of the electricity consumed and credited to the grid.

2012–13

Rooftop programmes: Karnataka, under its solar programme, targeted 25,000 solar rooftops of 5–10 kW. In 2013, Karnataka released a tender worth 34 crores INR (5 million USD) to set up 1.3 GW rooftop projects across 1,943 houses.

Following this, Kerala also launched the 10,000 rooftop power plants programme in 2012. Under this programme, each applicant was eligible to apply for a 1-kW project only and the state government also offered a discount of 39,000 INR (~580 USD) on project installation in addition to a 30% capital subsidy offered by MNRE.

2015

Revision of solar targets: In 2015, the Government of India revised the JNNSM's earlier target of 20 GW to 100 GW solar by 2022. This target of 100 GW includes 40 GW from rooftop solar PV. In order to meet these revised targets, the government announced other initiatives such as 30% capital subsidy on rooftop systems, achievement-linked subsidy scheme and accelerated depreciation benefit to promote the growth. Later on, these incentives and schemes were revised based on the deployment and sustainability of the market.

2015-16

Largest rooftop PV plant: In 2015, Punjab commissioned a 7.5-MWp rooftop project on a single roof. Later, TATA Power Solar commissioned a 12-MW rooftop solar project in Amritsar on a single roof under a gross metering arrangement with a PPA signed with Punjab State Power Corporation Limited (PSPCL) for 25 years. This project was the largest solar rooftop project in the world to be set up in a single phase. The project produces 150 lakh annual units of electricity and saves 19,000 tonnes of carbon emissions each year.

2016

Interest in the operational expenditure **(OPEX) model:** In order to support the growth of the rooftop solar market, the OPEX (Renewable Energy Service Company [RESCO]) model was introduced in parallel to the capital expenditure (CAPEX) model. The benefit of the OPEX model was that no upfront capital investment was demanded unlike the CAPEX model. Under this model, consumers pay monthly charges based on the units consumed for setting up rooftop projects. However, the ownership rights of the system are held by the installer (RESCO).

2016-18

International line of credit to support rooftop deployment in the country: The rooftop sector in India is lagging behind in meeting the annual installation targets set by the Government of India. The major reason identified was the lack of low-cost financing in this area. Huge upfront cost and high-cost loans contributed to the slow growth. However, for the past 2 years, rooftop solar has been able to gain scale with the availability of international lines of credit from various multi- and bilateral institutions to support domestic banks. This has created developer and consumer interest in the rooftop solar sector and at the same time, the rooftop systems, with the availability of concessional financing, have become financially viable for end consumers.

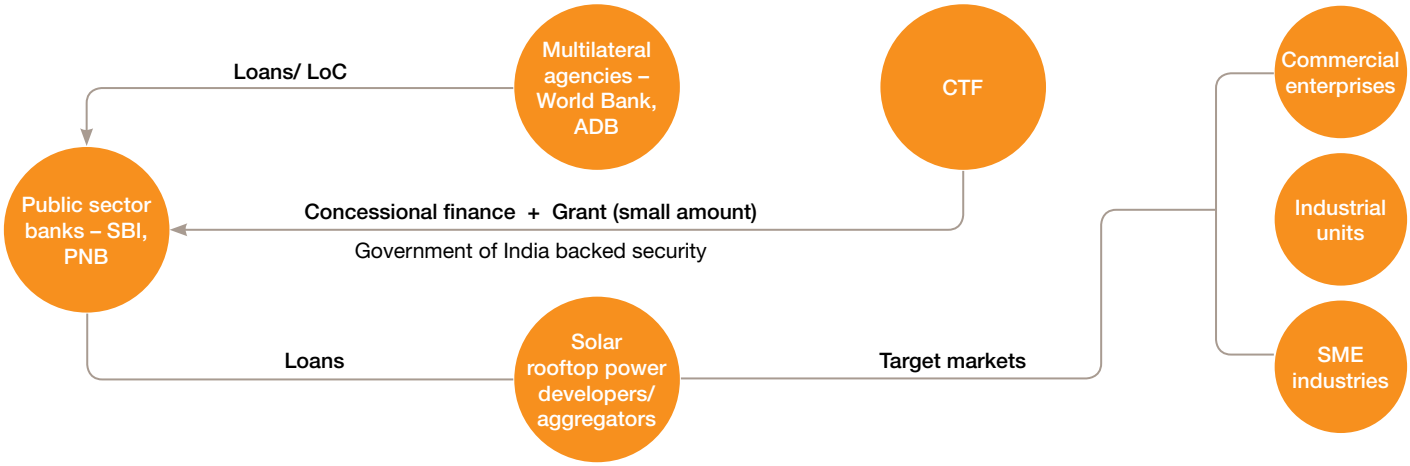
Available lines of credit to support rooftop deployment

Year	Lender	Borrower	Line of credit	Programme objective
2015	KfW	IREDA	340 million USD	To address the key barrier of financing in rooftop solar PV in India; IREDA launched a loan financing scheme @ interest rates of 9.9–10.75% with 9-year repayment and a 1-year moratorium
2016	World Bank and CTF	SBI	625 million USD	Programme for results (PforR) to support government strategy for enhancing and expanding its rooftop solar development targets; expand and incentivise the market for rooftop solar by way of low-cost financing
2017	Asian Development Bank and CTF	PNB	500 million USD	Finance-large scale rooftop solar systems on industrial and commercial buildings throughout India; contribute to the government's plan to increase solar power and meet carbon emission reduction targets
2018	Green Climate Fund	Tata Cleantech Capital through NABARD	100 million USD	First private sector facility to support the rooftop solar segment — commercial, industrial and residential housing sectors; the programme aims to provide concessional loan assistance to rooftop solar PV

The biggest push to rooftop deployment shall, however, result from the availability of innovative and low-cost financing structures that can boost the scale of the sector. Banks play a very crucial role in the development of this sector by providing subsidised loans to developers and end users. One such contribution has been extended by the Clean Technology Fund (CTF) supported by other multilateral agencies like the World Bank and Asian Development Bank (ADB). The World Bank signed a 650 million USD agreement with the State Bank of India, while the ADB signed a 500 million USD agreement with Punjab National Bank (PNB). Both multilaterals will combine the share of CTF received, with a specific focus on the deployment of rooftop solar projects. In this scenario, the available concessional financing from the CTF is adding significant value. Traditionally, banks were sanctioning loans to rooftop developers at a rate of 10–12% and in some cases, the rate reached up to 14% depending on the credit rating of the borrower and the risks associated with the project. The banks were offering higher interest rates due to the absence of any concessional funding support and limited experience in the rooftop segment in India. However, with the availability of CTF money, the interest rates for lending project loans has been reduced to 8.5–9.5% on a project-to-project basis, offered by the banks receiving such concessional funding.

The financial structure and the implementing agencies involved in the current World Bank and ADB programme are illustrated below:

Schematic of concessional funding



The above programmes are proposed to support the implementation of the grid-connected rooftop solar programme of MNRE, with a major focus on mobilising private sector equity investments and commercial lending, thereby increasing the deployment and uptake of rooftop solar PV to achieve the Government of India's target of 40 GW by 2022.

MNRE, the lead ministry responsible for rooftop solar targets, is playing a major role in providing overall policy guidance and coordinating with the development partners. The ministry will also ensure that the lessons from these programmes are internalised in other government-supported initiatives.

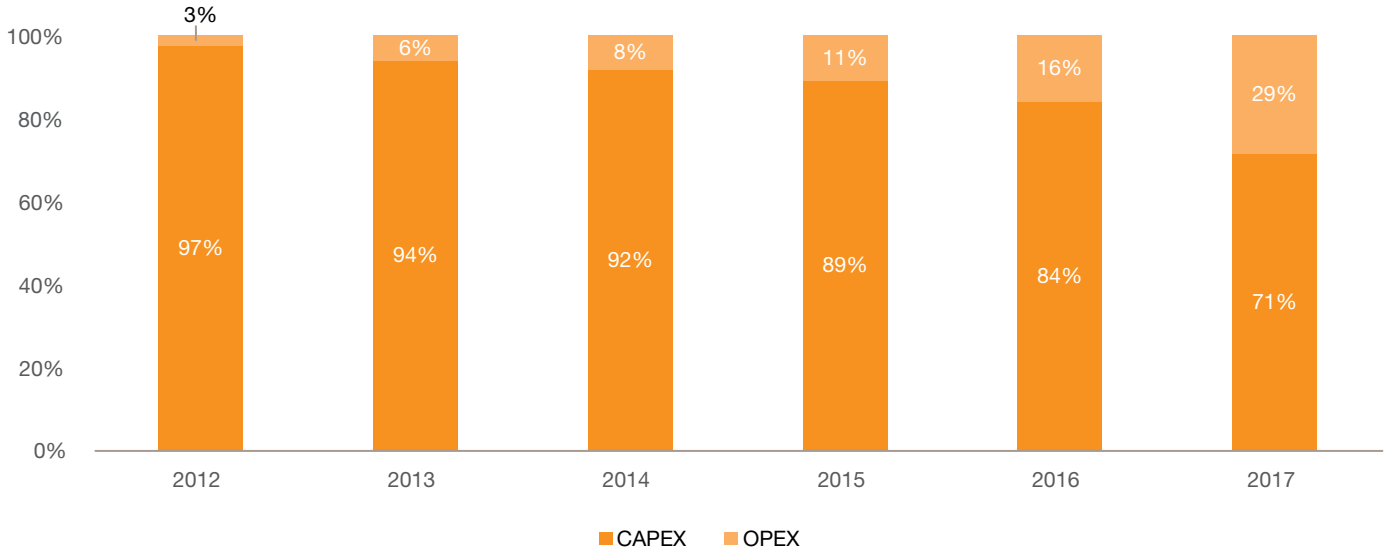
Banks (SBI and PNB) will be the implementing agency, lending loans to the developers, customers, aggregators and intermediaries that are qualified in terms of technical capacity, relevant experience and creditworthiness as per the respective bank's loan scheme document. This access, available at low cost, will enable large-scale deployment of rooftop solar using different business models.

Distribution utilities are majorly responsible for providing and operating grid power and the network and in turn manage the grid integration of rooftop projects. Distribution Companies are also responsible for providing timely approval on net metering and other regulatory and technical clearances. To support the DISCOMs, the programme also plans for their capacity building for efficient management of grid integration of these variable rooftop projects.

States, on the other hand, are also supporting the rooftop deployment programme by announcing their respective rooftop policies or targeting rooftop capacity addition in the solar/ renewable policy. Thus, **state nodal agencies (SNAs)** play a major role in deploying the grid-connected rooftop programme at the state level and at the same time encouraging developers to install possible rooftop projects in the identified commercial and industrial locations. SNAs, in coordination with central agencies, are also promoting rooftop systems by identifying relevant government buildings for the deployment of rooftop projects under the MNRE subsidy scheme.

The rooftop solar market has majorly been driven by the CAPEX model in which the consumer fully owns, finances and consumes the energy generated from the PV system. The consumer, in turn, is fully responsible for all capital expenditures and bear all risks of operations, management and maintenance. The other model which evolved lately is the OPEX model or third-party financing model in which a RESCO provides all necessary capital for installation, operation and maintenance of the rooftop system. In exchange for all services and risks, consumers sign a PPA with the RESCO. This OPEX model has started picking up pace as it is becoming one of the promising solutions to address several barriers to scaling rooftop solar PV. This model is expected to dominate the rooftop solar market, considering the benefits to consumers in terms of no upfront capital and installation cost as well as the elimination of operational risks and management services. However, the only challenge to the current low growth of this OPEX model is the lack of low-cost debt capital, which affects the ability of companies to advance it. The growth of the OPEX model in the past six years is presented below:

Market share of CAPEX and OPEX model in India (rooftop solar)



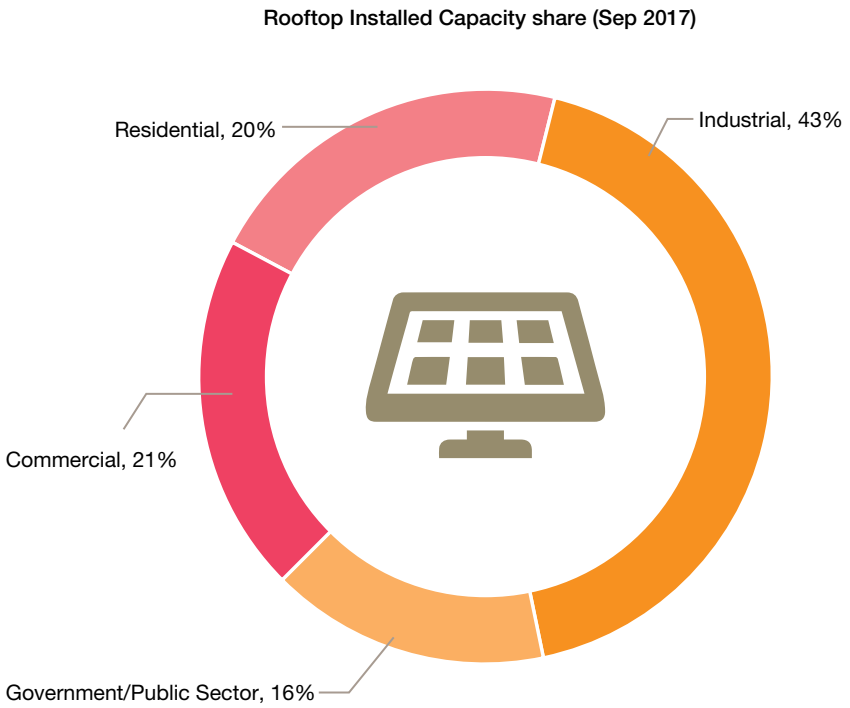
Source: PwC analysis

Target market

In India, the residential sector has been highly subsidised and the system sizes have been extremely small. This has resulted in lower financial viability of rooftop solar PV installations. However, analysing the commercial and industrial (C&I) sector, the grid tariffs resulting from cross-subsidy charges have been increasing, encouraging C&I customers to switch to rooftop solar PV and make huge savings in their monthly electricity bill. It is from this demand that the identified nationalised banks (SBI and PNB) are targeting to support C&I customers in the deployment of rooftop solar PV in India. Another positive factor is the lack of government subsidy along with the higher demand for rooftop as compared to the residential sector. With CTF money available at concessional rates, the interest rates for project financing are comparatively lower than the traditional project financing terms of other banks. Hence, the end user (the C&I segment) gets the lowest possible rooftop PV tariff/system cost which enables them to make huge savings.

