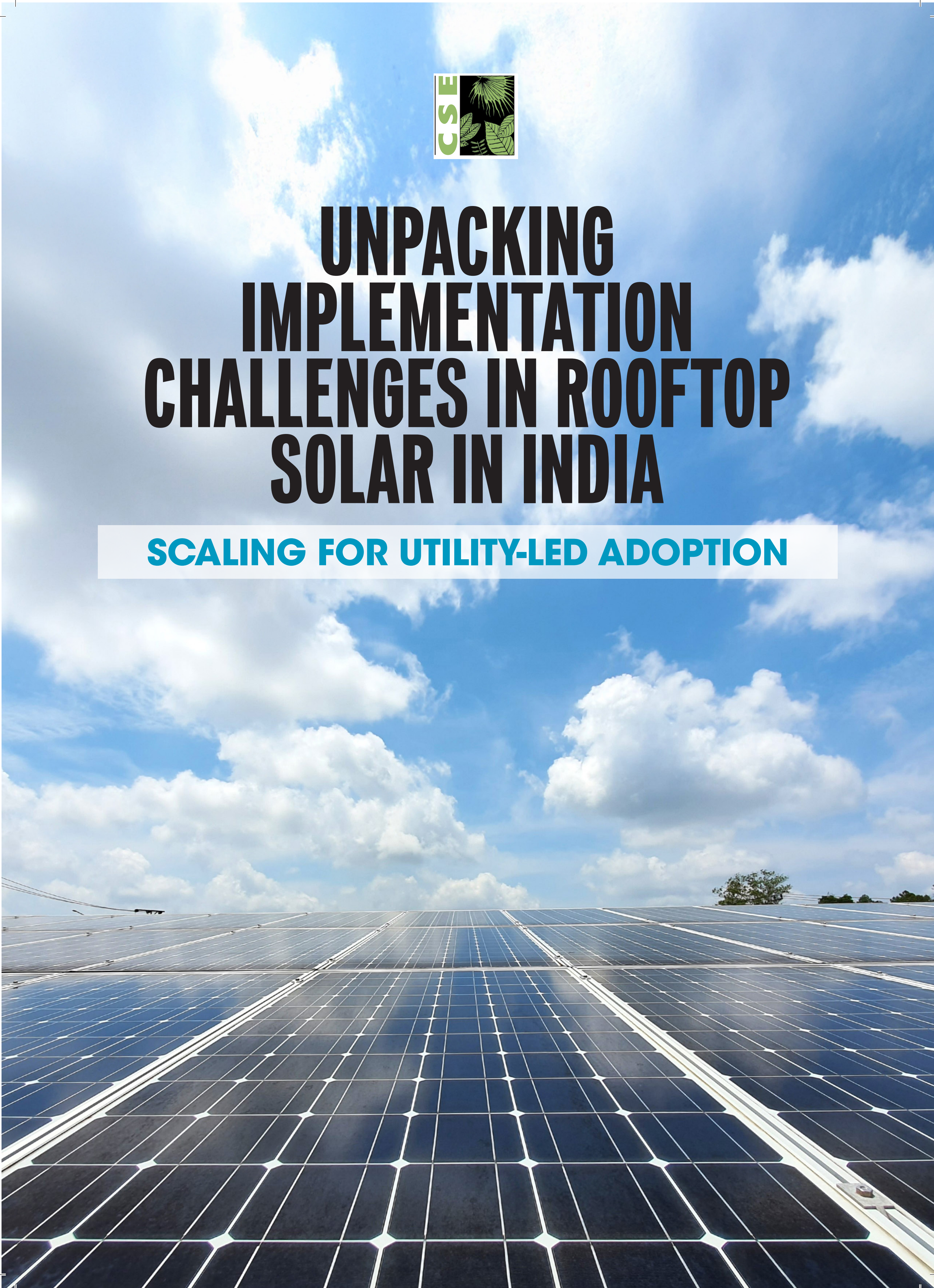
UNPACKING IMPLEMENTATION CHALLENGES IN ROOFTOP SOLAR IN INDIA

SCALING FOR UTILITY-LED ADOPTION



UNPACKING IMPLEMENTATION CHALLENGES IN ROOFTOP SOLAR IN INDIA

Scaling for Utility-led adoption

Author: Arvind Poswal

Research support: Isha Khandelwal

Editor: Yashita Mishra

Cover and design: Ajit Bajaj

Layout: Kirpal Singh

Production: Rakesh Shrivastava and Gundhar Das

The Centre for Science and Environment is grateful to the Swedish International Development Cooperation Agency (Sida) for their institutional support
The Centre for Science and Environment is grateful to the Bread for the World (BfW) for their support

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Citation: Arvind Poswal 2025, *Unpacking implementation challenges in Rooftop Solar in India: Scaling for Utility-led adoption*, Centre for Science and Environment, New Delhi

Published by
Centre for Science and Environment
41, Tughlakabad Institutional Area
New Delhi 110 062
Phones: 91-11-40616000
Fax: 91-11-29955879
E-mail: cse@cseindia.org
Website: www.cseindia.org

Contents

1. Executive summary

The rooftop-solar based energy generation is a promising technology which can benefit; consumers with competitive electricity tariffs, distribution companies (DISCOMs) with improved revenue streams and deferment of capital expenditures, and offset thermal based electricity consumption thereby contributing towards climate change adaptation.

As of May 2025, the total installed capacity of solar energy in India is 108 GW, of which RTS contributes nearly 18.3 GW—nearly 17 per cent of the total solar energy installed. The RTS sector is further split into commercial and industrial (C&I) and domestic (residential), with the C&I contributing 13.2 GW and the remaining 5.1 GW coming from residential segments. The progress to 18.3 GW has been incremental and adoption rates have been sluggish since 2014, when the rooftop programme was given a deliberate policy push. The total installed capacity of RTS (including off-grid distributed solar) in March 2014 was 189 MW (0.18 GW); it was nearly 17 GW in March 2025. Nearly 70 per cent of this growth has been from C&I segments, on account of high applicable electricity consumption tariffs applied on these consumers.

The rooftop programme has been given a major push via the recently launched PM Surya Ghar scheme targeting one crore households to shift to solar. This has brought renewed traction in RTS adoption rates in the country especially from residential/domestic consumers. Industrial and commercial consumers currently do not benefit from any central subsidy. However, with the declining costs of solar PV modules and improvements in public perception of RTS based electricity generation this segment is recently witnessing steady capacity additions. Simultaneously, there has been a decrease in consumers opting for OPEX/RESCO mode as compared with CAPEX business models. The share of OPEX based models rose steadily from 2015 to reach 48 per cent share in 2018 and thereafter declining to under four per cent in 2024. The inability to leverage RESCO/OPEX based RTS models has been a flaw in the implementation of the programme in India especially in facilitation of Utility-led demand aggregation models where bulk of the RTS potential lies. There are several benefits to Utilities in opting for OPEX/RESCO based models such as; capital cost savings from avoided energy costs from erstwhile thermal/conventional power procurement, load shifting and meeting of peak demand, and reduction in distribution network losses and line congestion management. Utilities are also best placed towards facilitating RESCO models in their service areas as large semi-government entities which can maintain long-term contracts and support financial bankability of projects, which shall in-turn improve investor confidence and directly promote growth in the sector.

As per consultations with stakeholders to understand the most immediate and pressing implementation challenges in RTS RESCO/OPEX markets, the challenges identified were related with operational aspects of RESCO models, financing constraints, inflexible policies, and role of State Nodal Agencies/DISCOMS towards promoting such models. The most recurring challenges arose on the following counts; First Demand Aggregation for prospective RTS consumers and lack of system details to identify consumers raising overall operating costs for project developers. Second, payment security mechanism of existing projects and contract enforcement towards billing payments and grievances. Third, applicability or rather lack of novel business models suitable for the end user, as consumption patterns across the consumer segments are also very diverse. These create further challenges downstream at consumer, project developer and DISCOM's end in terms of owning-managing and financing a RTS system. Resolution of implementation hurdles in RESCO based solar rooftop business models should be based on facilitating long-term programme implementation while addressing immediate problems as well. As per our analysis the three most prominent factors to reform are related with policy regulation and institutional governance, market development via investment and advisory support services which shall create financial structures to boost credit-lending the RTS RESCO markets.

Given the nature of political-economy in India, the involvement of utilities is essential, since ultimately, they form the most significant aspect in terms of billing, operational interface, and familiarity with the RTS markets. They are also the operators which are the most impacted, therefore, prioritising use cases under utility-centric RESCO models is key. Clusterisation of projects such as group-housing societies, special economic zones (SEZ), public sector units etc. can create economies of scale for demand aggregation, inclusion of a risk assessment matrix for consumers and developers should be prioritised which shall help address consumer switch to alternate service provider or ensure operational functioning by the developers in case of insolvency. Lastly, unlocking financial mechanisms and credit extension a standardised developer rating system should be established which assesses profiles based on project history and financial status. Standardisation shall also help develop financial products which shall reduce due diligence and negotiation timelines for credit related paperwork. This can lead to enabling low-cost debt financing framework which can be used to mobilise finances during early aggregation phases based on securitisation of PPAs.