The percentage share of all segments in the rooftop sector is presented below:

Rooftop installed capacity share (India)



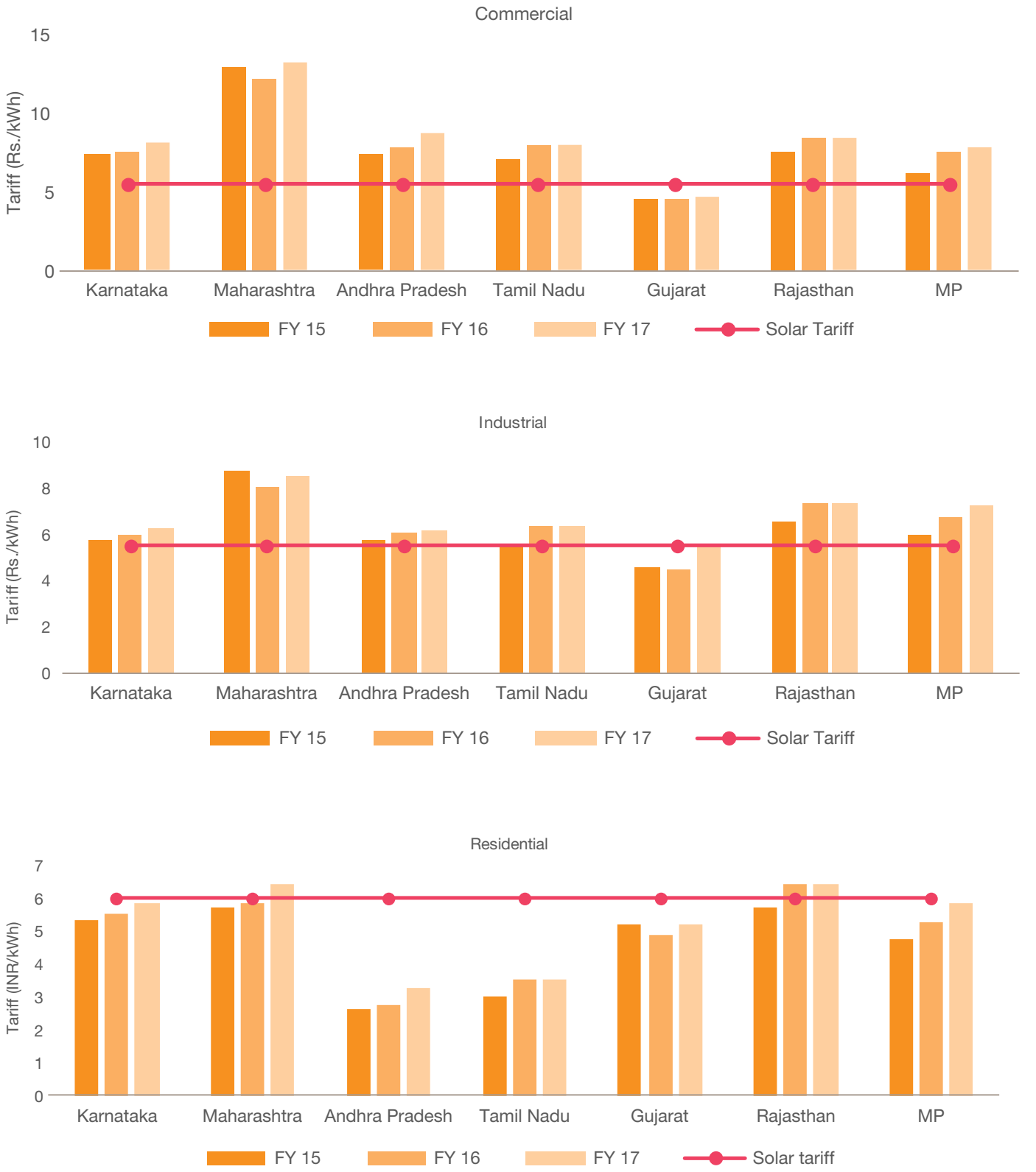
Depending upon the business model chosen, the end user gets the benefit of low-cost financing. This benefit is further increased with the aggregator business model, where the banks disburse lump sum money to the selected aggregator holding a portfolio of projects. Developers/aggregators, in turn, purchase bulk equipment at reasonable rates, thereby providing the most competitive rates/tariffs to the end customer. This model, with CTF money added, is gaining significant scale in the country. However, analysis in this regard has proved advantageous to each stakeholder involved and projects with this aggregator model are being evaluated for disbursement and execution by the respective banks (SBI and PNB).

Additionally, the residential sector as well as government buildings in India is eligible for a subsidy arrangement announced by the Government of India. However, even with a 30% capital subsidy for the residential sector for rooftop installations, the highest penetration has been seen in the C&I segment, contributed to mainly by the large system size (due to larger space and higher demand) and the higher grid tariffs. Thus, not just subsidy, *demand, penetration and project viability* are also major factors driving the sector growth.

To compare the viability of rooftop solar systems with the grid tariffs, electricity tariffs for the past three years in all segments have been analysed for four Indian states that were selected based on the following criteria:

Solar irradiation (greater than 5 kWh/m2/day), *rooftop solar targets assigned by MNRE* (greater than 2000 MW until 2022) *and state interest in terms of policy and capacity installation.*

Rooftop solar viability in various segments



A comparison with all the major customer segments presents the most viable case for commercial consumers where the grid tariffs are quite high and are further expected to increase. Though most states like Tamil Nadu and Punjab have fixed their grid tariff for certain consumer categories for 3–5 years, solar tariffs, which are expected to fall further, remain competitive. Huge savings in electricity bills and contribution to the green effect have led to widespread demand for rooftop solar PV. However, certain gaps like project financing and agreements with distribution companies need to be addressed to gain strong momentum in the sector.

Key stakeholders

With the 40 GW target for rooftop solar PV for 2022 and only around 1GW on ground as of date, the various stakeholders involved need to play a significant role in the scale-up plan. Each stakeholder, including policymakers, nodal agencies, distribution utilities, developers, banks and end consumers, have to contribute to the deployment of rooftop solar PV. Some of the major stakeholders that can contribute to rooftop solar growth are listed below:

Key players in rooftop solar sector

	Policy	Regulation	Utilities			Technical	Funding Agency
			Generation	Transmission	Distribution		
Central Level	Ministry of Power Ministry of New and Renewable Energy Solar Energy Corporation of India NTPC Vidyut Vyapar Nigam Ltd (NVVN)	Central Electricity Regulatory Commission (CERC)	National Thermal Power National Hydro Power Corporation (NHPC) Neyveli Lignite Corporation (NLC)Corporation(NTPC) North Eastern Electric Power Corporation Limited (NEEPCo)	Central Transmission Utility (CTU) Power Grid Corporation of India Limited (PGCIL)		Central Electricity Authority (CEA)	Indian Renewable Energy Development Agency (IREDA) State Bank of India (SBI) Punjab National Bank (PNB)
State Level	"State Energy Development Agency (Nodal Agencies) eg. Gujarat Energy Development Agency ; Maharashtra Energy Development Agency "	State Electricity Regulatory Commission (SERC)	State Power Generation Company (GenCo)	State Transmission Utility (STU)	State Distribution Company (DisCom)		
Private Sector			"Independent Power Producers: ReNew Power Limited Amplus Solar Adani Solar CleanMax Solar Cleantech Solar Hero Future Energies Acme Cleantech Tata Power Solar IndiaBulls"	"Independent Transmission Service Providers: Tata Power"	"Private DisComs: Tata Power Delhi Distribution Ltd."		Private Banks: Yes Bank; Canara Bank; other multilaterals

The roles and responsibilities of the various stakeholders responsible for implementing rooftop solar PV projects in India are represented below:

Role of stakeholders in rooftop solar deployment

Role of Stakeholders

Banks/ Financial Institutions

- Providing subsidized project financing/ lending terms
- Supporting new and existing business models
- Identifying customers/ developers (aggregators) to promote deployment of rooftop solar

Distribution Companies

- Provide clarity on permitting provisions, safety provisions, interconnection provisions, clearances, etc.
- Timey closure of approvals for net-metering arrangement/ No-Objection Certificate for rooftop projects

Policy Makers- Central Govt.

- Defined policy and yearly plans for achievement of targets
- Timely release of subsidy for rooftop projects
- Support in timely closure of projects with grant of timely approvals/ clearances

Rooftop Developers

- Efficient means of Engineering, Procurement and Construction of rooftop projects
- Sustainable and most competitive tariffs, to promote deployment
- Targeting end consumer, promote scalable business models

End Consumer

- Identify the benefits/ need for solar rooftop projects, considering the savings model
- Support in achievement of National Targets for rooftop PV

State Nodal Agencies

- Release of state tenders to invite interest of developers/ end consumers
- Strict penalty on non-compliance of Renewable Purchase Obligations
- Sign PPA with the government buildings

Each stakeholder has his own roles that are quite critical for the deployment of rooftop solar PV in India. However, at this stage, each stakeholder has a set of concerns and these need to be addressed either through capacity building or training programmes to get a full scale up.

Key challenges

India's path to achieve 4 0GW from rooftop solar installations by 2022 has seen considerable efforts from the government, regulatory commissions and other concerned agencies in terms of incentives, policy and regulatory framework, etc. With these efforts, a basic framework exists in all parts of the country and growth has been seen in the rooftop market. However, to achieve the 40-GW target by 2022, various gaps need to be addressed at each stakeholder level to attain exponential growth in the sector.

The figure below maps out the challenges faced by each stakeholder on the path of rooftop solar deployment in the country.

Solar rooftop challenges

DISCOM

- Lack of capacity building on rooftop systems- DisComs view of losing revenue from customers
- Lack of single window facility for project clearances
- Limited technical expertise on grid integration of small scale rooftop systems

Financial institutions

- Availability of collaterals
- Credit rating of customer/Payment insecurity
- Challenge in rooftop rights of individuals
- Non-availability of secondary market
- Small size; high cost of financing
- Lack of standard PPAs- deemed generation missing in most PPAs

Rooftop challenges across stakeholders

Developers

- Limited availability of low cost project financing
- Credit rating of customers/payment security
- Availability of feasible roofs for project installations
- Delay in subsidy; affecting project financials

End consumer

- Subsidy delays
- Delay in project clearances
- Lack of availability of low cost systems with poor quality; hence quality /system performance marks a challenge

Regulatory bodies

- Gaps in Net Metering regulations
- Non-Compliance of RPO by eligible entities

The challenges in the rooftop segment can be classified as follows:

Financial challenges

One of the biggest challenges for the slow deployment of rooftop solar PV in India is the limited availability of financing. Rooftop projects, being smaller in size compared to utility-scale projects, banks/financial institutions face significant challenges, one of which is collateral security from small enterprise or residential customers. Since the sector is still gaining maturity in terms of size and generation (capacity utilisation factors), the funding risk is a major barrier faced by financial institutions.

Also, for similar due diligence as in large-scale solar projects, the lender's engineer fee component increases for rooftop projects due to the limited size and increased number of scattered locations. Various models, including the aggregation model and concessional interest rate options, have been tried by various financial institutions; however, the scale is yet to be picked up.

Another challenge related to the limited interest of domestic financial institutions is the credit rating of customers which results in payment risks from customers.

Additionally, though debt funding is available for setting up a rooftop project, there is limited equity investment being made in the rooftop projects. Investors are focusing on the deployment of utility-scale projects because of lower risks associated.

Debt funding available for rooftop solar projects through domestic sources is at a very high interest rate, which makes the projects financially unviable. Various initiatives, however, have been taken on this front through the use of concessional funding and other international lines of credit, which has helped in bringing down the interest rates by 1.5–2%. However, limited availability of these international concessional funds is posing a challenge for future projects.

Technical challenges

Since rooftop solar projects are quite small in size compared to large utility-scale projects, grid integration of these variable solar projects is a challenge faced by most distribution utilities. For this, most multilateral and bilateral agencies are focusing on capacity building programmes for DISCOMs and bring in international learnings on grid integration solutions.

Limited technical strengths of the lender's engineer, on the other hand, in carrying out due diligence activities and appraisal of rooftop solar projects are a significant challenge slowing down rooftop solar deployment.

Policy and regulatory challenges

Some of the incentives offered by the Central Government includes Central Financial Assistance (CFA) of 30% on residential and government buildings. This incentive, however, is posing a bigger challenge for developers as subsidies get delayed and developers suffer financial loss in terms of cash flows projected. These delays prevent developers from executing projects on residential spaces or other target markets where any subsidy arrangement is offered. The market, on the other hand, has almost reached grid parity in most sectors; hence, subsidy in such cases actually spoils the market growth. The changing tax structure and implementation of duties are posing challenges to the growth of rooftop solar sector in India.

Another barrier to progress in the case of the OPEX model is the delay in getting approvals and clearances for the net metering arrangement. Though single window clearance exists, the delays in approvals (including Chief Electrical Inspector General [CEIG] approval) affect the timely execution of projects.

Non-standardisation of PPAs to include certain terms like deemed generation and right of way are posing a challenge to financial institutions in executing respective projects. Non-availability of these terms increases the risk of banks/financial institutions, thus affecting the overall cost of the rooftop project.

Commercial challenges

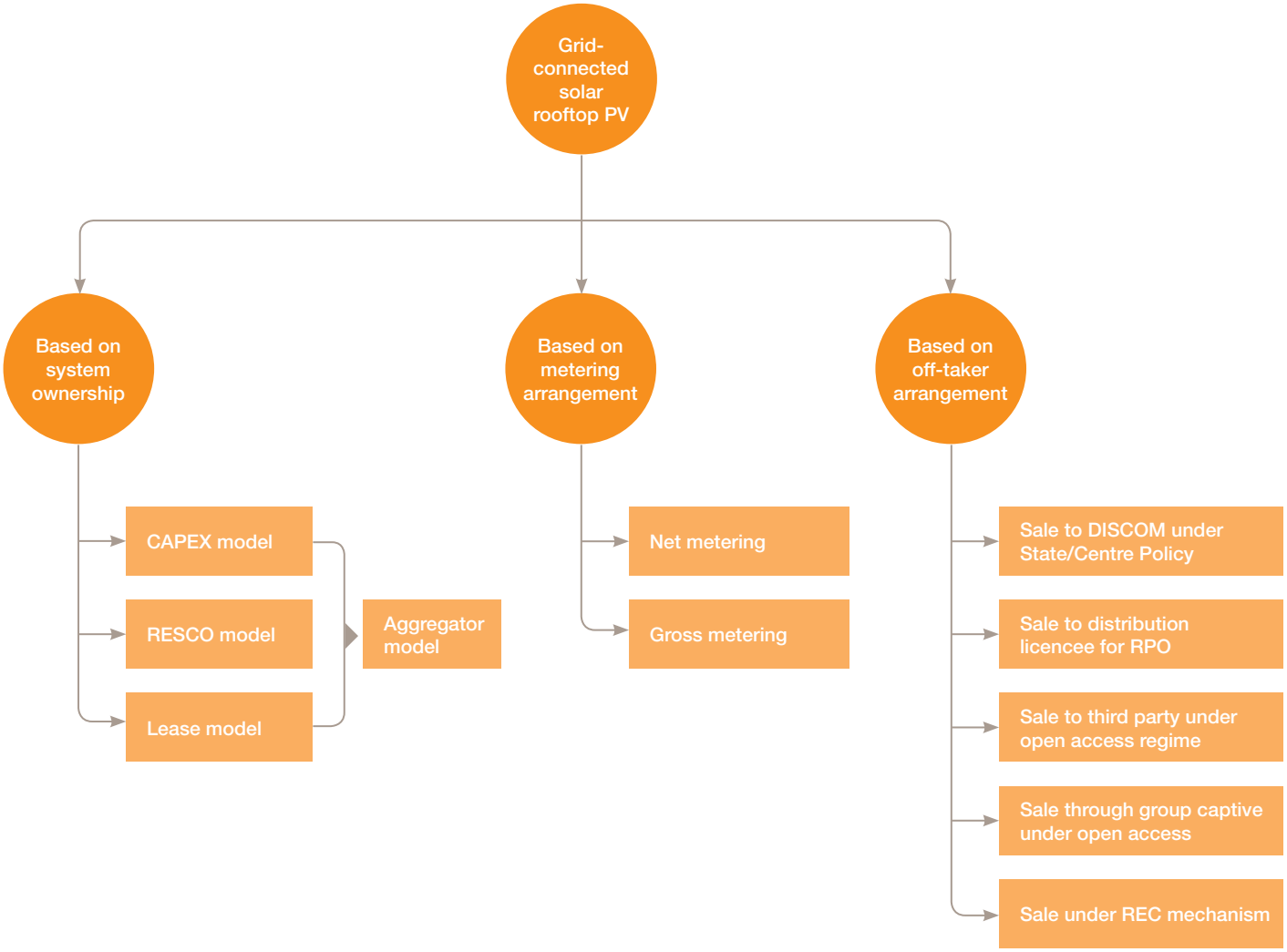
Though non-availability of FiT in rooftop projects has helped bring down the tariffs, a competitive mechanism, on the other hand, actually poses a bigger risk to large and serious players. With limited eligibility criteria in bid proposals, most small players bid at an exceptionally low tariff, thereby disrupting the market. Most large-scale developers also fear this as a challenge in terms of quality of equipment offered at such low tariffs. Most of these projects, unviable at a low cost, are later put on sale for acquisition which, in turn, affects the quality and generation from the project and at the same time results in loss of customer interest.