2. Background and state of implementation of rooftop solar based energy generation

The case for rooftop solar (RTS) emerges from its huge potential for decentralised renewable energy generation. Unlike land-based solar, which is very land-intensive, the use of decentralised solar resources can enhance renewable capacity (RE) capacity locally, reduce the users' electricity bills, increase overall financial capital savings by reducing immediate requirement for transmission infrastructure, reduction in transmission and distribution power losses, improved revenue streams and others in a phased manner. The presence of existing upfront subsidies and reduction in terms of net electricity units consumed (from the grid), besides contributing as an environmentally conscious energy generating alternative makes RTS very attractive. Currently, the barriers in implementation include initial costs (e.g. opportunity cost of RTS versus low residential tariff rates, upfront capital costs for other customers), long-term return over investments (six–eight years), lack of established financial markets, technical considerations at DISCOM's front and related constraints of absorbing power generated from RTS.

As of May 2025, the total installed capacity of solar energy in India is 108 GW, of which RTS contributes nearly 18.4 GW[1]—nearly 17 per cent of the total solar energy installed. The RTS sector is further split into commercial and industrial (C&I) and domestic (residential), with the C&I contributing 13.2 GW and the remaining 5.1 GW coming from residential segments.

The domestic sector contributes 27–30 per cent to electricity consumption, just behind C&I at 41 per cent. The rooftop solar photovoltaic segment is an immensely promising solution to reduce conventional issues which are plaguing the power sector and offers a strong chance towards shifting to DRE-based power under both the segments. Currently, solar system costs are the least expensive in India, as a result of f continuously reducing capital investment costs from massive price reduction in solar PV module prices, and the presence of multiple solar energy focused schemes and programmes which are inclusive of attractive central financial subsidies.

Yet, the progress has only been incremental and adoption rates have been sluggish since 2014, when the rooftop programme was given a deliberate policy push. The total installed capacity of RTS (including off-grid distributed solar) in 2014 was 189 MW (0.18 GW); it was nearly 17 GW in March 2025. Nearly 70 per cent of this growth has been from C&I segments, mainly on account of high applicable electricity consumption tariffs applied on these consumers.

Figure 1: Current installed capacity of RTS as per various segments

Source: India RE Navigator

Government programmes and schemes shaping the RTS sector in India

India's efforts to decarbonise electricity consumption with RTS system began with the launch of the Jawaharlal Nehru National Solar Mission (JNNSM) in 2010, with the initial target being under 2 GW by 2022. Initially, since the technology was new, the emphasis was on showcasing its efficacy and relevance in the incoming years. the growth was scarce and since RTS's modalities were being carved out, such as the net-metering, feed-in-tariff mechanisms for RTS generators, remuneration policies for increased adoption with a deliberate state-level push to increase installations via dedicated programmes and additional subsidies. The major rooftop solar initiatives have been the Grid-Connected Rooftop and Small Solar Power Plants Programme under phase I in 2015, and then expanded to phase II in 2018. Under phase I, the target for RTS in India was revised to 40 GW by 2022.

Since the inception of the programme, several initiatives to accelerate RTS development have been introduced, such as:

- Introduction of net-metering, gross metering, group-net metering in almost all states,
- Reduction of minimum load limit for open-access energy transactions to 100 kW from 1 MW (under Green Open Access rules) and facilitation of net-billing mechanism,
- Increase in financial incentives for installations (subsidy provisioning for consumers),
- Introduction of novel business models under OPEX mode, such as community RTS solar, utility-led RTS solar,
- Targeting specific sectors, such as government-institutional buildings, SMEs and MSMEs enterprises and industrial and institutional clusters.

Examining implementation of the RTS programme under different phases

The first major push towards widespread RTS adoption was the initiation of the Grid-connected Rooftop and Small Solar Power Plants Programme in 2015, with a target of 40 GW of RTS installations by 2022. This marked the **Phase I** of the programme with 30 per cent of capital subsidies towards new installations against benchmark costs, and up to 70 per cent for special category states (North-Eastern and hill states). Only the residential, institutional, and social sectors were eligible for Central Financial Assistance (CFA), and not commercial and industrial installations. The programme aimed to implement capacity of 4.2 GW through the State Nodal Agencies (SNAs) and other related government entities (such as SECI, several PSUs). The programme saw limited success due to several reasons:

- Multiple entities (state designated agencies) in tendering processes leading to overall delays and confusion regarding tender details, bid capacity, method of implementation etc.
- Strong resistance from DISCOMs over net-metering and possible revenue losses. Including manpower requirements towards additional responsibilities from RTS installations.
- Lack of mandatory notifications and driving policies in states, which could target potential users.
- Approaching multiple agencies for installations of RTS and low user awareness It became evident that DISCOMs were required to play a key role in this programme, since most of the systems were being sanctioned under net-metering routes; management of billing and distribution networks was also based on DISCOM's participation in the implementation. The role of the DISCOM became central from its operational jurisdiction in management of RTS related business. This phase also witnessed implementation of net-billing mechanisms and increase of installations in OPEX/RESCO based business models, especially for corporate C&I segments.

Phase II was introduced in 2018–2019 where-in DISCOMs were made the nodal implementing agencies for rooftop solar. The target for Phase II was 40,000 MW (40 GW) of RTS installed capacity by 2026, thereby extending the implementation further by four years. With 2 GW already installed, the residential sector contribution was set at 4,000 MW, while the remaining 34,000 MW was to be contributed by the commercial and industrial sectors. During this phase, the Central Financial Assistance (CFA) was also increased to 40 per cent (up to 3 kW) and 20 per cent for capacities between 3 kW–10 kW—only for residential owners. Programme evaluation conducted by independent agencies as well as MNRE revealed that the financial assistance offered was not sufficiently lucrative to drive adoption targets. Hence, further increase in subsidy was sanctioned only for systems under 5kW, since majority of the residential consumers fall under this consumption bracket. For other segments, there was no CFA assigned, as RTS was already emerging as a popular alternative to conventionally high-grid connected electricity tariffs, which were on average Rs 10/kW, as compared to solar generated tariffs of under Rs 5/kW.

Since DISCOMs were central towards enabling adoption and were likely to bear additional expenses such as billings, inspections, and related paperwork, there was an introduction of incentives for utilities (DISCOMs) based on additional MW capacity of RTS within their distribution networks, with higher incentives for higher achievement rates and a dedicated roles-and-responsibility chart for implementing RTS. The installed capacity increased by 83 per cent, jumping from 1.8 GW in 2019 to 10.4 GW in 2023.

In order to reduce administrative paperwork on installations, the Ministry of New and Renewable Energy (MNRE) launched a digital initiative where prospective consumers could apply on a digital platform, access guide on the various processes, as well as track their application status. This was also necessitated to reduce the compliance burden on the DISCOMS which was deemed high as per programme evaluations. The launch of the National Portal for Rooftop Solar created seamless application procedures with details on applicable subsidy, application tracking and documents uploading, eliminating the need for physically submitting applications MNRE also introduced empanelment of solar service providers and vendors to arrest quality issues in PV installations. On the regulatory front, a few states introduced grid-charges on RTS which reduced the quantum and duration of energy banking. Simultaneously, a few states such as Delhi, Uttar Pradesh and others also introduced more subsidy in addition to the centrally sanctioned subsidy.

Launch of the PM Surya Ghar Muft Bijli Yojana (PMBSY)

The third phase was marked by the launch of the PM Surya Ghar Muft Bijli Yojana (PMBSY) in 2024. Recognising the requirement of higher subsidy allocation, especially for residential segments with lower rooftop capacities (under 3 kW), this scheme specifically targets installation of one crore RTS systems exclusively for residential consumers by financial year (FY) 2027. With a budgetary sanction of Rs 75,000 crore inclusive of subsidy, the scheme provides a maximum subsidy of Rs 78,000, capped at 3 kW capacity. The scheme also revamped the National Portal for Rooftop Solar with additional features, where prospective users could independently register themselves, removing the previous arrangement where they had to visit or contact the local DISCOM office—potentially reducing the paperwork towards installing RTS on their premises. With recent promulgation of guidelines for utility-led demand aggregation models, there is an opportunity to re-work RESCO based models to cater to rising demand from tier-2 and 3 cities as well as rural households within village clusters. The market outlook changed from the introduction of the new scheme, with rising demand from tier-2 cities and emerging vertical dwelling units in urban areas.

Table 1: National programmes on rooftop-solar and their achievements against targets

Programme	Targets set	Achieved
JNNSM 2012	2 GW by 2022	200 MW
National Solar Mission Phase I (2014–2017)	40 GW by 2022	1063 MW
National Solar Mission Phase II (2018–2023)		9285 MW
PM Surya Ghar Scheme	1 crore households by 2027	*

Source: MNRE Physical Progress
* Publicly only installed capacity figures are available and not number of households

Analysis and introspections from the programme

The Indian rooftop solar (RTS) market was expected to experience exponential growth, driven by a shift in consumer profiles and evolving value propositions. Early adopters were primarily cost-sensitive consumers attracted by potential savings on electricity bills and the availability of government subsidies. Over time, consumer confidence has increased due to improved awareness, better product quality, and more reliable installations. Furthermore, rooftop solar is increasingly viewed as a primary energy source rather than just a backup to grid supply.

Several policy and operational improvements have supported this trend, including simplification of procedures, fixed subsidy structures, reduced working capital liabilities, and accelerated subsidy disbursement mechanisms. Under the current framework, subsidies are typically transferred directly from MNRE to consumer bank accounts within 40–45 days, contingent upon verification by DISCOMs against a defined checklist.

Despite these advancements, the RTS segment has not matched the success of utility-scale grid-connected solar programs, which have seen significantly higher capacity additions. The limited growth in the rooftop segment can be attributed to multiple factors:

- Residential consumers, a key target group, remain highly price-sensitive, and willingness to shift to solar is based solely on quantum of subsidy disbursement.
- Low prevailing retail electricity tariffs in many regions reduce the financial attractiveness of RTS installations. Which prevents large-scale shift to RTS since upfront capital costs can be significant for consumers above 10 kW thereby restricting working capital requirements for small industries/ commercial applications.
- Institutional focus in earlier policy design led to inadequate engagement with the prospective consumer groups, the central role of DISCOMS was recognised later and to date they continue to be apprehensive of large demand surge from RTS.

Community-level adoption and decentralised energy planning, alongside continued regulatory streamlining and targeted financial incentives, will be critical to unlocking the full potential of the rooftop solar market in India.

Rooftop solar under RESCO mode at IIM Lucknow Campus

Image credit: CSE

Existing business models for rooftop solar in India

Selecting the right business model is key for successful adoption of rooftop solar. The business models likely include principal aspects such as, flexibility and cost-effectiveness, tailored towards consumers' operational and consumption needs. There are two principal routes towards adoption of RTS globally—CAPEX-based or OPEX/RESCO-based. The former includes direct capital investment in the rooftop system by the end user or consumer, who benefits from the reduction of energy bills in the future. The latter being OPEX/RESCO-based business models, where the project developer (RESCO) facilitates project financing, installation, and maintenance. The consumers enter a Power Purchase Agreement (PPA) with the developer and pays for energy generation services at a pre-agreed tariff for a fixed period (usually 10–25 years PPA).

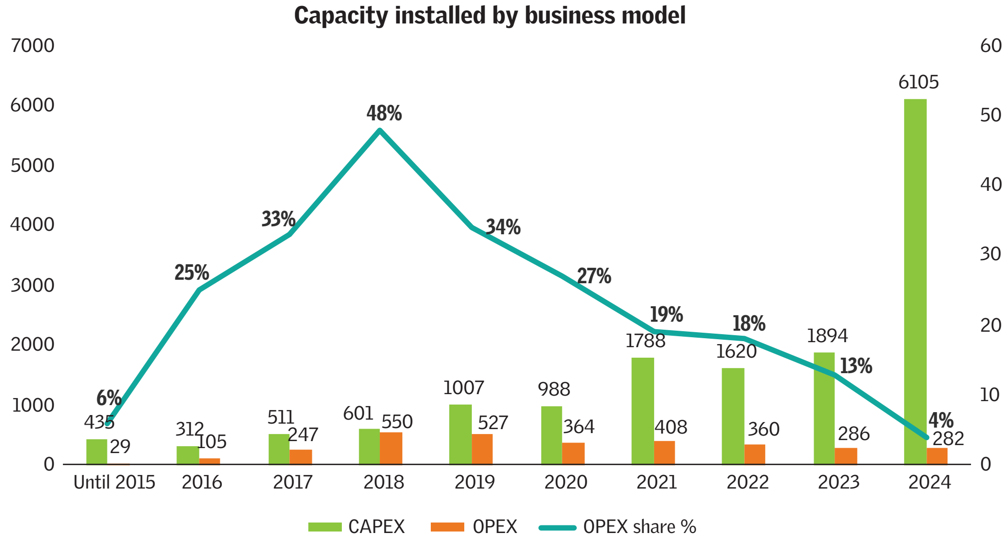
Both models have their own distinct advantages and disadvantages which has influenced business models centered on upfront or deferred cost payments, and ownership, single or multiple (joint ownership). Other prominent models also emerged from the phase II of the RTS programme, such as community model, rent-a-roof lease model, and utility aggregation model through direct involvement of utility as financer. Currently, conventional RESCO-based models employ the following characteristics: the RESCO (project developer) installs the RTS on the premises of the consumer and enters into a PPA with the consumer while bearing all operational costs. Tariffs for RESCO models are usually significantly lesser than conventional grid-tied tariffs. For example, in a few RESCO-based projects, tariffs have reached under Rs 2/kw. The excess generation is exported to the distribution network and an additional PPA is signed with the DISCOM. Under some models, there is no excess generation and the consumer benefits from reduced electricity tariffs.

Table 2: Different modalities between CAPEX and OPEX business models

CAPEX	OPEX
Self-finance with upfront investment	Third-party financed (developer/financial institution)
Maintenance and operations by self	Third-party maintenance
Long-term energy savings plan	Power purchase at low cost
Tax benefits like accelerated depreciation	No direct tax benefit, some generation-based incentives may be allowed
Long-term commitment and ownership	No long-term commitment
Project quality and due diligence	Includes performance guarantees
Surplus power sold to DISCOM (net-metered)	Scalable solutions with options to purchase additional power post self-consumption

Source: CSE

Figure 2: Share of OPEX vs. CAPEX projects year-wise



Source: RE India Navigator

Creating a utility-centric ecosystem for RESCO/OPEX models

Examining the developments in the last decade, the growth of the solar RTS sector is rapidly progressing pan-India. Installed capacity has also surged within the last four years, from 4.4 GW in 2021 to 18 GW in 2025 with growth projections estimating 30 GW in 2027. Under these scenarios, it becomes increasingly prudent for utilities to adopt a technological facilitation approach and aid in RTS growth trajectory. The nature of energy distribution is also rapidly evolving, making utilities feel the need to become financially stable in the long-term by investing in solar rooftop businesses.

Typically, as more and more consumers shift towards RTS generation, the limited pool of consumers left shall increasingly be subjected to higher tariffs on account of continuous loss of revenue and reduced ability to cross-subsidise other consumers. The current cost-plus regulatory framework (as per Electricity Regulatory Commissions) allows for recovery of power supply costs through retail tariffs. However, with increasing adoption of rooftop solar—particularly in the commercial and industrial (C&I) segments—DISCOMs are losing a critical share of their high-paying consumer base. This erodes their ability to recover fixed costs and cross-subsidise lower-paying consumers. Additionally, the administrative burden of RTS integration and the cost of upgrading local distribution infrastructure add to DISCOMs' operational and financial stress.

Benefits to utilities from shifting towards solar RTS under OPEX

Utilities can avail several revenue benefits arising from the systematic shift towards distributed energy generation.

First, they can increase capital savings from avoided energy costs from displaced power procured from other sources (in cases when customers are shifting to RTS). The extent of this benefit depends on the value of the power (consumptive load at DISCOM) displaced.

Second, benefits from reducing/shifting emerging daytime peak demand can be availed. With the implementation of the Time-of-Day (ToD) framework, utilities can avoid the high cost of meeting peak demand during noon hours.

Third, RTS reduces transmission and distribution (T&D) losses since generation and distribution is immediately localised thereby reducing line losses and network congestion challenges besides avoiding capital expenditures in investment for creating additional transmission infrastructure.

Fourth, utilities are well-placed to develop business opportunities within RTS business models. With help of an engineering, procurement and construction (EPC) contract, utilities can build operations to test and develop pilots for business models, accommodating domestic (RTS with storage) as well as transport (electric vehicles) electricity consumption.

Lastly, there are regulatory benefits in terms of increased renewable energy consumption in meeting Renewable Purchase Obligations (RPO). The latest notification on RPO compliances, 2023 mandates dedicated power procurement from distributed energy sources—rising from 1.5 per cent in 2024 to 4.5 per cent by 2030 of total electricity consumption—with applicable penalties for non-compliance. These benefits can greatly supplement DISCOM finances, particularly on account of substantial deficits in revenue collection and the necessity of state-sponsored subsidies. The Forum of Regulators (FoR) on their *Analysis of factors affecting viability of DISCOMS and recommendations for its improvement*[2] mentions facilitating DRE systems as transformative solutions to reduce losses and enhance grid efficiency by displacing LT consumers.

How can utilities participate under OPEX/RESCO based RTS business models

Utilities can play a huge role in transforming RTS in India by opting for RESCO/OPEX via two possible approaches—**facilitation and/or direct investment**.

Under the facilitation approach, the power utility undertakes procurement of solar power services from RESCO via aggregation of demand from a large number of prospective consumers for an aggregated capacity. This allows economies-of-scale by aggregating several smaller installations which can be collectively bid under one mega installation.