Business models

For successful and smooth operation of rooftop solar PV systems, business models based on various situations and conditions have been identified and tested in the country. However, there is no model that fits all requirements and hence the models vary according to the requirements of the end customer. They are designed as per the specific needs of the individuals and the legal framework.

Rooftop solar systems can thus be classified based on system ownership, metering arrangement (the way electricity is billed influences the profitability of the PV investments) and off-taker arrangement which are further classified based on customer needs.

Solar rooftop business model in India



Classification based on system ownership:

1. CAPEX model

Currently, the most prevalent model for rooftop solar installations is the CAPEX model where the rooftop owner buys the rooftop solar system, owns the system and uses the benefit of the generation for internal consumption. The customer may or may not take a loan to fund part of the investment and may or may not have availed capital subsidy. This model has the advantage of being simple and uncomplicated; however, the rooftop owner bears the risk of the project. Around 90% of all rooftop-based solar project capacity installed so far in India falls under this category. The CAPEX model has been one of the most widespread models in Germany where low-cost loans (as well as generous subsidies) have helped propel the market.

The CAPEX model has been the most preferred business model because of the various advantages such as quick payback period, risk-adjusted returns over longer duration, low payment risks and sole ownership of all power sources. There are some challenges associated with this model such as requirement of upfront capital, high interest rates on the money borrowed, delays in subsidy, etc., but these can be mitigated with the availability of concessional loans.

2. RESCO model (or OPEX model)

In the OPEX (Operational expenditure) or third-party model, a RESCO invests capital in the rooftop solar system and sells power to the rooftop owner/ occupier at a rate lower than their grid tariff but at a rate which enables the RESCO to make a profit. This model is often called the OPEX model because the rooftop owner pays for the system over a number of years during its operation. The 'third party' refers to the company entering the typical relationship between the building owner and distribution utility as the third party. These projects account for around 10% of the rooftop solar installed capacity.

The key advantage of this model is the technical risk that is taken up by the RESCO, and thus, the rooftop owner does not need to invest capital upfront. This reduces the liquidity risk and provides better tax benefits. The OPEX model has been quite prevalent in the US, where this model along with tax breaks proved attractive to a large numbers of consumers. Like other models, this model also has some challenges such as high payment risks associated with long-term PPAs and legal risks arising due to availability of land that can be mitigated by the availability of concessional funds.

3. Lease model

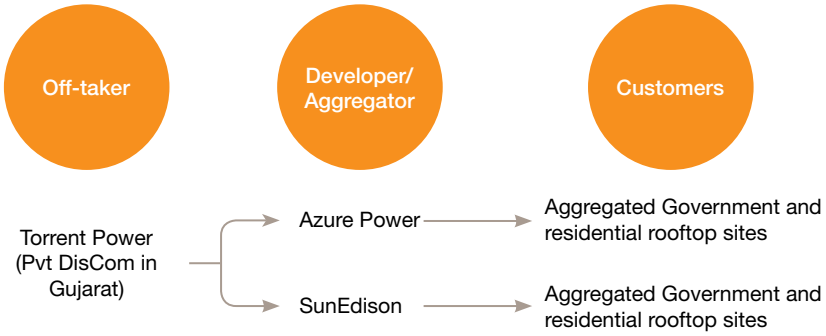
A third option in the rooftop system is the lease model, in which the customer leases the system from an installer/ developer but pays for it over time. This lease may be either a financial lease or an operating lease. At the end of the lease tenure, the asset is fully transferred to the customer. Thus far, the lease model is not popular in India because of the way taxes currently apply to lessors.

This model provides balanced cash outflows, thus enabling better use of capital and lower planning risks. However, there are certain issues associated with payments such as payment default issues, limited tax benefits, reduced returns for equity holders and ownership issues. Most of the risks associated with payment and returns on equity can be minimised through the availability of concessional loans.

4. Aggregator model

Under this aggregation model, the third party/RESCO, aggregates the demand of various customers and installs rooftop solar captive power plants up to the total capacity of the cumulative contracted load of the selected group of customers connected with the same distribution transformer. This model helps the aggregator to gain scale and offer the most competitive pricing. This model is now picking up pace in India and has been tried by various DISCOMs and banks. The flow diagram for an aggregator model used in Gujarat is illustrated below:

Aggregation model in Gujarat



The model is also being tested by various corporates where procurement of renewable energy is increasingly becoming a central piece of companies' corporate sustainability strategy. However, the size of rooftop deployment, in most cases, is limited due to the lack of space on individual roofs. This limited size of projects also increases the transaction cost for the RESCO/vendors, thereby decreasing project viability. Hence, if this demand from various corporates is aggregated to improve project size (which shall significantly improve the project economics), the deployment of rooftop shall increase exponentially.

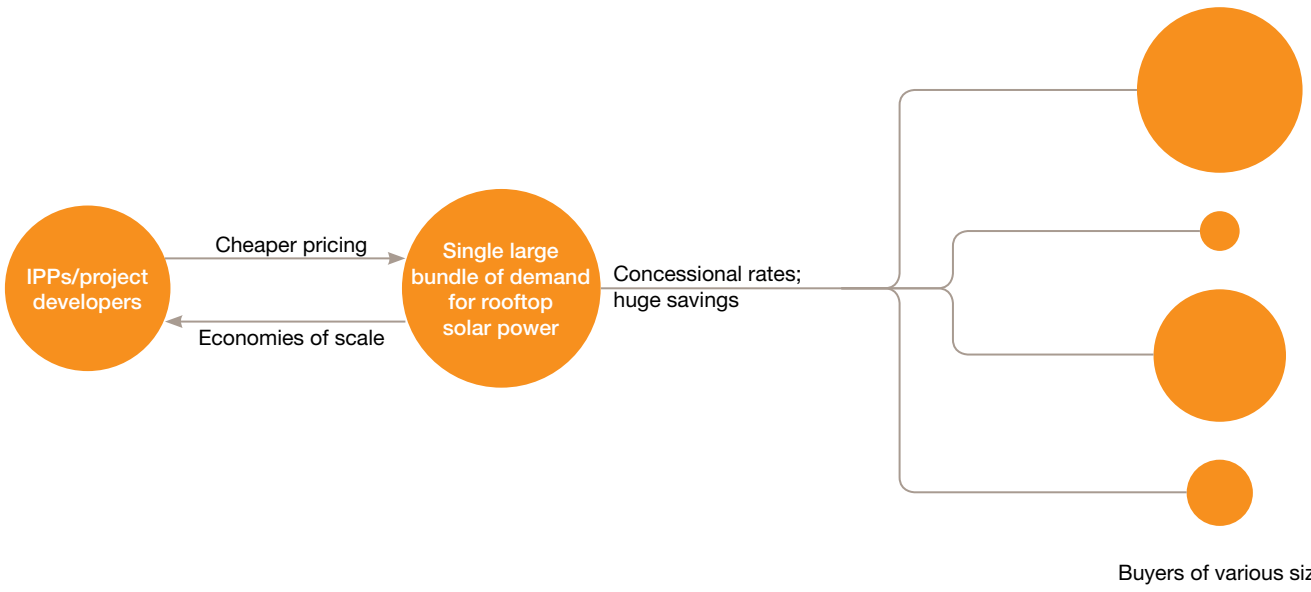
This model is the most preferred because of certain advantages such as low transaction cost, economies of scale, better risk management, lower risk of project failure arising from any one individual buyer and combined creditworthiness of buyers. These factors help mitigate the financial risk to project developers and also support them in reducing project financing costs. However, there are few challenges associated like PPA risks, ownership risks, issues faced with DISCOMs, but these can be minimised by making concessional funding available.

Financial institutions are also supporting the aggregation model as it saves both time and resources for conducting project due diligence. The aggregation is done, mainly, at the developer's level as the projects are offered for financing at the level where either the PPA (with selected off-taker) is already signed, or negotiation with the off-taker has been done. Hence, at this stage, the projects are already aggregated by developers. Thus, banks have a limited role in aggregating the projects.

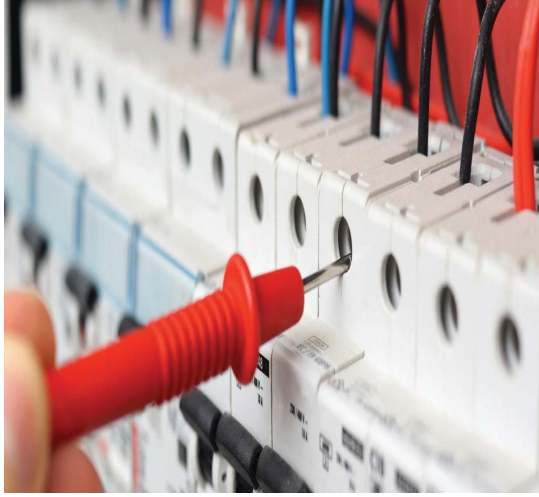
Few non-banking financial companies (NBFCs), however, consider aggregating small-size projects that are under the ambit of single DISCOMs (to avoid the challenges of dealing with different distribution utilities for the clearance and billing process) and preferably in a single large city (most financial institutions with limited presence across India consider limiting the projects to larger cities in order to reduce cost). The developers, on the hand, aggregate these projects either based on their location, with the selected projects connected to the same distribution utility or the demand aggregated based on the consumer category. In order to gain a complete line for rooftop financing, developers are also aggregating the portfolio of projects so that the project financing cost can be significantly reduced and end consumers can be offered competitive tariffs.

The model has been used quite frequently in the available lines of credit offered by banks like SBI and PNB where the complete portfolio of projects is offered a line, and major developers are aggregating demand to avail this concessional line of funding. The schematic of the aggregator model is represented below:

Rooftop solar aggregation model



Classification based on metering arrangement:



1. Gross metering

Gross metering is the arrangement which measures generation and import of grid electricity separately. By metering the total number of solar energy units generated and total number of units consumed, gross metering allows the utility to charge customers separately for import, generation and net consumption. This is imposed by having two separate meters or dual metering (dual element electronic, import and export meter).

In this type of arrangement, all of the energy generated is exported to the grid and the consumer gets no incentive to increase self-consumption. In this arrangement, the PPA is signed between the owner and the utility where the utility agrees to pay the owner either FiT or tariff as fixed by the regulatory commission of each state. Systems can be installed by either the roof owner (self-owned) or by a third-party player who enters into a roof lease agreement with the roof owner.

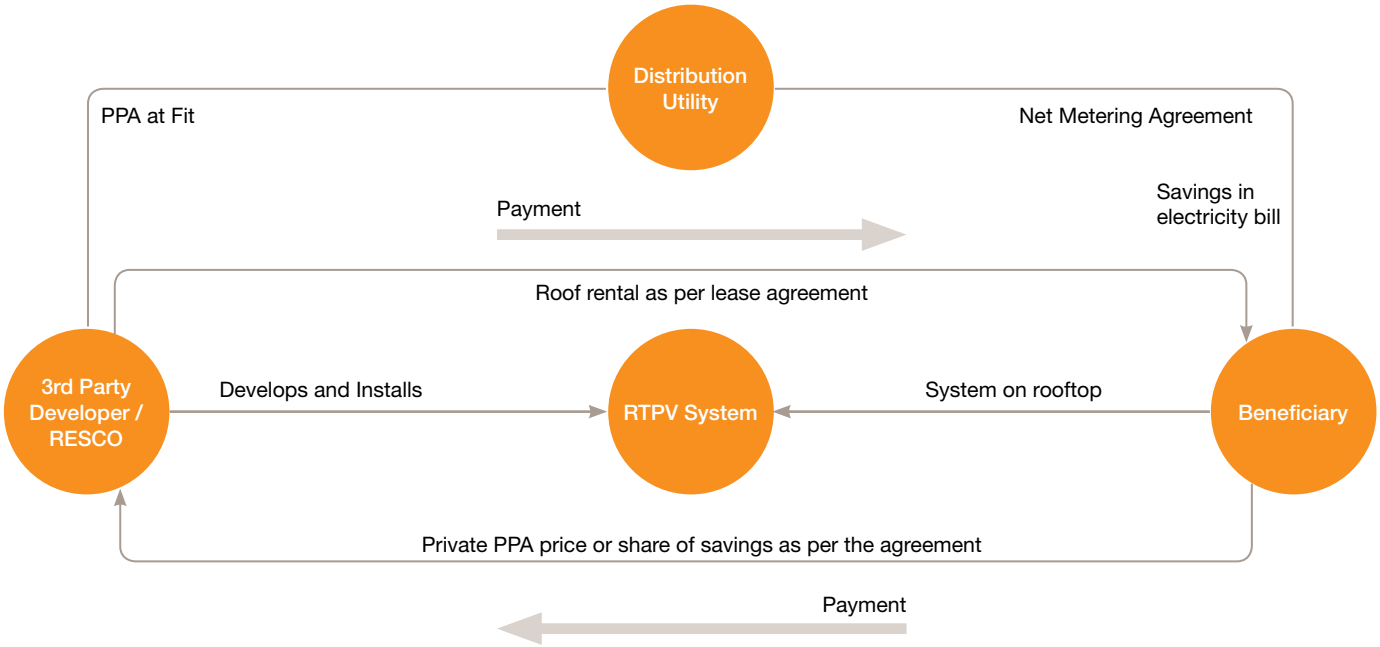
2. Net metering

Net metering is the arrangement under which power generated is first consumed internally and the excess energy, if any, is fed to the grid that can be commercially settled with the distribution utility based on the net metering regulation of respective state.