In the investment approach, the utilities aggregate projects and finance systems, and engage RESCOs for EPC models. Utilities also set certain standardised benchmarks for tariff setting, capital investment costs, and sizing of systems based on technical compatibility, which improve service delivery. This approach improves business facilitation in two ways. One of them is contract enforcement, since utilities are better placed as a large corporation, often with semi-government control, as compared to private companies who may not be able to enforce and mandate long-term contracts. The other way is by improving financial bankability of projects, since presence of utilities enhance confidence of lenders which ensures further improvement in risk profiles of projects and directly promote growth in sector.[3]

Factors for promoting utility-led business models:

- Within the service area, a detailed assessment of energy use based on sanctioned load and average monthly electricity consumption for consumers is pre-requisite to efficient demand aggregation programmes.
- Introducing standardisation of solar services, such as quality of installation (modules, inverters, other components), and accreditation of vendors and development of vendor management services.
- Concessional financing of solar products should be promoted.
- Power purchase agreement (PPA) based on selected chosen business model, contract drafting, and enforcement for payment assurances are vital.
- Skill development and capacity-building related investments to allow operational design for a larger market penetration of RTS is another important factor.

VARIOUS METERING ARRANGEMENTS PERMISSIBLE UNDER RTS

Net-metering

The rooftop solar model is based on a grid-connected solar photovoltaic (PV) installation with DC modules. These systems are integrated with a dual-functioning electricity meter, present at the consumer's premises. This is called a net-meter, a function that accounts for withdrawal and injection of power for consumption, based on applicable charges. A consumer primarily uses solar power during the day, selling the excess to the DISCOM, and consuming from the grid during non-solar hours. The net-meter accounts for the net consumption over a defined period cycle, which may range from monthly to quarterly or annual. Typically, the applicable tariff rates are assumed to be same for injection and withdrawal of power from the grid, thereby offering the most savings to the consumers while also availing of rollover of surplus energy generation.

Gross-metering

Under this metering arrangement, the total power generated from the RTS installation is first fed in the grid during solar-hours at feed-in tariff rates (or APPC) decided by the DISCOM with reference of state electricity commissions. The consumer continues to use power from the DISCOM as usual for applications charged at conventional retail tariff rates. Later at the end of the month/cycle, the total energy consumed is offset against total gross generation from the RTS system. The consumer does not see maximum benefit since the feed-in tariff rates are often quite cheaper (Rs. 2-4 lower than retail tariff rates) as compared to retail tariffs consumed during the billing month/cycle.

Net-billing

This mechanism is similar to the net-metering arrangement with the exception that the power exported during solar hours is billed at a slightly higher tariff than APPC costs, for simplicity known as net-billing tariff. At the end of the billing month/cycle the energy accounting occurs to settle the bill based on net-import/export of power. This metering arrangement offers a middle-ground for consumers and DISCOMS, the total savings are higher than gross-metering but not as high as net-metering and also allows Utilities to bill exported power units appropriately and without financial losses.

Rooftop solar under RESCO mode Image credit: Tata Power

Table 3: Current business models under ULA-RESCO

Business model	Role of utility
Facilitation approach: Key features—utility only facilitates service and consumer owns • Utility does demand aggregation either for procurement of systems or of solar power, and engages a third party (RESCO/EPC) to deploy RTS while charging a facilitation fee for risks.[4]	
Utility-anchored	• Collates and aggregates demand from interested consumers for EPC services. • Selection of EPC/RESCO vendors in a competitive bidding process for tariff discovery. • Responsible for vendor management services, standardisation of products and components, alongside project management services in lieu of a facilitation fee.
On-bill financing with subtypes	• Self-owned model with CAPEX costs collected in equated monthly installments (fixed) based on net of electricity use. • Utility facilitates access to finance to lower cost of borrowing and hedges risks from consumers/EPC via fixed and continuous revenue. • A sub-model includes utility assuming roles of only collecting payment from consumers and passing the same to EPC/RESCO with fee. • Assurance of payment security for the EPC/RESCO from tripartite agreement and reduction of other counter-party risks.
Investment approach: Utility directly invests in the RTS system by either owning or leasing them. • Treats solar RTS like conventional generation sources.	
Utility as master RESCO with subtypes	• Aggregates and generates demand alongside conducting open-competitive bidding for projects. Utility can direct or indirectly invest in the projects. • Rooftop leasing with scope of rentals or rebate, based on the capacity of the installation. • Lowers the overall transaction costs, payment security mechanism, lowered interest rates, large customer acquisition for cost benefits • Subtypes include roof-leasing model, community solar, etc.

Source: CSE design

3. Methodology: CSE stakeholder consultation—survey on functioning of RESCO/OPEX RTS models in India

The CSE team interacted with multiple stakeholders in the RTS implementation based on a pre-designed questionnaire to comprehensively understand the implementation issues in RESCO-based models. The stakeholders represented project developers, distribution companies (DISCOMs), state nodal agencies (SNAs), institutional consumers with RESCO-based RTS installations, amongst others. The questionnaire and discussions themed on immediate issues in implementing RESCO projects, mechanisms to identify potential projects such as demand aggregation, contract enforcement for operations and maintenance, payment security mechanisms, user experience with RESCO projects by developers and consumers, adequacy of current policies and regulatory regimes for RESCO, and design approaches to scale RTS RESCO.

The thematic areas of the questionnaire were based on experiences of respective stakeholders towards understanding the following:

1. Declining share of RESCO-based models in India since 2019 and reasons for the drop in deployment
    a. Impact of schemes, tariffs, and market perception for OPEX projects.
    b. Role of SNA and DISCOM towards facilitating RESCO.
2. Scope of business models in OPEX/RESCO for various consumer segments
    a. Existing business models which can be revived and facilitation may be improved.
    b. Business models for various consumers categories; residential, corporate, government-institution based, rural consumers, etc.
3. Immediate operational problems in the RESCO/OPEX based business models
    a. Demand aggregation and payment security mechanisms.
    b. Operational challenges of DISCOM and SNA.
    c. Operational challenges of vendors and project developers.

4. Current applicable regulatory and policy regime for RESCO/OPEX in various states
    a. With regards to metering infrastructure and their limits.
    b. With regards to banking of excess energy, green open access under RESCO.
5. Financing for RESCO projects with removal of subsidy for various categories of projects
    a. Scope of standardisation of finance products for DRE.
    b. Urban-rural split in terms of financial access for DRE.
    c. Lending quantum for vendors and developers opting for projects under RESCO.

i) As per the discussions with stakeholders, the most recurring and prominent issues have been highlighted below:

1. **Declining share of RESCO/OPEX:** Inability of a RESCO provider to aggregate multiple houses (consumers) with variable loads but different meter connections to achieve scale in generation. The market is catered towards CAPEX models, because of the availability of subsidy, falling costs of solar modules (and equipment), as well as simpler, straightforward procedures.

    The RESCO developer is constrained in terms of identifying suitable customers as it is very cumbersome to visit each potential location, identifying potential sites with enquiries on sanctioned load, rooftop area (square-metre), annual electricity consumption, and tariff costing and others. In absence of a data repository with even basic information means the developers have to rely on internal networks for scouting newer projects or solicit enquiries based on consumer interest, which may be very limited and further even lesser will materialise into workable projects.

    There is flexibility in the policies with regards to business models opted especially for government institutions and likes. However, market perception of RESCO models remains abysmal, several institutions are unaware of a RESCO model. Currently, the Renewable Energy Implementation Agencies (REIAs), DISCOMs, and SNAs separately float project tenders (depending on the state) for awarding projects under RESCO compared to a scenario in which the RESCO developer is able to identify site and undertake designing and installation based on a directory of list of probable projects. The current mechanism of REIA tenders is exclusively for government institutions and related segments and does not cover C&I and privately-owned buildings, which themselves could benefit from RESCO models. The role of SNAs have now been very limited, since DISCOM is the nodal implementation authority and there is little communication between both of them towards facilitating

RTS RESCO.

2. **Awareness of RTS RESCO business models:** While there is availability of RESCO models, the awareness of the same is lacking amongst consumers and often several small-scale developers as well. The rooftop solar market currently is based on a heavy narrative of subsidy-driven installations. The current publicity around RTS is also subsidy-related and there is no awareness of consumers on alternate business models.

   In the words of a prominent developer, the first enquiry by a prospective consumer is on the quantum of subsidy. Since RESCO projects currently do not offer subsidy (prior to 2024, there was some CFA available for institutional and social consumers, now available to residential consumers under the PM Surya Ghar Scheme), it becomes difficult to convince consumers to shift to solar. The C&I segment actively takes cognisance from long-term cost savings in installing solar projects. while there is some traction for institutional and almost none for residential except for group-housing societies.

   Conventional CAPEX-based project initiatives have witnessed extensive public awareness campaigns and dissemination, including multi-format advertisements and media engagement. The same is completely lacking for RESCO-based projects which often have zero publicity. During discussions with smaller project developers revealed that most were in fact unaware of such a mechanism. The project developers also often lack the necessary skillsets to change the perceptions of customers, since any additional time in consultation may or may not translate into RESCO-based operations. Instead, they believe that a CAPEX customer is better and easier to manage as well, as their role is limited once the project execution has been done.

   As for SNAs and DISCOMs, both face administrative duress within their conventional workstreams to implement directives which are not directly mainstream. However, some SNAs and DISCOMs have taken active lead in terms of project identification and releasing of tender. This approach must be replicated by others.

   The scope for operating under RESCO for group-housing societies, institutional clusters, and government institutions is significant, with various business models available which can bring economical energy tariffs. Yet, some challenges persist. For group-housing societies, it is cumbersome amongst the residents to arrive at an optimum understanding towards RTS installations; the project developers are also hesitant to work with the residents and instead prefer to work with the realtor for long-term prospects. For institutional consumers, there is a lack of awareness or credible push (whether internal or external) towards shifting to RTS RESCO.

3. **Operations and maintenance for Solar RTS projects**: Typically, solar installations under CAPEX mode come with developer-backed standard warranty of five to seven years, covering system breakdown and including the options of free repair and replacement. Post-warranty, chargeable maintenance services are available.

   In comparison, the RESCO RTS projects offer long-term maintenance, often up to 25 years at no additional cost to the consumer. This is because the project developers ensure optimum operational and maintenance aspects for energy generation, as the generated energy units directly translate into increased revenue earnings for them and any shortfall from nameplate generation shall reduce revenues.

   Since the market is now heavily skewed towards CAPEX modes and most of the installations are relatively new, they are not facing major operational breakdowns. However, as systems age—particularly after eight to ten years when module degradation and associated deration factors increase, leading to an increase in O&M requirements and increased costs for the consumer-owner.

   The developers are aware of probable issues emerging after seven to eight years but the option of CAPEX with immediate business is very convenient. Also, the number of accredited installers has significantly increased and many smaller project developers also collude and work together in a market where one consumer is getting approached by multiple developers, each trying to convince them to avail their services, yet almost none of them mention RESCO-based options available to the consumers.

4. **Financing for projects**: Since the RESCO models rely exclusively on third party financing, securing credit for capital costs of installation requires extensive documentation for the bankers/financiers to demonstrate feasibility of the installation. The lack of payment security mechanisms prevents securing assets based on revenue arising from energy billing. Therefore, project developers have to showcase credit history and industry creditworthiness, such as CIBIL score, balance sheets (for C&I), or other documentation which can generate confidence among the financers for loan repayment and servicing. The industry relies almost exclusively on monthly financial billings for energy use which are a source of cash flows. Any additional credit extension or new loan for the project developers relies on uninterrupted cash flows from existing projects.

   Securing and assuring cash flows from several aggregated consumers creates huge transaction costs for the developers. Besides, there is limited awareness of bankers/financiers to evaluate lending for RTS projects. This is especially aggravated in the case of smaller SMEs, and enterprises which often do not have significant credit histories to assess their creditworthiness. There is still no standardisation of solar-based products and services for the RTS sector; this extends towards RESCO installations as well. Developing standards shall greatly enhance lending in the RTS segments. The lack of standardisation has also led towards asymmetric development of loans products within the industry, for example, an auto industry SME may get a lower interest rate in comparison to agricultural industry. Overall, stringent collateral requirements, high interest rates, lengthy procedures, and shorter tenure periods have been highlighted very frequently.

5. **Perspective of consumers across categories:** While the benefits from RTS are now well-established, trusting a nascent industry and an even newer business is still an issue. Most consumers fail to look at the 25-year horizon window, and instead they seek break-even for the solar modules within five to six years. This means that consumers themselves are not viewing (or rather not being nudged into thinking) solar RTS projects as long-term sustainable measures, as witnessed from their participation in the RTS market. They view it as a mechanism to reduce their current consumption alone, and not as a mechanism for overall reduction and optimisation of electricity consumption.

   This has been a recurrent issue that consumers and some project developers have not yet gained confidence in. The consumers also prefer direct ownership rather than rental or energy savings-based agreements which are not available in RESCO models. Despite the RESCO model offering least interaction on maintenance and energy generation aspects since they are directly covered by the RESCO developer, the perception of ownership still outweighs the convenience of renting.

   Typically, under CAPEX mode, the onus of scheduling maintenance and nameplate capacity energy generation is mainly on the owner-consumer rather than the RESCO developer. This is more streamlined in the RESCO model, where a consumer need not follow with the RESCO developer on optimum maintenance and energy generation, since the financial model operated by the RESCO takes care of that. Consumers opting for green open access under RESCO modes can potentially achieve significant savings in costs and electricity consumption. The challenge lies in coordination for installations, since several agencies are involved, this often leads to delays and escalates transaction costs for businesses. A suitable mechanism to address RESCO-based Green Open Access remains absent in regulations.

6. **Impact on utilities/Role of SNA:** Since the installation of RTS is directly against the business revenue of utilities, they will continue to be resistant till a governing mechanism is created for them to invest in RTS businesses. Earlier, when the implementing agency was SNA (prior to 2019), they were able to aggregate projects for large consumers which the developers were keen to implement, since the size and scale was available. Since this was being done nationally, the SNA had to onboard the utility for implementation, as per the regulations. However, with utilities now serving as the primary implementation agencies, there is a clear conflict of interest—especially when RTS installations must target their most profitable consumer segments. The potential for RESCO models is tremendous in the country and they must move the value proposition of RTS systems from energy-savings to cost-benefits for all stakeholders.

   Given the nature of political-economy in India, the involvement of utilities is essential. Ultimately, they are the most significant in terms of billing, operational interface, and familiarity. Therefore, prioritising use cases under utility-centric RESCO models is key. Ideally, utilities should develop their own cost-benefit analysis and extract themselves from marginal power plant procurement and move these requirements towards decentralised solar systems.

   Additionally, there should be a standard setting and an evaluation framework, with standards for installations in order to maintain them as long-term power generating assets; this is in addition to developing a monitoring framework for such installations. Under the current additions, cities may soon witness GW level connections, and MW level RTS in urban clusters. This reinforces the business case for utilities to proactively upgrade network infrastructure and prevent congestion. Since RTS systems can potentially decongest distribution infrastructure and defer capital investments, these should also be added to the overall cost-benefit being undertaken by the utilities.

   The most recurring phenomenon in implementation is outlined first, followed by observations of stakeholders on project viability, operations, and scope of enhancement under current regulatory regimes. The background conditions for facilitation and challenges under various business models are also discussed. Three most prominent discussions on identifying capacity size, securing finance for project installation, and creating a model which assures reasonable Return on Equity (ROE) have also been analysed.

ii) Perspectives on demand aggregation, payment security, and creation of business models

The stakeholder responses gathered on understanding implementation challenges largely **revolve around three primary matters:** *Demand aggregation towards achieving economies of scale; assurance of payment on monthly billing as per discovered tariffs; identification of a unique business model based on size and configuration of the project.*

1. **Demand aggregation**: Currently from a financial perspective, RESCO projects are typically viable only above a certain capacity—discussions indicate this threshold to be around 80 kW or more. While smaller projects (examples with 25, 30, and 45 kW as well) are existent, they often do not make a strong business case, unless specific circumstances such as projects being in vicinity, thereby reducing maintenance overheads, or a reputed consumer with a strong ability to ensure timely payments.

   However, most developers mentioned the challenge in maintaining a smaller capacity site as opposed to a higher capacity, besides the levelised cost of electricity (LCOE) which is often higher in smaller capacities and the direct benefit may neither be achieved by RESCO developer nor the consumer. The project developer has to secure details on current and monthly average electricity consumption, secure regulatory approvals and permits, conduct on-site estimation for rooftop availability and project sizing, tariff determination, etc. Doing this across multiple small sites is time-consuming. The project developers have to also secure validation of bankability of projects—including the consumer's ability to timely and continuously make payments for electricity units consumed—to secure financing based on their expertise in installing such systems.

2. **Payment security mechanism**: Another major concern with the developer is on-time payment of the system. Since RESCO-based projects are highly cash-flow dependent, project developers are also wary of consumers (individual, residential, government, or institutional) skipping or delaying their monthly payments for some reason. C&I consumers are more punctual in terms of payments, as compared to institutional or government consumers—where often the project developers require multiple visits to facilitate payments.

   The payment security mechanism is often not fully honoured, offering limited scope for grievance redressal. As a result, developers remain wary of entering into RESCO agreements with business consumers, and instead prefer CAPEX routes. The lack of enforcement of payment security contract reduces the confidence of the RESCO towards new and prospective consumers. For example, there is a provision of letter of credit or bank guarantees for the project developers to encash in case of non-payments, but this is seldom held in accountability from the beneficiary customer. Developers fear that invoking such clauses may lead to premature termination of contracts. This also has a cascading effect on newer projects, as the developer is now reluctant to install under RESCO modes until PSM and enforcement are honored.

During CSE's consultation, a few of the developers also mentioned the absence of a designated authority within institutions responsible for clearing line expenditure for electricity, causing delays in monthly payments. Payment security remains a key concern—RESCO developers often claim regarding payment delays, especially from government institutions, such as state offices. Inability to claim compensation and presence of an asset lock-in reduces interest. While a contract is signed, but it is rarely honored. For example, a representative from a solar RESCO provider mentioned how even when a local police station with installation on its premises may default on payment, a RESCO developer realistically cannot deny generation or insist on payment defaults. This leads to limited recourses in securing and extracting payments without a payback contract mechanism.