Further, based on the ownership pattern, the net metering arrangement can be of two types:

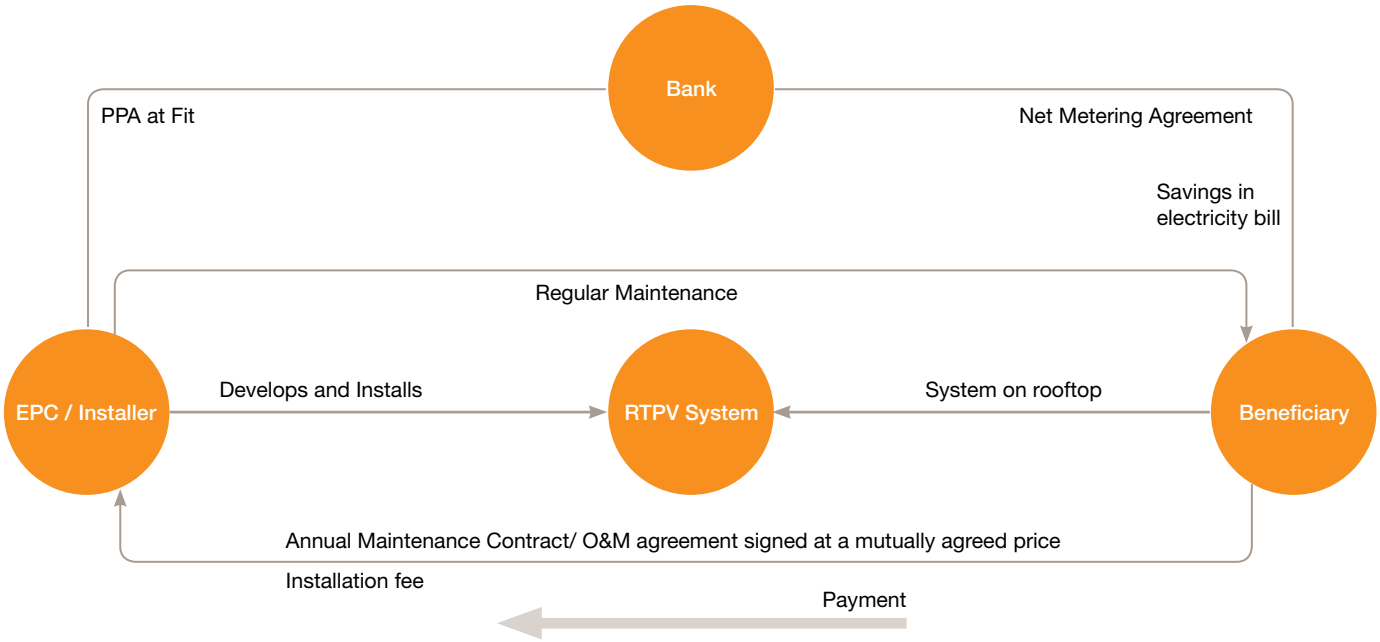
1. RESCO: In this model (see figure below), the third party owns the system on the rooftop of the consumer. The electricity generated from the project is consumed by the rooftop owner (consumer) at a mutually agreed tariff as per the PPA signed between the consumer and the RESCO. In case of excess generation, the surplus power is fed into the distribution grid and the same can either be adjusted in the monthly bill of the consumer or the distribution utility can provide banking facility for a particular time period as defined in the state regulation. In case the owner is generating more energy, then the excess energy is sent to grid and the owner is paid for the excess energy generated. If the electricity generated is lower than consumption, then the owner has to pay the differential of excess energy consumed as per the regional tariff. The RESCO, on the other hand, might include the clause of sharing of revenue in case of excess generation.

RESCO flow diagram



2. Self-owned: In this model (as shown below), the rooftop owner installs a solar PV plant through the EPC mode (operation and maintenance [O&M] might be outsourced) and continues to own the system. The power generated is consumed by the rooftop owner and any surplus power generated is fed to the grid, with an arrangement of paying for the surplus power fed or banked, as allowed in the state net metering policy. The rooftop owner pumps its own equity and arranges the loan for the project. Hence, the owner evaluates the payback period and returns generated from the installed system while replacing a certain part of power from the grid. No tariff is applicable on the rooftop owner for solar power generated.

Self-owned flow diagram



Classification based on off-taker arrangement:

1. Sale to DISCOMs under Central/ state policies and plan

Under this model, the generated power is sold to the state DISCOMs under the Central or state policies or any other state plans in future. Most of the Indian states have specific plans for setting up renewable energy projects in the state. The projects can be set up under such policies and the power generated can be sold to the state DISCOMs.

2. Sale to distribution licensee for meeting Renewable Purchase Obligation (RPO)

This model essentially involves sale of power generated by a rooftop solar power plant to the distribution utility to meet the Solar RPO for the state. Under this power off-take option, the utility will have to enter into a PPA with the purchaser or the distribution utility. Such a model is time-tested and comparatively less complex. However, the lesser complexity of this power sale model comes at a price of dependence on the willingness of the utilities to procure renewable energy power and the creditworthiness of the utilities to pay for the power purchase.

3. Sale to third party under open access regime

The model involves sale of energy to an open access consumer of the same DISCOM area within which the generator is located or to a different DISCOM within the state, using the network of the DISCOMs or transmission companies in order to wheel the power from the point of injection to the point of usage. Such a market model of third-party sale is largely made feasible with the introduction of provisions for open access transactions specified in the Electricity Act, 2003, and through the subsequent regulations framed by the State Electricity Regulatory Commission. The Electricity Act, 2003, defines open access vide section 2(47), reproduced as under:

'Open access' means the non-discriminatory provision for the use of transmission lines or distribution system or associated facilities with such lines or system by any licensee or consumer or a person engaged in generation in accordance with the regulations specified by the Appropriate Commission.

Open access allows a bulk consumer, according to the framework developed by the appropriate commission, to contract directly with the generation company or with any other source of supply (other than the incumbent distribution licensee in whose area the consumer is situated). The open access framework also offers the generating company the freedom to supply power to consumers who are eligible to avail open access.

4. Sale through group captive under open access regime

This model is very similar to that of the third-party sale model discussed in detail in the above section. However, in this model, the consumers need to have a minimum level of stakeholding in the rooftop project set-up. Hence, in case a developer wants to set up a rooftop project and sell power through the group captive route, then the shareholding/ capital structure of the rooftop project should be such that the plant gets qualified as a captive generation plant.

5. Sale under the Renewable Energy Certificate (REC) mechanism

Under the REC mechanism, one REC will be issued to the renewable energy generator for generating 1 MWh of electrical energy fed into the grid. The RE generator may sell electricity to the distribution company at the regulated price equivalent of the average pooled cost of power purchase by the utility from all sources excluding renewable energy sources and its RECs to obligated entities at the market price through the exchange mechanism in a transparent manner. The RE generator may sell the certificates only through power exchange to such obligated entities who have to meet their RPO target. The purchase of RECs will be deemed as a purchase of power generated from renewable sources and accordingly will be allowed for compliance with the RPO target. The REC mechanism will enable obligated entities in a state to procure RECs generated from any of the states in India and surrender the same to fulfil their RPO target.

Value Chain

The solar rooftop value chain comprises the following components:

Solar value chain

Primary activities

- Strategic sourcing
- Project finance
- Vendor management
- Logistics
- Project development
- O&M

Modules Inverters BoS

Inbound Outbound

Support activities

Firm infrastructure

Human resource management

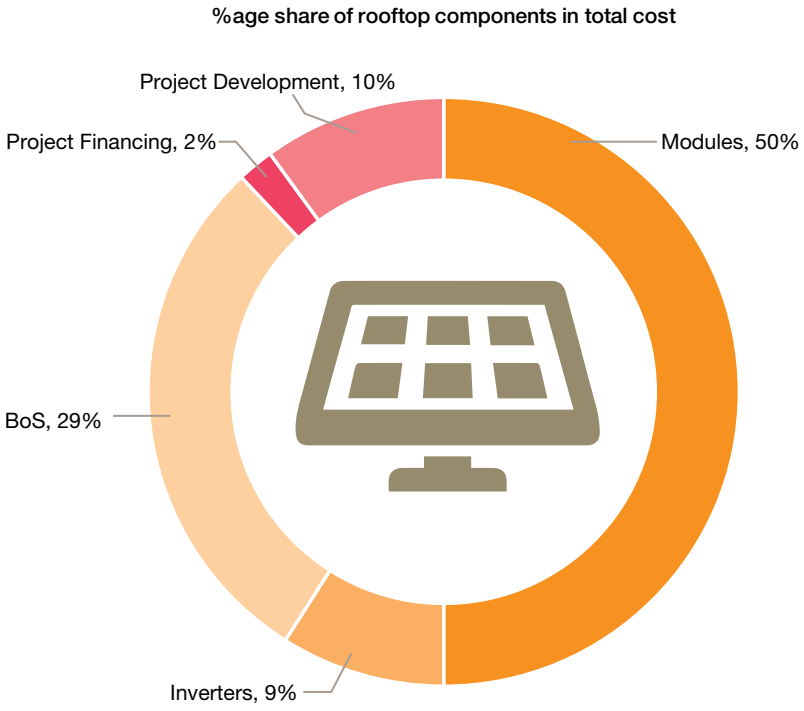
Procurement

Technology

Concessional funding: Equity investments from pension funds, life insurance companies, PE funds, concessional line of credit from DFIs/multilaterals

The share of each component in the value chain is estimated as below:

Percentage share in rooftop system cost



The value chain of rooftop solar projects aims at strategic sourcing of raw materials, procuring the best quality goods and delivering them to consumers at the right time, in the right quantity and at minimal price, thus optimising the overall value chain. Supply chain management increases efficiency by minimising cost and hence improving profit. Thus, there is a strong need to focus on the supply chain of the solar industry so that the costs are sustainable and add value to the end consumer. The downstream market—the developers—are growing in terms of market share but are struggling to deliver profits due to strong competition.

While the supply chain focuses on delivering the best output at each stage, the value chain focuses on the value generated by the construction of solar panels/parks/rooftop projects at each stage. Here, we would focus on the role of value chain financing, the need for it and its impact on each of the activities of the entire value chain.

The various activities involved in the value chain for the construction of rooftop solar projects are discussed below:

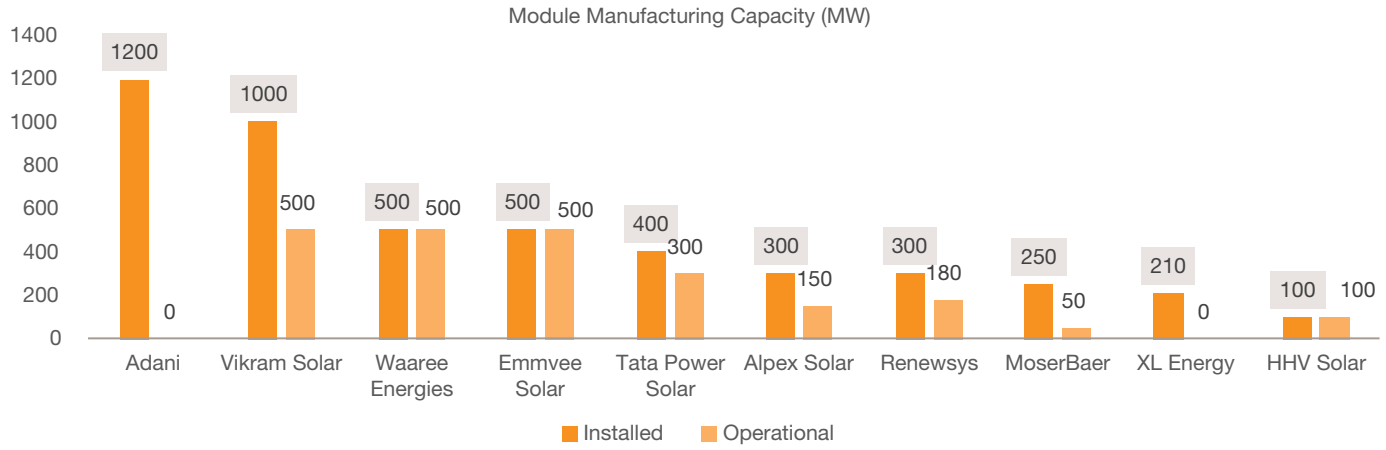
1. Strategic sourcing:

It aims at gathering information and leveraging the purchasing power of a company while procuring the raw materials for manufacturing the solar panels. This is not limited to solar panels only but also includes inverters, trackers and other balance of systems (BoS). However, solar modules account for the maximum portion of the solar system cost (~50% of the project cost; see Figure 42).

Given the limited domestic module manufacturing capacity in India (with cells and other components imported), domestic modules are comparatively more expensive than imported modules. Thus, large-scale procurement for modules is done through imports. Procurement for rooftop solar projects is done mainly from Indian manufacturers due to limited scale and size. However, with increased deployment, the focus will shift to bulk procurement to offer competitive pricing.

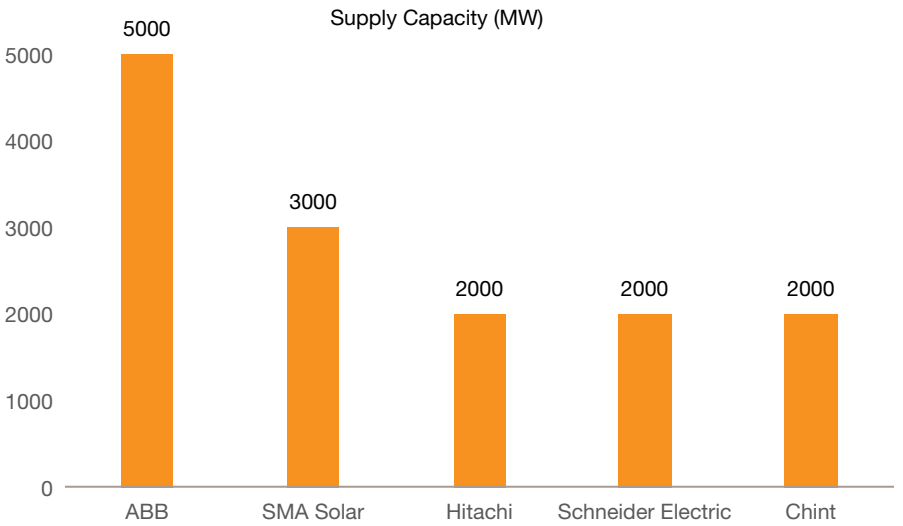
India's current installed module manufacturing capacity is 8.4 GW,[10] while the operational capacity is only 5.5 GW because of obsolete technology and sub-scale capacity. Module costs impact 35% of the project cost. Adani is the leading module manufacturer with 1.2 GW module manufacturing facility followed by Vikram Solar (1 GW), Waaree Energies and Emmvee each with capacities of 500 MW. However, the operational capacities are 500 MW for each of the players excluding Adani. According to MNRE, Adani has no operational capacity as of May 2017. The portfolio of key solar module manufacturers is shown in the graph below:

Module manufacturing capacity



Inverters, on the other hand, impact 10% of the project cost. As of June 2017, the top five solar inverter manufacturers in India account for 70% of the market share. ABB leads the market with supply capacity of around 5 GW followed by SMA solar with supply capacity of 3 GW and Hitachi, Schneider Electric and Chint have supply capacity of 2 GW each as on June 2017.