3. **Applicability of novel business models**: Interactions with developers highlighted the aspect of business model that creates an ecosystem which benefits all the players involved—consumer, developer, and DISCOMS. Every project installation can have a varied business model which can be used to benefit the consumers, project developers, and DISCOMS. For example, a model may sell excess electricity to DISCOM after supplying to consumers, and developers can earn additional revenue from it. The consumer letting his rooftop/alternate space for installation can also receive some rental from the RESCO developer. Several business models exist but most are restricted (either by DISCOM or consumers) to achieve further scale.

   The most commonly observed model involves RESCO developers installing RTS for consumers who, instead of using grid-based electricity (thereby incur higher charges), shifts to solar with demonstrable savings in electricity consumption. If the consumer wishes to install a higher capacity of RTS system than sanctioned load limits or opt for rental payments for roof rights (in case of higher system sizing under gross metering). They have limited options since getting permits from DISCOM and working the mechanism towards rental payments remain limited. Other limitations also stem from the inability to leverage existing metering arrangements, such as group-net metering for large institutions, with several sub-connections.

Another factor for slow uptake of solar rooftop under the RESCO model is declining cost of solar PV modules. The solar PV modules account for more than 65 per cent of the total capital costs of the project. However, with falling solar PV module costs, nearly halved from 2014 to 2024, consumers and developers prefer and benefit from CAPEX. Consumers prefer ownership, while developers face reduced liability in terms of operational and maintenance costs under limited-period warranties. This was also the primary reason for RESCO's popularity and growth in share of installations till 2018–2019, as high cost of installations deterred several consumers from upfront investment.

Case study: Madhya Pradesh business model (MPUVNL) for RESCO based RTS

The CSE team held consultations with Madhya Pradesh Urja Vikas Nigam Limited (MPUVNL) to understand their RESCO/OPEX model, also focusing on its mechanisms for aggregating demand and facilitating project bidding. Usually, as per established conventions, the entire bidding capacity in total is available for bidding, with individual projects cumulatively summing to the name plate capacity mentioned in the tender. For example, a tender for installation of 500 MW of rooftop solar under RESCO mode requires bidding for individual projects cumulatively adding up to 500 MW. Under this model, the onus is on the project developer to identify prospective consumers and aggregate capacity to bid successfully. Identifying each consumer alongside details of their sanctioned load, rooftop size, credibility, and debt servicing ability is very difficult.

The business models under RESCO-based installations are typically aggregated larger capacity installations, often more than 100 kW. This requires high capital investment from the project developers (typically 40–45 lakhs/100 kW), which restricts the markets towards large project developers with good credit ratings and assured cashflows from business activities. Developers remain cautious when engaging with consumers perceived as payment risks, especially given weak enforcement of contracts and limited grievance redressal mechanisms, leading to less participation in the bidding and auctioning processes. As witnessed from SECI's RESCO based tenders in 2014–2015, participation from project developers was very low, highlighting bankability and viability of projects as key criteria for developer participation. MPUVNL recognised this early and created mechanisms to facilitate increased participation from developers under RESCO.

In the case of the MPUVNL, instead of bidding for the nameplate capacity and releasing an open tender, the MPUVNL team first identified prospective consumers—typically government and private institutions under the MP government's purview. This arrangement meant demand aggregation and identification was prior arranged by the MPUVNL, alongside availability of details on location, sanctioned load, etc. This meant the developers already had a list of prospective consumers and their relevant details during the initial stage itself. This pre-identification of sites (in a way demand aggregation) enabled high economies-of-scale with efficient planning and credible financing. This reduced the overall overheads (transaction costs) of the developers, ultimately leading to higher participation by project developers. The competitiveness of the tender increased and thereby achieved low tariffs—some as low as under Rs 1.50/kWh.

The MPUVNL model is further discussed below on each of the foremost parameters: demand aggregation for projects, achieving cost-economics, handholding developers, aspects of operation and maintenance, and financial model.

Reducing information asymmetry for demand aggregation: RESCO/OPEX models are best-suited for institutions with considerable electricity consumption but limited financial ability to pay upfront costs for installations, besides being unable to maintain and operate the systems themselves for the duration. As identified earlier, there is a huge information asymmetry in terms of potential project sizes and requirements of potential sites. Since a developer cannot physically verify and ask prospective consumers for details and might miss out on credibility of the customer to ensure timely payment, lack of this information increases the risk for the developers. This results in higher tariffs quoted and makes the projects unsustainable.

To resolve these issues the MPUVNL team created a unique 'virtual data room', with detailed technical and financial details required by the developers, such as estimated rooftop area, transformer sizing, average annual electricity consumption, sanctioned load, GPS coordinates and other details. This system provided sufficient prior information to the developers without having to visit a particular site. This was done by fetching information from various institutions and then pooling them together, which enabled developers to remotely view detailed information regarding the prospective sites and consumers, allowing them to create viable tariffs to participate in the process.

Availability of this information on potential consumers with their details eliminated the demand aggregation problem for the developers (since financial viability is possible only beyond 80–100 kW). There were significant efforts undertaken by the team at MPUVNL in order to finalise details for the data room, including physically approaching the prospective consumers towards gathering these details—a herculean task to conduct simultaneously in several districts of Madhya Pradesh. Simultaneously, these details were being verified and uploading several rows of information within distinct consumer files onto the data room. As per interactions with MPUVNL, more than 80 per cent of the required data was successfully captured.

Achieving cost-economics: The unique aspect of the RESCO models developed in MP was designing of the tender in a way which reflected the energy requirement and creditworthiness of the customers. Unlike traditional RESCO based tenders which bid for a particular cumulative capacity (such as for 500 MW cumulative or other numbers), the MP models used specific site-based tenders (instead of capacity-related), allowing flexibility for developers to quote nominally feasible prices. This was done without having to convince institutions to opt for solar RTS, which was the case in traditional tenders.

This site-based bidding mechanism improved operational efficiency, as institutions with adequate rooftop space and credible payment history attracted developer interest, regardless of their type or administrative profile. To further enhance participation and lower tariffs, MPUVNL also offered subsidies to boost investor and developer confidence.

Creation of a data room with site-related data had additional features, where institutions of similar load profiles and rooftop area could be grouped together, enabling developers to determine viable tariffs. For example, a large institution with higher consumption, thereby higher installed capacity can benefit from lower tariffs from economies of scale; smaller institutions within close vicinity can replicate this under group net-metering.

The MPUVNL team grouped similar institutions based on various parameters such as ownership, size of project installations, and type of institution. These were grouped into 27 clusters, each comprising individual installations ranging from 25 kW to several megawatts. As each group was distinct and their site information was available, the bidding process was also less cumbersome. Instead of bidding for each project separately, a bidder can put a combined bid for all the projects in the group. The collective bidding was organised in a reverse-bidding manner, with MPUVNL setting the floor price of Rs 4.07/kWh. The MPUVNL team also worked with the beneficiary institutions to ensure pre-clearance from respective institutions towards signing of PPAs. Grouping was designed done to club institutions with similar characteristics (rooftop size, payment credibility, etc.) together. This led to a reduction of economic uncertainty from the project as various information towards calculation of tariffs were available. Projects were grouped in such a manner so as to minimise cross-subsidy—since smaller institutions will not be able to benefit from economies of scale, but clubbing them together assured a viable and profitable project size. This grouping of institutions also ensured that the credit profile of the consumers was also factored in, since assurance of payment security to the developers remains a major concern in any RESCO-based projects.

In 2019, there were subsidies available for institutional projects (excluding commercial and industrial consumers) to the extent of 28–30 per cent by MNRE, along with an additional 15–20 per cent support from the state government. This further triggered a reduction in solar tariffs, since the available CFA was viable towards encouraging further deployment. The presence of CFA assisted developers in suitably adjusting their quoted tariffs, leading to tariff quotations for as low as Rs 1.38/kWh in some cases. The reduction in tariffs was because of substantial facilitation done primarily on three aspects.

First, the grouping of institutions allowed developers to identify lucrative consumers with the ability to pay.

Second, presence of subsidies from both the center and the state ensured minimum project viability and operability with continued interest.

Third, the grouping assisted developers in recognising institutions which would honor timely payments, thus ensuring assured payment security of the installations. The risk of defaults in payments was also factored in, such as central government institutions were more reliable payers than local and state institutions, as reflected from the tariffs offered. While there were concerns from developers on the full clearance of the subsidies, largely this model leapfrogged competitive RESCO based installations in the state.

Operations and maintenance: Under RESCO/OPEX projects, the solar project developer shall be responsible for regular operations of the installations; unlike in CAPEX, where their responsibility absolves after a notified period. As the solar installation now acts as a conventional power-generating system, whereby optimum operations increase viability and improve revenue generation, the project developers are automatically incentivised towards maintaining the system. Since tariff costs are tied to the units generated, any reduction in consumption arising out of system issues directly affects earnings per unit. Therefore, it is in the interest of the developers to keep the systems in optimum conditions so as to maximise power generation and subsequently gain financially benefits from increased generation.