Inverter supply capacity



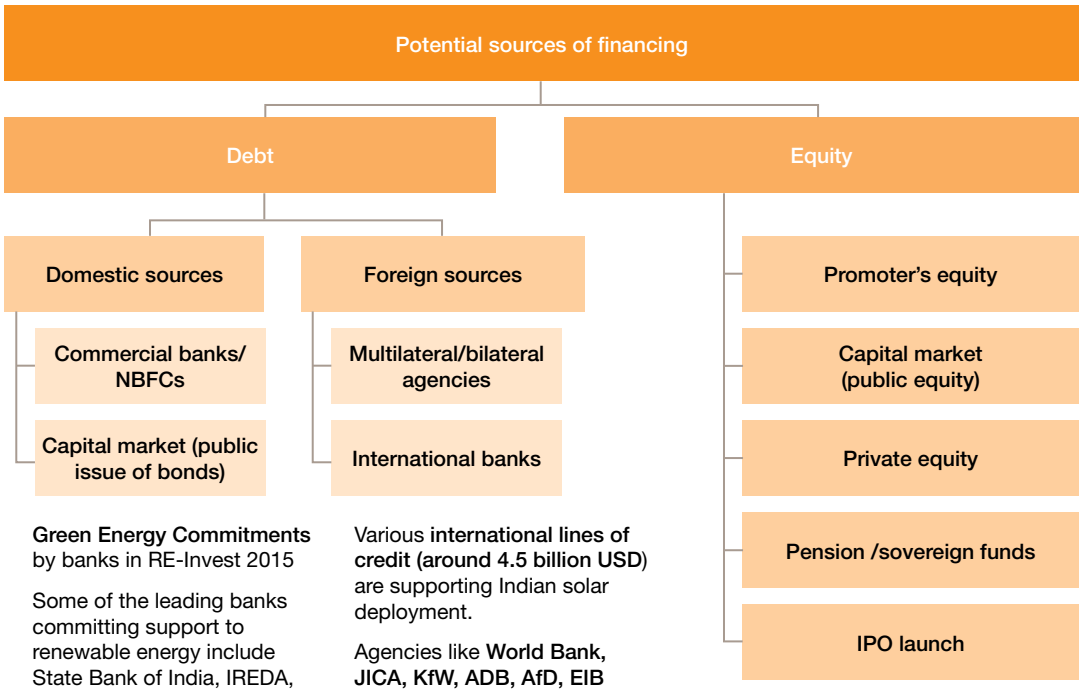
10 https://mnre.gov.in/file-manager/UserFiles/information-sought-from-all-Solar-Cell-&-Module-manufacturers-as-on-31052017.pdf

Thus, to support domestic manufacturing in India, some kind of concessional funding or subsidy support is required. Subsidy support is already available to support the market; however, additional concessional funding in the form of subsidised seed funding can help large-scale deployment of the manufacturing base in India. As the manufacturing set-up involves huge upfront capital, popular equity sources like pension funds and private equity (PE) firms which support the solar sector in India need to be considered for equity investment in the manufacturing sector. Concessional sources of equity capital with minimum returns can support the scale-up in India.

2. Project finance

Project financing involves long-term financing of the project either through a recourse or non-recourse financial structure. Both debt and equity are used to finance the project and the cash flows generated are used for repayment of the loan. In the case of the rooftop solar value chain, project financing plays a significant role at each step to improve the overall output through the value chain.

Financing instruments in India



Green Energy Commitments by banks in RE-Invest 2015

Some of the leading banks committing support to renewable energy include State Bank of India, IREDA, ICICI Bank, L&T Finance, PTC India, Yes Bank, and IIFC.

Total of **around 121 crore INR** committed by approximately **29 domestic** banks to promote renewable energydeployment

Various **international lines of credit (around 4.5 billion USD)** are supporting Indian solar deployment.

Agencies like **World Bank, JICA, KfW, ADB, AfD, EIB and GEF** are supporting huge investments, followed by blending concessionary funds.

Agencies like **KfW** are investing/ funding the Green Energy Corridor to support **interstate/intrastate transmission of renewable energy**

Recent shift from traditional mode of **own equity by investors** (savings from other business to claim tax benefits)

Move **to IPO route, private equity investments, pension funds.**

Huge interest in Indian market due to the **regulatory framework, push towards renewable energy, technology upgrading and improved returns**

Large portfolio of projects with limited risk due to PPA with Central and state agencies, **creating equity urgency in the market**

Huge interest from pension funds and PE firms such as **Abu Dhabi Investment Authority, Canadian Pension Fund, Singapore Sovereign** Fund; PE firms investing in Solar and Wind companies – **Goldman Sachs, GIC, I Square, Morgan Stanley**, etc.

3. Vendor management

This activity aims at managing existing vendors as well as targeting new ones. While procuring raw materials, it is essential to obtain quotes, turnaround time, service/product quality, evaluate performance and maintain relationships. Vendor management is important in not only the manufacturing sector but also the service sector (in this case, banking/financial institutions).

4. Logistics

The third step of activities is the management of logistics which includes transportation of goods from one department to another in the value chain at optimum price. It is easy to minimise the logistics cost, and with a proper understanding of how the carrying costs involved work, it is possible to minimize the inventory management costs. Various sources reveal that the inventory management expense helps to cut down the logistics cost, but low-cost financing and lower interest rates help to optimise the value chain.

5. Project development

Project development involves licensing, due diligence, technical designing, structuring and construction activities for the project. As of December 2017, around 350 infrastructure projects faced a time overrun and a cost overrun of around 2 lakh crore INR (29.6 billion USD). This calls for strong project management skills to avoid time and cost overruns. Strong risk management and technical expertise in managing projects can prevent overruns.

6. O&M

It includes activities such as facility monitoring, cleaning solar modules, breakdown management, repair work and warranty management. This stage is quite critical as it affects the system generation and life of the project. Successful commissioning of rooftop projects needs to be supported by the most optimum and best possible operation and management activity. Most customers build the O&M cost into the project cost so as to get the best possible outcome with the investment made.

All the activities listed above need strong technical domain knowledge as well as functional and financial knowledge in order to create value and generate profit out of the value chain. Thus, providing loans at subsidised prices for skill development is the need of the hour to attract more players and make the business profitable.

The macro factors impacting the rooftop solar sector are competitive bidding, higher interest rates and high cost of raw materials, thus diminishing the profit margins of the developers and impacting the landed cost of power with rooftop systems. Despite the issues, there are opportunities for growth and profit throughout the solar value chain. To survive in the current market conditions, a strong focus on the following is needed.

Capital flows

Companies should track expected cash inflows and outflows at a very detailed level in the entire value chain. They should look for low-cost financing options to leverage equity returns. Solar project developers can check the impact of cash flows at each and every step of the value chain, and this would help them with increasing equity for project development.

Increasing profits

Solar rooftop projects are easier to build as compared to other power projects as they substantially reduce the land and infrastructure cost and also bring in savings in terms of laying transmission lines owing to the decentralised nature of projects. However, lack of project management skills leads to time and cost overrun, thus affecting profitability. Since the solar rooftop industry is growing at 82% Y-o-Y, companies are focusing more on the execution of the project. This calls for capacity building of developers as well as financial institutions/banks. Larger players also need to implement lean construction techniques to increase productivity and decrease labour costs.

The Government of India is focused on producing clean energy and reducing emissions by 2030. In recent years, schemes such as Make in India[11] are adding value to this sector with a focus on the domestic manufacturing sector.

Currently, solar cell manufacturing capacity is around 1.7 GW. Around 85–90% of the modules are imported from China and this leads to a huge forex transfer of approximately 20,000 crore INR (2.96 billion USD) because the Chinese modules are around 10% cheaper than Indian manufactured solar modules.

Apart from the few initiatives listed above, the Indian government needs to develop a larger policy framework to support the domestic manufacturing of solar panels. This will help in controlling the revenue generated in the value chain from going outside India.

Role of concessional funding:

The Government of India has offered various incentives for manufacturing modules in India such as capital subsidy, operating cost subsidy and export incentives. In December 2017, the Solar Energy Corporation of India floated an expression of interest (EoI)[12] for setting up of 20 GW solar PV manufacturing capacities in India. This shows the government's focus on developing India's local manufacturing capacity. Hence, the concessional line of funding, if extended to the Indian module manufacturing supply chain, can provide a boost to the manufacturing potential. This will enable Indian module manufacturers to compete with international markets and contribute to the reduced landed tariff for solar projects, which will in turn lead to increased deployment and impact the final module price of Indian manufacturers. The line of credit can also be utilised for capacity development of manufacturers by helping them to make their plants operational and increase production capacity by adopting the latest technologies.[13]

Corporates, these days, have realised the potential savings of installing captive renewable energy projects. Various public sector players such as IOCL, ONGC and CIL, and Central and state government offices are showing interest in setting up solar projects. If subsidised loans are provided to these players, they can utilise their rooftop space for installing captive projects and thus add to the government targets of achieving 40 GW.

11 Make in India was a nation-building initiative started by the Government of India in 2014 to boost local manufacturing. It was started to make India a global design and manufacturing hub.

12 http://seci.co.in/web-data/docs/EOI-%2020000%20MW%20Solar%20PV%20Manufacturing%20Scheme.pdf

13 https://mercomindia.com/seci-tenders-5gw-solar-manufacturing-capacity/

Financing instruments for the rooftop sector

While significant capacity addition has been on large-scale utility solar power plants, rooftop solar is picking up pace in India with the availability of innovative financing schemes and technology advancements, thus improving project economics. To support this, both the World Bank and ADB are running rooftop programmes to provide concessional funding through domestic banks.

World Bank-SBI Rooftop Solar Programme

Programme description

The proposed Grid-connected Rooftop Solar (GRPV) Programme is the first-ever CTF-funded project that uses an innovative financing instrument, Programme for Results (PforR), with a focus on supporting government programme and achieving outcomes. The biggest challenge identified in GRPV projects is the unavailability of commercial loans to rooftop aggregators and developers at a concessional rate to support market growth. Hence, to address this challenge, the current programme was launched by making long-term concessional financing available to stakeholders for large-scale deployment of GRPV in India and sharing international experiences on the successful implementation of large-scale rooftop programmes implemented across the globe. The programme also includes technical assistance (TA) and capacity-building support to the major stakeholders, including DISCOMs, regulators, state agencies and banks. The programme is designed for a five-year duration from September 2016 to September 2021 and includes fund contribution from various institutions, including CTF, IBRD, GEF, public and private sector financing agencies and SBI.

The funding from GEF is specifically focused on building a risk mitigation mechanism to support lending to NBFCs and small and medium enterprise (SME) commercial and industrial customers for GRPV as well as support the strengthening of the investment climate and capacity building of the main stakeholders involved in the expansion of GRPV. Additionally, CTF and IBRD funds shall support the commercial bank (SBI) in extending loans for GRPV at a concessional rate (at or near the base rate, defined as per RBI directives). Under this programme, once the CTF and IBRD funds are exhausted, SBI can continue the second phase of this programme with its own resources and/or through syndication with other banks (which shall be subject to availability of a creditworthy pipeline of projects and success of Phase 1 of the programme). The rates of sub-loans, under the second phase, can rise depending on the project schematics. The current IBRD-CTF programme has a unique financing structure, leveraging multiple sources of funds from various multilaterals and concessional funding sources to support the reduction in the interest rates for the GRPV.

The programme is designed along two pillars: ***transformation and inclusion***. Under transformation, the programme intends to achieve reduction in GHG emissions through renewable energy generation. Under inclusion, the focus is on achieving access to electricity by increasing availability of electricity generation in the system. Additionally, the programme emphasises on the 'finance-plus' approach, whereby it goes beyond bank financing and contributes to transfer of knowledge and international best practices, reform of processes and systems, strengthening of institutional capacity, and exploring innovative financing mechanisms. The programme is designed to support the World Bank's corporate commitment to increase renewable energy lending and address climate change concerns.

The current programme supports all major business models prevalent in GRPV implementation in the country. The business models widely used in this field are depicted below:

Business Models

OPEX Model
Third-party model with no upfront capital investment and outsourced operating expenditures

Utility-owned Model
Distribution Utility owned model installed and maintained by Utility or maintenance delegated to third party

CAPEX Model
Customer-owned model in which the solar rooftop facility is owned, operated and maintained by the customer or owned by customer and maintained by third-party

Rooftop Rental Model
Third-party owned model with solar panels on rented roof space; power sold to DisComs at agreed rate under gross metering model

NBFC Model
Model under partnership of 2 parties- NBFC, having license to make consumer loans and Business, looking to invest in solar panels. Together rooftop installer is identified to find customers interested in BOOT model

PforR scope

The IBRD-CTF PforR intends to cover the following three result areas.

The PforR programme shall benefit all the stakeholders involved in the GRPV project implementation. The instrument will add significant value to implementation by (i) ensuring a sharp focus on achieving the Government of India's targets; (ii) allowing flexibility in implementation and use of funds through streamlined procedures; (iii) supporting development of the bank's programme through institutional capacity building.

PforR objectives

Strengthening institutional capacity building

- Includes technical assistance (capacity building) of main stakeholders (building blocks):
- SBI; DISCOMS; state nodal agencies; accredited rooftop PV inspectors; state power departments; state electricity regulatory commissions

Market development of GRPV

- Includes development and implementation of market aggregation models for installers and customers with feasible roofs
- Undertake marketing and business development for deal origination
- Provide lending capital to developers/aggregators
- Target lending to SMEs, NBFCs

Expanding GRPV generation

- Support installation of more than 400 MW grid-connected solar rooftop PV systems using storage options:
- In case of CAPEX, minimum of 100 kWp capacity per project
- In case of RESCO, aggregated capacity of at least 1 MW, with sub-projects of capacity not less than 20 kWp

Rooftop programmme beneficiaries

Program Beneficiaries

GRPV customers & State Residents

- Customers to be benefited from electricity generated
- State residents to be benefited from improved consumer education and consumer awareness, reduced air pollution and improved health impacts

Economic Agents & Global Community

- All economic agents engaged in supply chain- sub-contractors, O&M providers
- Global community to be benefited from avoided greenhouse gas emissions

DisComs

- To be benefitted from the electricity passed on to their network through net metering or gross metering and through technical assistance under the programme design

Third party aggregators, developers, vendors

- To be benefitted through access to debt; allowing business to grow

SNAs & SERCs

- To be benefited from technical assistance and capacity building activities planned in the programme

SBI & its Branches

- To be benefitted through strengthening of institutional capacity building

Implementation arrangement

The implementation agency in the programme shall include the ***government***, the lead ministry responsible for achieving the Government of India's solar target of 40GW rooftop solar PV with MNRE providing overall policy guidance, and ***SBI***, the borrower and implementing agency for PforR. Under this programme, SBI will extend loans to GRPV customers, developers, aggregators and intermediaries based on the technical qualification criteria and creditworthiness of the borrower.

Programme financing

The total programme budget is 800 million USD. The contribution of each agency is presented below:

Financing sources in the World Bank programme

Source of finance	Amount (million USD)	Percentage of total
IBRD	500	63%
CTF (loan and grant)	125	16%
GEF (support TA to stakeholders)	23	3%
Private and public sector financing	150	19%
SBI	2	0.3%
Total programme financing	800	100 %

The contribution from CTF comprises a loan component of 120 million USD on concessional terms and a grant of 5 million USD. CTF loans are offered under softer concessional terms with a maturity period of 40 years, including a 10-year grace period, service charge @ 0.25% per annum and principal repayments at 2% for years 11–20 and 4% for years 21–40. A management fee of around 0.45% of the total loan amount (5,40,000 USD) will be charged. IBRD funding, on the other hand, has a maturity period of 19 years, including a grace period of 5 years. With these financing terms offered to SBI, the bank has been able to offer finance projects to the project aggregators and developers at interest rates of approximately 8.45–9.5% (i.e. one year marginal cost of funds based lending rate [MCLR] plus 20–50 bps based on the risk rating of the customer) and a loan duration of around 15 years with 12 months (post the commencement date) as a moratorium period.

Programme status

With the concessional financing terms, SBI has been able to sanction around 356 million USD, adding to 575 MW of solar rooftop capacity to the grid. Some of the developers availing this financing include Azure Power, Amplus, CleanMax, ReNew and others. The capacity of projects sanctioned ranges from 25 kWp to 16 MW. The key outcomes of the programme includes **GRPV capacity deployment and CO2 emission reduction (tonnes)**. GRPV capacity deployment is mainly focused on through the implementation of third-party models in addition to customer-owned models. The focus is on the aggregation model where access to working capital will allow qualified private sector developers and aggregators to buy the required inventory, aggressively acquire customers, and push for large-scale deployment of rooftop solar PV systems among customers using different business models. In terms of CO2 *emissions reduction*, the planned programme intends to reduce GHG emissions by 14.8 million tonnes over the life of the project compared to thermal projects.

Some of the installations (Project Yamaha with 1,100 kW capacity) completed under this programme supported through SBI financing are presented below:

Yamaha solar installation (1,100 kW)

ADB-PNB Rooftop Solar Programme

Project description

The CTF made another contribution to support the Government of India's 40 GW plan by extending a line of credit to PNB along with support from ADB. The total financing consists of a 505-million USD multi-tranche financing facility for the Solar Rooftop Investment Programme (SRIP). The facility is sovereign-guaranteed and comprises 5 million USD for capacity development TA. MNRE and PNB would be the executing agencies for the TA. Three major components of the TA programme would be:

- PNB Institutional Capacity Building
- Market Development
- Awareness Campaign

In this facility, PNB is the borrower and India will provide a sovereign guarantee to ADB for the programme. The programme focuses on extending concessional loans to finance large solar rooftop systems on commercial and industrial buildings in India. The programme shall include loan extension under any possible business model (as per the PNB guidelines and project viability); however, the larger focus will be on aggregated projects. The TA component of 5 million USD is to integrate the building blocks of the Government of India's rooftop sector development initiative to ensure viable market demand by strengthening the capacity building of the borrower bank, PNB, and other market development elements. The programme comprises funding contribution from ADB and CTF on concessional basis.

The total duration of SRIP is December 2016 to December 2022.

The current scheme is targeted to capture commercial, institutional and industrial consumers, including MSMEs, as the scale of deployment is high and consumer interest in green energy is high. At the same time, developers have better credibility for payments from large C&I consumers as compared to small-scale residential rooftop owners.

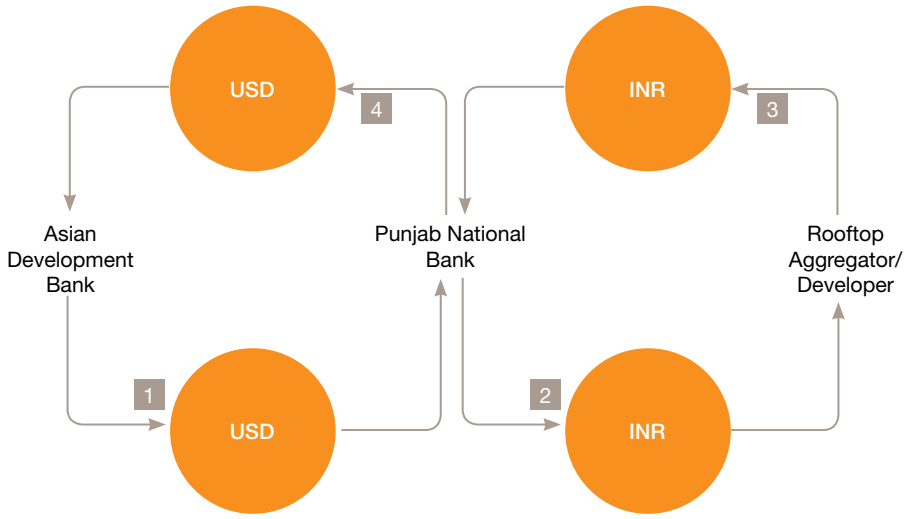
The current SRIP is focused on achieving ADB's objective to double the annual climate financing from 3 billion USD to around 6 billion USD by 2020. Of this, 4billion USD will be dedicated to mitigation that includes increased support for renewable energy. The 500-million USD multi-tranche facility is designed to cover the following broad objectives:

Programme objectives

1	Promote energy efficiency and renewable energy
2	Promote energy sector reform, capacity building and governance
3	Support India's INDC targets to lower emissions intensity
4	Financial intermediation, an important instrument for on-lending
5	Maximise access to energy for all

The fund flow arrangement under the programme is depicted below:

Fund flow arrangement



PNB, in this arrangement, has an option to utilise the ADB's USD funds without conversion. Based on the reimbursement method, ADB will reimburse PNB in either INR or USD, a decision to be taken at PNB's discretion to help it hedge the foreign exchange risk. In case the disbursement from ADB is in INR, the exchange rate will be determined based on the INR-USD exchange rate on the value date of the ADB foreign exchange transaction.

Programme financing

The financing under SRIP includes **330 million USD from ADB's Ordinary Capital Resources (OCR)** and **170 million USD from CTF**. The funds from CTF are provided at concessional terms with a maturity period of 40 years, including a 10-year grace period. Principal repayments from years 11–20 would be 2% and from year 21–40 would be at 4%. Additionally, a multilateral development bank fee of 0.18% and a service charge of 0.25% would be applicable. Thus, CTF money is available at a weighted average cost of funds of approximately 0.25%. The total investment under the ADB's programme comprises 1 billion USD (refer to Table 7).

ADB investment

Source	Amount (million USD)	Share
ADB loans		
OCR	330	33%
CTF	170	17%
Equity (assuming 30% of project cost)	300	30%
Debt from commercial banks	200	20%
Sub-total	**1,000**	
Technical assistance		
CTF (grant)	5.0	
Grand total	**1,005**	

This type of concessional funding received by domestic banks is a major contributor towards improving the project financing terms to support market deployment. With this type of concessional financing extended to banks, the major difference is in the loan pricing (interest rates), which has a significant impact on the project financials and improves the viability of the rooftop projects compared to traditional grid power. Based on this funding, PNB has released reasonable financing terms for lending loans to rooftop projects. The loan tenor extended by PNB under this scheme is 15 years with a moratorium period of 1 year from first disbursement or four months from CoD[14] (whichever is earlier). The scheme has been able to provide low-cost financing at an interest rate of one year MCLR (i.e. 8.25%) with a spread of 30–50 bps based on the risk rating of the borrowing firm.

Implementation arrangement

PNB will be the implementation agency for SRIP. Under this programme, PNB will establish a dedicated solar rooftop unit with internal capacity to support the programme implementation.

Since the programme is a multi-tranche financing facility, funding of 500 million USD will be released in three tranches. Tranche 1 of 100 million USD comprises CTF fund with an implementation duration of December 2016 to December 2018, tranche 2 of 150 million USD comprising CTF and ADB funds with an implementation duration of December 2018–2020, and the final tranche of 250 million USD from ADB funds will have a duration of 2020–2022.

ADB funds can be used by PNB to finance up to 50% of the total project cost with no upper limit on the project size. PNB, additionally, may use up to 20% of this fund to buy out qualified solar rooftop loans from other financial institutions under each tranche in order to better consolidate sector assets. Takeout finance may include subprojects that are either financially closed or are in the construction phase.

Project status

At the current stage, PNB has already sanctioned 20 projects of 104.59 MW capacity for 63.86 million USD under this ADB-CTF credit line. The scale of deployment foreseen is quite high with projects worth around 150 million USD in the pipeline.

Beyond deployment, PNB is also focusing on removing the current barriers hindering rooftop growth in the country. For the same, PNB is conducting awareness programmes along with the ADB team for SNAs/DISCOMs in Karnataka, Tamil Nadu and Goa. Besides, sensitisation programmes are being conducted in 16 states for potential customers as well as field functionaries at more than 10 zonal headquarters.

DSM project @ 1 MW installation

14 CoD - commercial operation date

While there has been significant capacity addition in the case of large-scale utility solar power plants, rooftop solar is also picking up pace in India with the availability of innovative financing schemes and technology advancements, thus improving the project economics.

To study the impact of innovative financing, especially the international concessional funding available for rooftop solar PV in India, financial assessments of the resulting tariff and other leverage terms are compared. This is done using a scenario analysis approach, considering the loan tenure and the interest rates with and without concessional funding. The impact assessment of concessional funding shall be useful to assess the resulting tariff that can support the market sustainability of rooftop solar projects compared to the conventional grid tariffs. At the same time, faster deployment of rooftop solar shall add to environment protection and reducing carbon emissions from traditional conventional sources of power.

Demonstration and implementation potential

This section subjectively reviews certain aspects of CTF funding, along the defined pointers or impact indicators. A neutral outlook is considered for assessing the impact of providing CTF financing, blended with the funding for rooftop solar projects in India received from multilateral development banks.

The project funding usually comprises debt and equity components with a ratio of around 70:30, varying from case to case. To evaluate the impact of adding CTF financing to the power tariff, detailed financial modelling has been done, using a 100-kW rooftop solar PV project as an example and considering two different scenarios—with and without CTF funds. CTF funds, in this case, have been provided at the most concessional rates (as explained in Case I: With CTF funds) to provide viability and low-cost financing support to the rooftop projects in India. The major differential in the project financing terms using concessional funding is the rate of interest and the tenure of loans extended to the project developers. Since the debt component in the financing package of a typical solar rooftop project is quite high, project financing terms play a significant role in reducing the project tariffs and thus making the project more viable. Also, since solar rooftop projects are mainly installed for the purpose of savings, reduced solar tariffs as compared to the conventional grid tariffs are a major driver. Thus, a scenario analysis considering two possible cases is done to compare the tariffs of a 100-kW solar rooftop system.

Key assumptions for rooftop solar PV system

Assumption	Unit Value
Installed Generation Capacity	100 kW
Capacity Utilisation Factor (CUF)	15%
Life of the system	15 years
Project Cost	INR 54,000/ kW
Loan Repayment Period	10 years
Interest Rate with concessional funding (CTF)	8.5%
Interest Rate without concessional funding	10.5%
O&M Charges	INR 600/kW
Annual O&M Expense escalation	5.72%
Annual Module performance degradation	0.5%

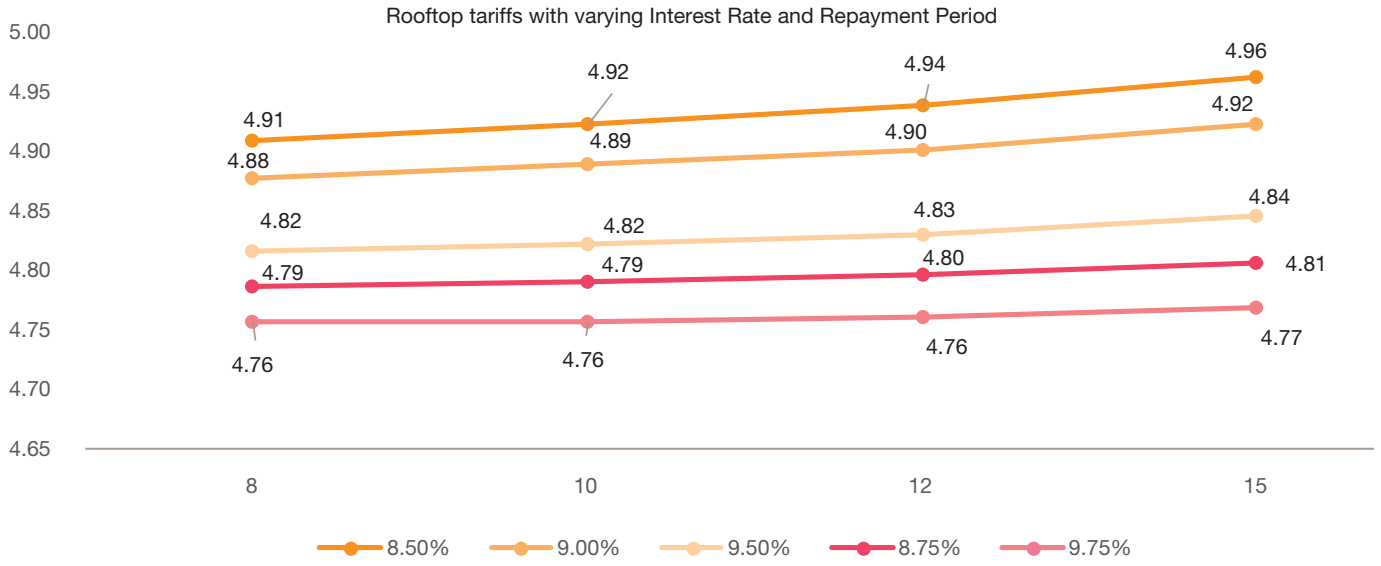
Considering the above assumptions, the financial impact on the projects with and without concessional funding is summarised below:

Case 1: With CTF funding (blended with funds from multilaterals)

The concessional terms offered by blended funds from CTF and multilateral development banks (World Bank and ADB) to Indian banks (SBI and PNB) have helped in bringing down the project financing cost by around 1.5–2% (i.e. interest rate offered by SBI and PNB under this line is MCLR + 20–50 bps), which significantly improved the project viability, both for RESCOs and the end consumers. CTF loans are offered with a service charge of 0.25% per annum on the disbursed and outstanding loan balance and 40-year maturity, including a 10-year grace period, with principal repayments at 2% for years 11–20 and at 4% for years 21–40. A management fee of 0.45% of the total loan amount will be applicable that will be capitalised from the loan proceeds. These terms offered by CTF, blended with the concessional terms offered by World Bank and ADB (comprising a 19-year loan tenure with additional an 5 years as a grace period, and interest rate as per the London Inter-bank Offered Rate [LIBOR] for 12 months), have improved the project financing terms.

Based on the assumptions in Table 8, the tariff was calculated as 5.08 INR/kW. Since lending terms vary with the riskiness of the project, a scenario analysis is conducted considering the rate of interest to vary from 8.5– 9.75% along with a repayment tenure of 10–20 years. The graph below summarises the impact on the resulting tariff by varying the rate of interest and repayment tenure.