Despite optimal system maintenance by developers under the RESCO model, concerns around payment security persist. Tender provisions included Bank Guarantees (with Letter of Credit) to safeguard against non-timely payments. However, developers expressed concerns on delays on payments, especially from the state institutions. Unlike conventional grid-based power model, the RESCO model lacked a clear payment timeline and provisions for interest on delayed payments. Although a the PPA is signed between the consumers and developers highlighting the range of functionalities of the PPA, however issues such as lack of no cut-off date for late payments or not honoring the terms of the PPA was prevalent. Despite making the tender documents comprehensive, the beneficiary institutions were unable to give payment guarantees to the MPUVNL but assured payments to the developers. Developing a common payment mechanism for each institutional group was also cumbersome as various institutions (public, private, or state) use different systems for monthly payments. This was reflected in the discovered tariffs as well for some beneficiary institutions—for example, the state government institutions had relatively higher tariffs,when compared with central, union, and private institutions. Also, the developers cited no point of contact for the payments in the respective institutions if payment defaults were made and had to use multiple alternative means towards securing payments.

Incorporating grievance redressal mechanisms: The RTS markets can greatly benefit from the facilitation approach, as highlighted by the MPUVNL in each stage of the tender process. They highlight the role of the SNA as beyond being an 'anchor' towards implementation to creating a self-sustaining ecosystem—including project developer concerns in the tender documents with suggestions, alleviating concerns of institutions post RTS installations, on-boarding of developers and prospective consumers together amongst others. This facilitation approach also had a grievance redressal mechanism with the MPUVNL team handling queries and removing implementation hurdles, such as mitigating risks in order to create a bankable contract with multiple institutions.

Once the bid capacity via individually aggregated projects was finalised, an open tender was released for tariff price discovery. As per the MPUVNL, despite the floor price of Rs 4.07/Kwh (minimum tariff acceptable to developers), which was later approved by the Madhya Pradesh Electricity Regulatory Commission (MPERC),

Table 4: Name of the projects with discovered tariffs

Insitution	Rate (Rs/Unit)	Capacity (kW)
IIM Indore	1.38	460
CAPT Bhopal	1.38	450
Power Grid 9 sites	1.58	692
Medical Colleges 4 sites	1.63	1003
National Law University Bhopal	1.67	300
School of Planning and Architecture	1.67	250
AG Office	1.67	170
IITM Gwalior	1.67	405
IITDM Jabalpur	1.67	180
Central Insitute of Plastic Engg & Tech	1.67	70
Sports Authority of India	1.67	150
Municipal Corporation Gwalior	1.69	1001
Medical Colleges 3	1.74	1990
Gov't Institutes 11 nos	1.91	3509
Gov't Colleges 72 nos	2.21	1557
MPEDC IT Parks 5 nos	2.23	350
Gov't Printing Press	2.23	100
Cancer Hospital, Gwalior	2.28	422
Police Establishments 14 nos	2.33	195
Engineering Colleges/ITI's 32 nos	2.35	928
Shri Satya Sai University Sehore	2.4	83
People's University Bhopal	2.4	802
GH Raisoni University Chhindwara	2.54	86
Shri Vaishnav Vidyapeeth Vishwavidyala, Indore	2.6	149

Source: Asian Development Bank Institute Development Case Study No. 2024-2 February

the majority of bids received were on average discovered at near Rs 2/kWh (see *Tables 1 and 2*). The achievement of this tariff highlights the facilitation role required by an institution for deployment of RTS, compared to other institutional-led pricing in Indian RTS RESCO markets, which have found it tough to bring to under Rs 3/kWh.[5]

The tariff also reflects other important aspects in demand aggregation, such as credibility of the institution with RTS installation—hinting at its ability to make timely payments and enforce contract. Use of specific business models curated as per the beneficiary installations, for example academic institutions and training centres of national importance, have benefitted from significantly low tariffs (IIM Indore, Power Grid, SPA-Bhopal, etc.) as compared with federal health and training centres (Government printing press and colleges, educational institutions).

The MPUVNL model highlights how the most prominent and established implementation challenges in RESCO/OPEX RTS—demand aggregation, payment security, and use of customised business models—can enable ease of business and achieve cost savings and spurring RTS deployment in India.

Case Examples under RESCO/OPEX based RTS

Site 1: Indian Institute of Management (IIM) Indore Installed Capacity 460 kWp, Project developer: Clean Tech Solar

The RESCO model facilitated by the MPUVNL led towards installation of RESCO RTS on IIM Indore campus in 2021. The total installation is housed over several buildings for a total of 4600 square metres, with a combined capacity 460 kW and discovered tariff rate of Rs 1.38 kW/h. The project is implemented under the net-metering mode with an annual generation of six lakh units. The project is an excellent demonstration for intensifying RESCO-based RTS models covering our three primary factors:

- First, identification of project with requisite details undertaken by MPUVNL, thereby completely facilitating initial variables such as roof size, sanctioned load, maximum transformer capacity etc.,
- Second, a reliable central government institute from which payment security can be assured with a goal towards timely payment fulfillment, and
- Third, a unique business model which reduced electricity costs, when compared with grid-supplied retail tariffs paid earlier. This led to significant financial savings for the institution while also contributing to IIM Indore's pledged GHG reduction.

The discovered low tariff signals confidence in supplying towards reputed consumers, as experienced during stakeholder consultations. The estimated annual costs for O&M related activities are under Rs 1 lakh. This is not just specific to IIM Indore, but includes bundled costs for O&M for projects in vicinity by the same project developer. This highlights the case for demand aggregation, wherein aggregated projects within close vicinity can also drive down O&M related activities' costs.

Table 5: IIM Indore RESCO RTS details

Investment by IIM	Nil
Rate of solar power	₹1.38/unit
Project commissioned in	Nov-20
Solar energy generated (Mar-24)	22,82,029 units
Total saving (on the basis of baseline grid rate of ₹8.49/unit)	₹1.61 crore
Average monthly saving	₹3.93 lakh
Annual CO_2 avoidance	514 tonnes
Environmental benefit equivalent to planting	23,376 adult trees

Source: As per details availed from the project developer/RESCO

Site 2: Devi Ahalya Vishwavidyalaya (DAVV) Indore Installed Capacity: 670 kWp, Project developer: Adani Solar

The DAVV university campus went solar with the technical assistance of the MPUVNL in 2019, with an installed capacity of 670 kW housed over several institutional buildings within the campus. The discovered tariff for this installation was Rs 1.91/kW, with implementation under net-metering mechanism. The factors were similar for this institution as well, prior identification and detailing conducted by the MPUVNL, and reputed institution backed by NAAC accreditation—assuaging the project developer's apprehensions on payment security. This has resulted in substantial savings for the educational institution as almost all consumption is during the day (solar hours) and consumption for evening hours is minimal. Therefore, they have been able to gain significant savings on their energy expenditure bills from shifting to solar-based power.

Solar RESCO site at Devi Ahalya Vishvavidyala, Indore

Image credit: CSE

Solar RESCO site at Devi Ahalya Vishvavidyala, Indore

Image credit: CSE

Site 3: Chandigarh City under CREST Chandigarh

The Chandigarh Renewable Energy and Science and Technology Promotion Society (CREST) has also pioneered developments in RTS RESCO-based deployments. Their models are also similar in terms of creation of demand aggregation and payment security mechanisms. Their RTS installations also target group-housing societies, besides institutions, for shifting to solar. This paved the way for residential consumers to seamlessly adopt RTS without upfront costs. The installations are under Build, Operate and Transfer (BOT) models, where after a certain period of time, the project developer transfers the ownership of the system to the rooftop owner or consumer. They have created a developer selection methodology which examines performance capability (such as track record, technical competence, size of pipeline, customer feedback, and O&M network).

The model adopted by CREST included prior capacity identification (government buildings, schools, colleges), residential consumers (aggregated with 3–5 kW capacities for an overall 5 MW target). The model also facilitated loans to consumers with a five-to-seven-year moratorium, with the Chandigarh DISCOM acting as an EMI collecting agent for the residential consumers who have paid ten per cent of the project costs to the vendor. This limited upfront investment with long payback periods ensured reduced transaction costs for the vendors, and EMIs facilitated by the DISCOMS assured of its payback or payment security. This led to better management of subsidy components by DISCOMs, reducing subsidy charges, better managing grid congestion, while also meeting RPO related obligations.

Solar installation in Chandigarh

Source: CSE

Site 4: Kerala's utility-led demand aggregation model

The Kerala State Electricity Board (KSEB) has offered three different schemes to residential consumers under Demand Aggregation models, based on monthly consumption of 120/150/200 kWh. Kerala introduced the Soura program under the Urja Kerala Mission (2019-20), becoming one of India's first DISCOM-led rooftop solar initiatives. Under this model, KSEB and RESCO developers bear the costs of the installations and O&M, while beneficiary avails a ten per cent discount on their bills. DISCOMs aggregate willing consumers and RESCO sells excess power to the DISCOM at competitive tariffs. They also expanded the models further to include consumers covering part payment costs, with the remaining from KSEB being abased on a monthly energy consumption. The terms of agreement include supply, installation, metering, testing, and commissioning of plant for 25 years with two-third of the capital costs. As per the details available from the Kerala State Electricity Regulatory Commission (KSERC), almost 77 per cent of the willing consumers opted for this scheme (Soura scheme)—registered under Model 1, Model 2 (KSEB-owned)—operate and manage the plant for 25 years, consisting of 15 per cent of the consumers.