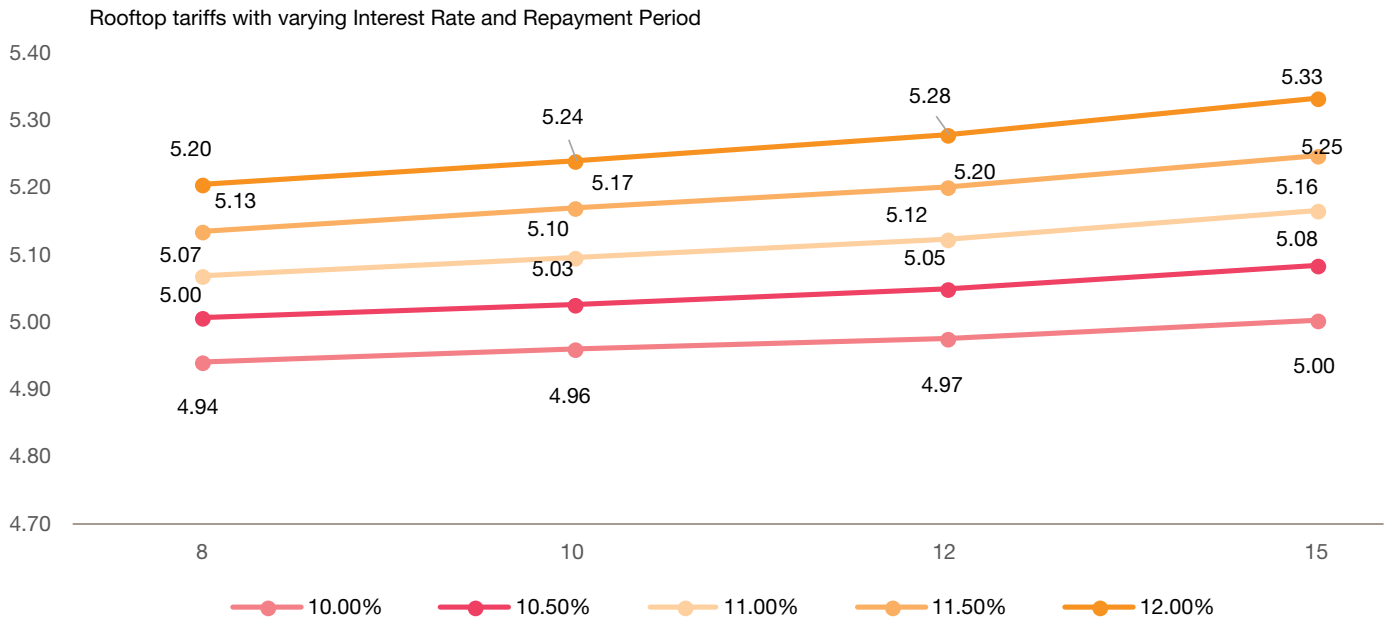
Rooftop tariffs with varying interest rate and repayment period



Case 2: Without concessional funding support

Considering the most likely scenario of 11% interest rate and same tenure of 15 years, a base tariff of 5.23 INR/kWh is discovered (levelised for 25 years). However, considering varied risks in different projects and differences in lending terms, a scenario analysis is conducted to compare the results. The graph below presents the tariffs after varying the rate of interest and repayment tenure. It can be clearly seen that by varying the rate of interest and keeping the same repayment tenure, the resulting tariff is higher than the one discussed above.

Rooftop tariffs with non-CTF financing terms



Thus, with the decrease in interest rates, the tariffs are improved to a certain extent, thus making the projects more viable. Hence, the contribution from CTF and other multilateral development banks who are extending line of credit at concessional rates to domestic banks is considered as a major factor for increasing the scale-up of rooftop projects. With this, many independent power producers (IPPs) have started showing interest in building a large portfolio of rooftop solar projects, thereby increasing the deployment of the rooftop market in the country.

An analysis of the potential for rooftop installations with the available funds reveals that more than 1 GW solar rooftop capacity addition can be targeted in the given duration of the two programmes.[15]

Capacity addition with CTF and multilateral funds

Capacity Addition with Clean Technology Funds in WB and ADB program			
World Bank Program	**Sep-21**	**Asian Development Bank**	**Dec-22**
SBI- Current Installation Status as of June 2018		PNB- Current Installation Status as of June 2018	
Projects Sanctioned (MW)	**Capital Used ($ Mn)**	**Projects Sanctioned (MW)**	**Capital Used ($ Mn)**
575	356	104.59	63.86
Possible Installations (MW)	**Capital Available ($ Mn)**	**Possible Installations (MW)**	**Capital Available ($ Mn)**
400-450	269	700-750	436.14
Total Rooftop Capacity Addition		**1700-1800 MW**	

Based on the challenges faced by the Indian rooftop market, including the high cost of financing and high credit rating risk of consumers, CTF contribution/support to domestic banks is quite a significant factor in increasing the deployment of rooftop solar PV in India. Support to domestic banks by providing concessional funding has influenced market growth by reviving the interest of developers in the deployment of large-scale projects. CTF has increased the market momentum for rooftop projects by addressing the major roadblock of project financing.

15 For future installation, the solar rooftop PV installation cost is considered as 54,000 INR/kWp and a debt of 70% is assumed.

Transformative: Potential GHG emissions savings

PwC has projected the rooftop installation of projects in India with CTF money (see table on previous page). The projections are made considering the available funds and the sanctioned capacity. Considering the estimated capacity of around 1,911 MW that can be deployed, it is estimated that GHG emissions of around 17,57,737 tonnes of CO2 can be saved over the 25-year lifetime of the rooftop solar PV with CTF support.

This estimate assumes a capacity of 1,911 MW of rooftop solar PV installation operating at a capacity utilisation factor of 15%, displacing an equivalent of around 2,511 GWh per year of 'thermal-based' power. A weighted average emissions factor of 700 t/GWh is assumed that accounts for decreasing emissions intensity associated with high renewable energy penetration rates.

Development impact: Socioeconomic benefit

The impact of rooftop solar projects is not limited to the environment in terms of reduction in GHG, but can be extended to socioeconomic benefits. Hence, the impact of large-scale rooftop solar deployment in the country will be on job creation. Rooftop solar is more labour-intensive than other ground mount solar and wind. Rooftop solar (based on a survey conducted by the Council on Energy, Environment and Water [CEEW]) provides 24.72 job-years per MW in comparison to 3.45[16] job-years per MW for ground mount solar. Analysing the job creation across the complete value chain shows increased job prospects in rooftop compared to ground mount solar.

Stage 1: Business development related activities in rooftop solar creates more jobs due to the small size of individual projects and the necessity to reach out to a larger consumer base. Around 1.53 job-years are created per MW.

Stage 2: The **design and construction phase** is considered a single phase as the size of individual installations is quite small and hence, a single team oversees construction and commissioning. Thus, approximately 8.85 job-years per MW can be estimated, with most of them requiring skilled (72%) and semi-skilled (20%) manpower.

Stage 3: The estimated job creation in the ***construction and pre-commissioning phase*** is around 13.84 job-years per MW, where additional construction workers are required to undertake construction activities, outsourced either to contractors or through independent construction workers.

Stage 4: O&M activities engage additional workers, especially in the RESCO model, where a dedicated team is employed for regular cleaning and maintenance-related work. Job employment estimated in the case of rooftop solar is around 0.50 job-years per MW.

Thus, with the above job opportunities in solar rooftop, funds from CTF and multilaterals can support the installation of 1,911 MW (refer to Table 9) of solar rooftop projects. The jobs created in this stage of the value chain are calculated below.

Job opportunities with CTF funding

Rooftop Execution Stage	Estimated Jobs	Job-year/MW
Business Development	2924	1.53
Design and Construction	16913	8.85
Construction and Pre-Commissioning	26449	13.84
Operation and Maintenance	956	0.5

16 http://ceew.in/pdf/CEEW%20NRDC%20-%20Greening%20India's%20Workforce%20report%2020Jun17.pdf

Looking ahead

With the advancements in PV technology, the cost of rooftop solar PV systems has declined significantly and become economically viable in various segments. In some markets, rooftop systems are even cheaper than the conventional sources of energy, yet the on-ground implementation is far behind the envisaged target to achieve 40 GW by 2022. Apart from pricing, other key drivers for rooftop solar deployment in the country are the targets for CO2 reductions and compliance with RPOs for those entities who are obligated to meet a certain part of their electricity consumption from renewable resources.

Thus, three scenarios—***optimistic, most likely and pessimistic***—are considered to project the possible growth in the rooftop sector and the possible capital investment required to support the growth.

The *optimistic scenario* defines the scenario where concessional fundings and other multilateral lines of credit continue to support domestic banks and in turn optimise the interest rates. These additional funding sources shall eliminate/reduce the biggest challenge to project financing in the case of rooftop solar PV projects in India. The assumption made in such a case is that with reduced interest rates, an improved percentage of rooftop solar PV can be deployed (around 40% of the yearly capacity addition projections and increasing the penetration by 10% each year). The cumulative capacity in this case represents the total capacity commissioned as on March 2018 and the additional yearly capacity that can be captured.

The *most likely scenario*, on the other hand, represents a situation of business-as-usual, where the rooftop deployment continues with the prevalent market interest rates @ 10–11% added through subsidised interest rates available from the current CTF and multilateral support. In this scenario, the deployment is limited with the available concessions; hence, penetration of 30% of the cumulative target capacity is assumed. The growth, however, is considered at the same 10% level. Yearly projections in this scenario represent 30% of the government planned yearly targets and a subsequent 10% addition each year.

The *pessimistic scenario* represents a situation of reduced/slow rooftop solar PV deployment with the non-availability of any concessional funding support or any investment from multilaterals to support rooftop deployment. The assumption in this case is mainly the deployment of rooftop solar by relying on the domestic market and domestic funding sources where the cost of capital is high. In this scenario, an assumption of 20% deployment is assumed and projected at a growth rate of 10% annually. Yearly capacity addition in this scenario is 20% of the government planned yearly targets in FY19 and a 10% increase in consecutive years. The cumulative targets represent the total of current rooftop capacity and the possible yearly additions in this scenario.

The projections considered are presented below:

Rooftop solar projections (GW)

	FY19	FY20	FY21	FY22
Government targets	16	23	31	40
Yearly capacity addition	6	7	8	9
Estimated cost (billion USD)	4.91	5.15	5.30	5.37
Optimistic scenario	40%	50%	60%	70%
Cumulative capacity	3.46	6.96	11.76	18.06
Yearly capacity addition	2.4	3.5	4.8	6.3
Estimated cost (billion USD)	1.96	2.58	3.18	3.76
Most likely scenario	30%	40%	50%	60%
Cumulative capacity	2.86	5.66	9.66	15.06
Yearly capacity addition	1.8	2.8	4	5.4
Estimated cost (billion USD)	1.47	2.06	2.65	3.22
Pessimistic scenario	20%	30%	40%	50%
Cumulative capacity	2.26	4.36	7.56	12.06
Yearly capacity addition	1.2	2.1	3.2	4.5
Estimated cost (billion USD)	0.98	1.55	2.12	2.68

Thus, with the above projections, the total debt and equity requirement in each year is estimated assuming a reduction of 10% in the rooftop system cost each year (base year - FY 19, rooftop cost considered is 54,000 INR/kWp).

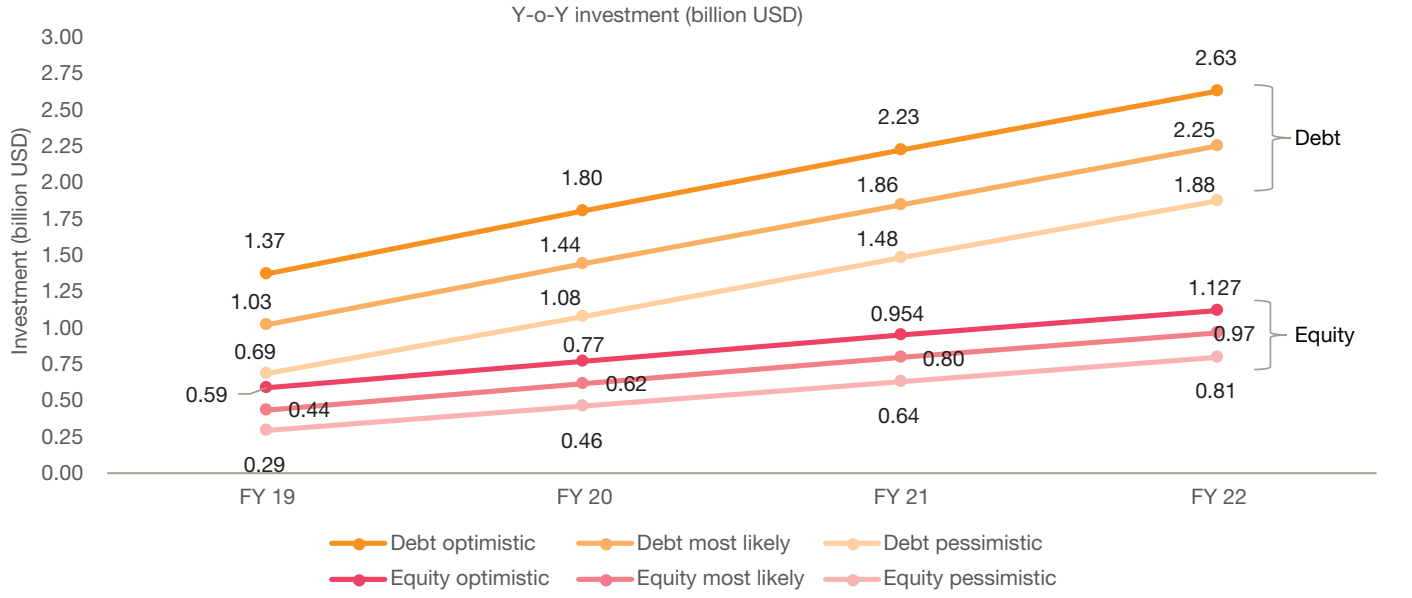
However, to achieve the projected targets, there is a strong need for concessional funds or international line of credit to support deployment. The market for solar rooftop has yet not reached a maturity phase to survive on domestic funds. With the grid tariffs also getting reduced, the rooftop tariffs need the strong support of concessional funds to complete with the existing grid tariffs. Domestic loans, as compared to concessional funds, are quite expensive and that makes rooftop projects unviable for consumers. Thus, the rooftop PV market needs more scale and experience to survive on domestic lending terms and become a self-sustained sector. Hence, concessional funds need to focus into two broad categories:

- **Investment support**
- **Advisory support**

The most important need in the rooftop sector is **investment support** through concessional funding sources (in terms of debt sources and/or private equity sources) as the market for rooftop, compared to other markets like large-scale utility solar, is not mature enough to achieve viability without the availability of concessional funds. Domestic loans increase project cost, which in turn increases tariffs. Rooftop projects are mainly installed under a savings model; hence, tariffs needs to be competitive compared to conventional grid tariffs to increase uptake. Thus, concessional funding, at this point, is key to scale up the rooftop sector in India. To achieve the projected capacity, concessional funding will play a major role.

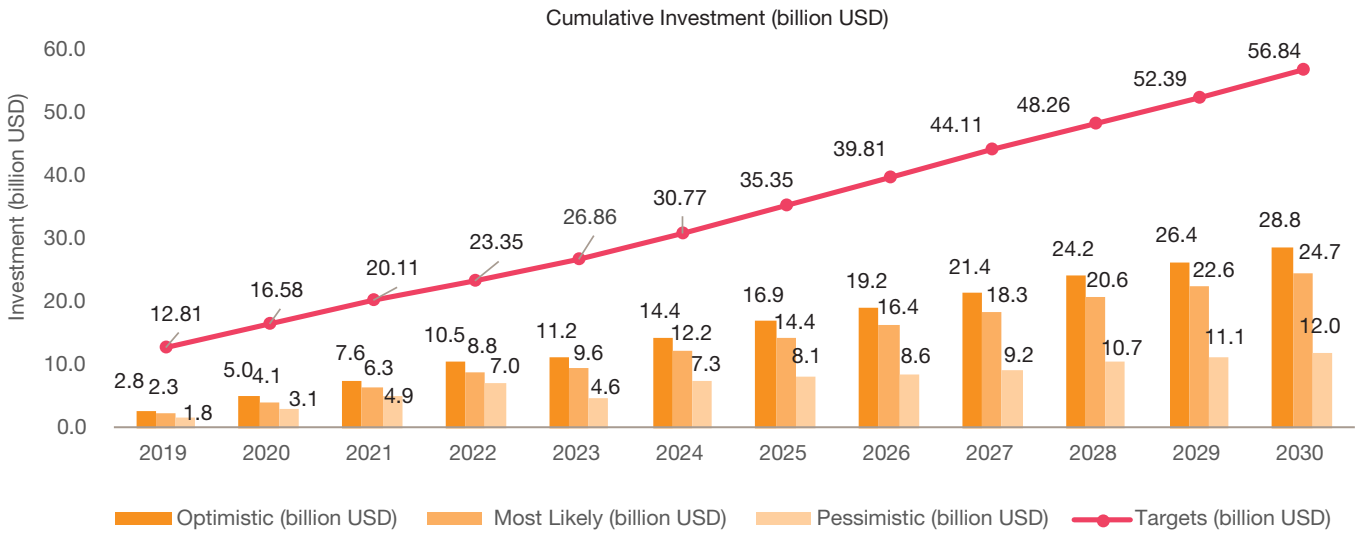
Thus, estimating the debt and equity investments will support the investment need/opportunity in the country for deploying rooftop solar. The debt to equity ratio is assumed to be constant at 70:30, following the project financing norms of IREDA and other banks like SBI, PNB and Yes Bank for all customers, including customers with a low credit rating. Thus, to achieve the yearly capacity additions for rooftop solar PV, the total investment and subsequent debt and equity requirement in each scenario are projected in the graphs below.

Investment portfolio for rooftop solar



Assuming the above targets and different scenarios of possible rooftop deployment in the country, the total investments that shall be required are projected below. The system costs are assumed to be declining by 10% in the initial years until 2022 and later on, the system cost is assumed as constant. The figures below show the cumulative investment that will be required if the above projected targets are to be achieved.

Cumulative investment to achieve projected rooftop solar growth



Looking at the above investment requirements and investor interest in the Indian rooftop sector due to the government's strong vision, various innovative (international) financing instruments have been tried and tested to drive investments in the sector by addressing the debt financing barriers and the equity risks of developers.

The current sources of debt funding include (refer to Figure 45).

1. **Domestic sources:** Commercial banks, NBFCs, insurance companies and capital markets
2. **Foreign sources:** Financial institutions, pension funds, charitable institutions, multilateral/bilateral agencies and international banks

The sources of equity funding mainly include funding from the parent company where equity investments comprise funds raised from pension funds, promoter equity, IPO and private equity. This type of foreign concessional funding is supporting the growth of the rooftop solar market; however, to reach the maturity phase, there is a strong need for continuity of these funding supports until the market is self-sustained, as in the case of the US and Germany.

Rooftop solar projects require a constant revenue stream in various stages and for smooth construction. The project construction life cycle from the pre-construction stage to the completion stage requires funds for developers to ensure timely delivery of the project. Hence, the availability of concessional funds at each stage is an incentive to stakeholders:

Feasibility stage

This is the first step for project development. If concessional funding is infused at this stage, then it accelerates the overall planning, construction and implementation process of the project with the availability of subsidised loans/funds incentivising developers to aggregate more projects. Developers will need to infuse lesser equity or will get access to loans at nominal interest rates, which effectively improves tariffs and hence makes projects more viable. With the availability of subsidised loans, the resulting tariff is also reduced, thus decreasing the financial risks involved in the project.

Construction stage

Concessional funding, infused in the construction phase of the project, impacts the overall cost of the project. With funds available at a subsidised rate, the construction can be faster. The developer will need to infuse the equity at the initial stage and the initial lending rate will be higher compared to a subsidised loan provided at the feasibility stage.

Execution stage

This is the third stage of the project life cycle when the construction is completed and the rooftop plant is ready for operation. Concessional funding at this stage will support the developer in improving project economics and offering concessional rates for the rooftop systems.

The rooftop market, being quite nascent, based on the uptake of just 1.2 GW compared to 21.8 GW large-scale utility solar, requires support in terms of concessional funding, in addition to advisory support in the form of capacity building and training programmes for the stakeholders. Concessional funds shall initially support the market growth, until the market has reached a self-sustained phase where domestic funding makes the projects viable for both consumers as well as developers.

Another important focus of concessional funds can be **advisory support**, to bridge the gap amongst various stakeholders involved in the deployment of rooftop solar PV. Hence, a major contribution in terms of capacity building of stakeholders—namely *distribution utilities, SNAs and banks/ financial institutions*—is required. At the same time, Central agencies like the *MNRE and Solar Energy Corporation of India (SECI)* require capacity building to support the scale up the plan for rooftop solar. Some of the activities that need to be covered under the capacity-building activities for these stakeholders are:

1. Distribution utilities: In order to penetrate rooftop solar PV at a fast pace, there is a strong need to support the distribution utilities in activities that involve:

   A. *Standardisation of rooftop application formats* (defining processing time for grant connectivity approvals) so as to allow fast deployment of the systems.

B. With the technological advancements, there arises a strong need to conduct technical *skill development* activities for the DISCOM team.

C. Since solar rooftop comes with its challenges of variable generation, there is a need to ensure efficient *methods of demand aggregation* to meet the demand with larger systems in place of standalone systems.

D. To support the banks/financial institutions in ensuring the credibility of the projects, there needs to be a focus on supporting DISCOMs in *standardisation* of PPA that should include deemed generation, right of way, etc.

E. To gain experience from successful rooftop programmes in international markets, study tours need to conducted for *DISCOM officials*.

F. To successfully co-ordinate the power requirements of consumers, a strong link between generation and transmission needs to be ensured; hence, *empowerment of Area Load Dispatch Centre (ALDC)* needs focused attention.

G. With the evolving scale and special technology, training/capacity-building operations need to be conducted for *development/testing/piloting of business models to accommodate electric vehicle-energy storage-rooftop*.

H. Lastly, to manage the most important challenge of small-scale rooftop projects, technical expertise to be provide for *grid integration* of the rooftop system based on some international experiences.

2. SNAs/regulators: Another important stakeholder where handholding/capacity building is required is the SNAs or state regulators. The focus areas for them include:

   A. Capacity building/training programmes – training on *efficient demand aggregation in the respective states, skill development training programmes for the officials*, learnings on new and feasible *business models* for rooftop deployment, support in *enabling market design for allowing larger rooftop penetration*;

   B. *Study* tours to learn from successful international programmes;

   C. Efficient methods for *rooftop vendor empanelment* based on technical experience of the vendors.

3. Banks/financial institutions: Banks are a very important link in the solar rooftop value chain. Though with the availability of concessional funding and international lines of credit at concessional rates, the biggest challenge of project financing in solar rooftop is finding a solution. However, beyond availability of funds at concessional rates, there needs to be an increased focus on the capacity-building activities of banks. Some of the areas that need attention include:

   A. Training sessions for officials to develop a *simplified loan appraisal process*;

   B. Identification of new and innovative *lending and insurance products*;

   C. Empanelment of lenders' engineers to make the due diligence process more efficient.

4. MNRE: The ministry is the main arm of the renewable energy programme. Hence, there is a strong need to provide advisory support to the ministry to enable it to achieve the 2022 target of 175 GW. Considering rooftop solar, there should be focus on capacity-building activities in order to support the MNRE in achieving the following goals:

   A. Creation of a *common platform* to enable all stakeholders (developers, EPCs, financial institutions) to interact and share the challenges faced in the execution of the current programmes/schemes. The platform will enable stakeholders as well as the MNRE to support large-scale deployment by considering a reasonable solution to the challenges identified. It will provide a common platform to share successful examples and hence support the implementation scale.

   B. Strong need to *design a scheme to incentivise distribution utilities* for customer loss due to rooftop and accommodate the variability of small-scale rooftop solar PV systems into the grid. DISCOMs have been struggling to uptake this programme; hence, an incentive scheme is the most important need in order to capture DISCOM interest.

   C. Another area of focus is *introducing mandates* for new buildings above 500 sq yd for rooftop solar installation to support large-scale deployment in residential areas.

5. **SECI:** It is another important link in the Central Government to support the large-scale implementation of the rooftop programme. SECI's role includes:

   A. Create a market for deploying rooftop solar PV in the country.

   B. Bring government establishments on board to support the implementation of the projected targets.

Hence, funding sources are required to support the above stakeholder activities through customised capacity building programmes.

Currently, the various multi-/bilateral agencies investing in the Indian solar rooftop market are focusing on TA programmes for capacity building of various stakeholders. The World Bank (GEF) and ADB have already committed 23 million USD and 5 million USD for capacity building of the respective commercial banks and other stakeholders supporting the rooftop deployment. Other capacity-building programmes have been launched by KfW and other development banks. Hence, along with the investment activities, these capacity-building activities play a significant role in the increased deployment of rooftop solar PV in the country.

Thus, concessional funding support in the form of debt or equity and capacity building will be required in order to deploy rooftop solar PV in the country. Lack of concessional funds might increase the project financing cost, which might in turn disrupt market growth and slow down rooftop penetration in the country.

Appendix: Stakeholder consultations – key messages

During the study, the major stakeholders responsible for rooftop deployment in the country were consulted. Various banks/financial institutions and rooftop developers were approached to understand the growth expected in rooftop solar and also the impact of concessional funding like CTF on the rooftop penetration scale.

Banks providing finance to the rooftop sector were approached to understand the need for concessional funding in order to improve the project financing terms in the case of small-scale rooftop solar projects. CTF has been one of the sources to improve project financing; hence, to compare the difference, both banks (receiving CTF funds and banks with no CTF funding line) were consulted.

Developers, mainly large-scale aggregators, were approached to compare the difference in installation/ financing terms with access to lines of credit from banks. Since the current lines of credit majorly support the aggregation model, developers were consulted to understand the impact of this evolving business model and the subsequent growth foreseen with this model.

Banks/financial institutions

PwC interviewed various banks and financial institutions from the government and private sector. Of the total banks and financial institutions interviewed, 40% are from the private sector and 60% from the government sector.

Methodology

PwC prepared a questionnaire that was discussed with the relevant stakeholders. The questionnaire focused on including the banks' view on the rooftop solar market potential, covering the current status and future expectations to support the deployment of rooftop PV to achieve the 40-GW target. Since the focus of the discussion was to understand the challenges faced by banks/financial institutions in supporting the rooftop PV market, the team also tried to gather the banks' views on concessional funding and the role played by these institutions in supporting the scale-up plan.

The team tried to conduct these consultations in person; however, a few of the discussions were conducted over the telephone based on the availability of the stakeholders. A summary of the discussions held with the banks and financial institutions supporting the solar rooftop programme in India is presented below.

Discussion points

All the banks and financial institutions consulted have a more than 40% share of the solar market, out of which the share of the rooftop solar market is at least 5%. Traditionally, banks charge an interest of 10–11% to IPPs for rooftop developers. These banks offer a higher interest rate due to the absence of any concessional funding support. However, other banks with concessional funding support are providing loans to developers at a rate of 8.35–10.55% depending on their credit ratings and risks in the proposed projects. The portfolio of projects for rooftop financing for the interviewed banks varies from 1 kW to 1 MW for a single project.

Since the rooftop market is at quite a nascent stage compared to large-scale projects, banks face challenges in successful disbursement of loans. One of the biggest challenges faced by most banks is the non-standardisation of PPA terms (no inclusion of deemed generation or right-of-way terms in private PPAs) which makes the projects quite risky and hence delays/increases the financing costs. Additionally, most rooftop projects have an off-taker risk as the buyer of electricity from plants is mainly the end consumer whose credit rating is a challenge in most situations. The size of rooftop projects is another big challenge for banks as the efforts required in loan closure of large projects are similar to those in small projects, which actually increases the financing cost of smaller projects. This is why most banks have preferred to finance projects under the aggregation model, where a portfolio of projects can be funded to make the financing terms viable. Most banks, as per discussions conducted, have no fixed selection methodology and rely on the portfolio presented by the developers. However, certain banks that have a limited presence in the country prefer to adopt a fixed methodology of aggregating projects (like specifying location and size) so that resource cost in conducting due diligence is saved.

Thus, our discussions reveal that banks are largely interested in funding/supporting the rooftop scale-up plans. However, concessional funding should be available for them to complete the financing terms of other banks and, at the same time, challenges on PPA standardisation, etc., should be resolved at the Central level. Additionally, a few banks also expressed a huge need for capacity building/awareness creation on solar rooftop projects among the various stakeholders involved, including DISCOMs, corporates, SMEs, individuals and lenders. Lastly, banks are seeking policy and regulatory support from the government in terms of timely approvals and clearances of rooftop projects.

Solar rooftop developers

PwC interviewed various leading private developers of rooftop solar PV in India. Since the scale of rooftop achieved in India is around 1 GW, developers do not have large portfolios. However, with the increasing availability of low-cost financing, developers have a huge portfolio in pipeline.

Methodology

PwC prepared a questionnaire asking relevant questions to stakeholders related to the rooftop solar sector in India. The questionnaire covered their areas of interest and views on future growth as well as the challenges faced by developers in the scale-up of the rooftop portfolio. The consultations were conducted in person to gain insights from the respective experts in the firm and understand the company's vision towards rooftop PV growth.

Discussion points

PwC consulted various developers, most of whom highlighted a similar set of challenges. The biggest challenge includes the non-standardisation of PPAs, which increases the risk of the project and, in turn, makes project financing a challenge. The availability of CTF funds (concessional funds) to banks has brought in significant momentum by reducing the interest rates for rooftop projects; however, the developers also perceive long-term availability of these funds as a challenge. Developers fear that once the funds are exhausted, the interest rates might increase, leading to slow progress in the rooftop sector. Since the scale of rooftop projects is small, most developers prefer domestic financing and hence domestic financing will be costly if no concessional funding support is extended.

Another challenge that affects the scale-up of rooftop is the subsidy for residential and government-owned buildings. The residential sector has huge potential, but delay in subsidy affects the financials of developers and results in loss of interest among residential customers. These delays do not allow the sector to grow. Subsidies also make project financing a challenge, as most of them are pre-conditioned to the use of domestic modules, which puts financial institutions (international funding agencies) under the risk of generation/quality of projects. Thus, the projects are on hold for a longer duration and at the same time become costly. This affects deployment in these sectors.

The aggregator model is the most preferred model by developers as it gives them a leverage to procure loans at reasonable terms by presenting the portfolio of projects and at the same time provides a scale to developers which helps them in procuring materials in bulk at reasonable rates. This model is expected to lower the cost and make the system viable for various categories of consumers. Thus, most developers find concessional funding a major contributor to the growth of rooftop PV and also envision faster deployment in the future with these funds available at reasonable rates.

In terms of business model, most developers are of the view that there is no single business model that fits the requirements of all customers in India, unlike the case in Germany and the US. Hence, business models in the Indian rooftop market need to be customised based on the needs of the end customers. These models will keep evolving based on the changing needs of customers.

Thus, developers also see huge potential for growth in the rooftop sector. However, the challenges like design constraints due to limited roof size and delays in net metering need to be addressed to gain the required scale in the rooftop PV sector, which shall evolve with increased penetration.

About PwC

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About CTF

The $5.8 billion Clean Technology Fund (CTF) provides resources to scale up low carbon technologies with significant potential for long-term greenhouse gas emissions savings. The fund is empowering transformation in developing and emerging economies by providing resources to support innovative and first-of-their-kind renewable energy, energy efficiency, and sustainable transport projects. The Dedicated Private Sector Programs, created under the CTF to finance large-scale private sector projects with greater speed and efficiency, have allocated a total of $467 million to geothermal power, mini-grids, energy efficiency, solar PV, and early-stage renewable energy programs so far. Close to $5 billion in CTF funds have been approved and are supporting the implementation of more than 100 projects and programs expected to support total climate-smart investment of more than $50 billion.

About the authors

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