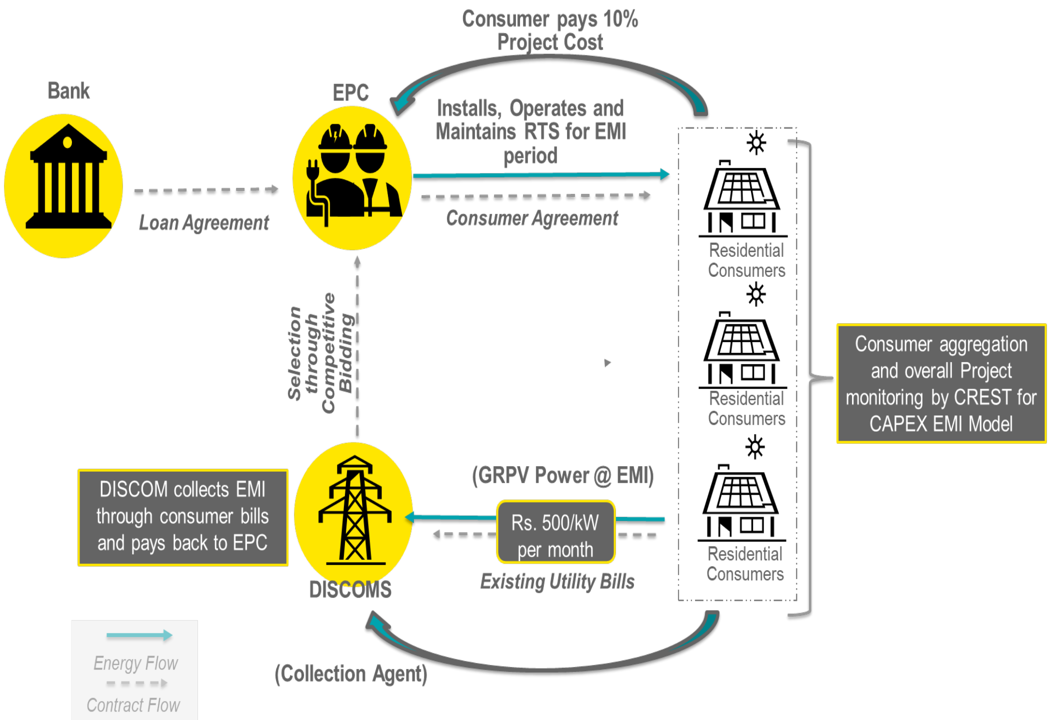
Table 6: Comparison of various business models implemented by KSEB under solar rooftop RESCO

Model-1 (Scheme-1)	Model-2 (Scheme-2)	Model-3 (Scheme-3)
The rooftop and land of willing consumers is utilised for installing solar plant by KSEBL. The energy generated will be fed into the grid for a period of 25 years and a fixed percentage (10%) of generation will be given as the incentive/ lease rent to the premises owner for his own use.	KSEBL will install rooftop or ground mounted plant in consumer premises and the energy generated will be sold to the consumer for 25 years through PPA, as per his requirement at a fixed tariff.	The consumer will be the investor and KSEBL will setup the solar plant for the consumer and excess energy if any after the consumption of consumer/ plant owner/will be fed into KSEB's grid and settled as per Net Metering Regulation.

Source: CSE

The KSEB model has been successful in promoting RTS in RESCO based models, however issues regarding mismatch between solar energy generation and consumption patterns have been observed. There is excessive power generation during the solar hours with medium demand surges and huge demand surges observed during the non-solar hours. The excess power during the solar hours is offset for consumers during non-solar hours, however, not all power is used by the 'prosumers' and the excess is procured by KSEB at average power purchase costs (APPC rates). This 'banking' of power arrangement wherein during non-solar hours when power availability is low and power prices are high financially

Figure 3: Chandigarh CREST solar rooftop RESCO based business model



Source: National Solar Rooftop Portal

strain KSEB, wherein it has to procure expensive power from markets often at high prices. The high costs (typically loss from expensive procurement) are passed onto the consumers which in FY2024-2025 are estimated to be Rs. 500 crores. These costs are directly passed to consumers including those without solar as currently less then two per cent of the customer base is 'prosumers'. As share of solar RTS increases it is anticipated that this shall further distort market costs and add additional financial burden on the consumers.

The case for battery-based storage of power emerges strongly here, for grid-scale storage (KSEB) and behind-the-meter storage (prosumers). In order to absorb and later supply excess power from RTS, KSEB can invest in battery storage in its distribution networks which shall serve dual purposes. First, it shall be able to suitably meet demand surges locally without having to procure additional power from expensive spot markets. Second, the BESS system shall also provide ancillary services support which enhances distribution grid stability via adequate demand response (peak shaving and preventing harmonics distortion while improving power factor). Also, by incentivising behind-the-meter storage the customers themselves can store excess power and use it during non-solar hours reducing the dependency on KSEB. This incentivisation model can mimic the conventional RESCO based models wherein at some additional costs KSEB can procure and install the battery systems on the consumer's premises.

iii) Issues and challenges identified in RESCO business models implementation arising on three fronts: Project developers, DISCOM/SNA, and consumers

The primary challenge is creating a viable business model which can sustain continued additions in RTS, while also providing equitable financial gains to stakeholders. Based on the consultations and field visits, the challenges are to be examined from the lens of the three primary stakeholders—the project developer, DISCOM, and the consumers.

Current policies offer several combinations of RESCO models. They have definitely improved under phase II of the programmes, the most recent example being the new RESCO-based business models under the PM Surya Ghar scheme. While the guidelines give flexibility on the type of models and their implementation, the fundamental issues outlined such as payment security and demand aggregation, are not utilised. Since solar costs are further decreasing, the market shall remain inclined towards CAPEX projects.

Some argue that RESCO-based models should definitely increase but to truly realise the potential for RTS—green energy in particular—the role, functioning, and operational aspects of the DISCOMs has to be reformed.

Developers: Demand aggregation and payment security or regulations cover some of the aspects, which has been described as follows:

1. *Demand aggregation:* For the solar market, size and scale are the most important parameters and most developers cannot create a scaling mechanism by themselves. For example, it is impossible for any developer to aggregate several customers in a particular region or locality by themselves. Even if they can handle the operational issues—such as signing of individual PPAs with several consumers, individual system design for every consumer, claim payments from all consumers based on electricity units generated, and deciding tariffs for individual categories of consumers can prove to be very cumbersome. Besides, challenges such as additional costs incurred for delayed payments, getting approvals, preventive maintenance costs, and system ownership transfer after the end of service period directly raise the cost of business and impact business models for developers.
2. *Payment security:* The solar generation businesses are highly cash-flow dependent models which require continuous and timely payments for the

service period. The payment risk stems from the inability of consumers to arrange due payment for energy services, which is amplified in the case of government institutions, particularly state government installations. Lack of a dedicated contract enforcement leads towards insufficient cash flows for the project developers, affecting their ability for investing in future businesses. Furthermore, absence of any grievance redressal mechanism prevents any other medium for seeking recovery and thus most developers seek alternative informal methods of securing pending defaults.

This is addressed under the gross-metering framework, where the utility is the direct procurer. Therefore, it has to pass timely payments. Absence of the net-metering framework, however, hinders further adoption. Lack of a tripartite agreement between the consumers, project developers and DISCOMS also restricts the role a DISCOM can play in terms of payment defaults and grievance redressal.

3. *Financing:* Current financial mechanisms for securing credit for installations under OPEX limit projects to large-scale and high net worth customers (typically AAA graded C&I customers). Most financers are unwilling to lend to smaller consumers with dubious credit history, which directly affects the ability of the project developer to seek financing for such consumer projects. While government-backed public institutions can demonstrate credibility, the same cannot be assured for smaller customers in the residential and C&I segments. Also, the supporting structures for seeking financial loans for solar projects leans heavily for the CAPEX models, which affects business decisions under OPEX/RESCO—as restrictive conditions exist for lending programmes by financial institutions. The financing norms also vary state to state, further creating high transaction costs for borrowing developers.

Distribution Companies (DISCOMs) and SNA

The DISCOMs, being the nodal implementation authority under current regulations, are required to play a facilitating role for RTS RESCO implementation. Despite provisions of financial incentives for DISCOMs, the RTS sector has not witnessed anticipated growth mainly because of variations in regulatory and policy architectures in states, apprehensions on technical and operational business, and financial viability from revenue impact from RTS.

1. ***Regulations and policies***: The central policies and schemes address the role of DISCOM in facilitating RTS deployment. However, the implementation especially in regards to the grid connectivity is highly variable amongst the states. Some states restrict net-metering above a certain capacity, which restricts consumer savings from excess exported tariffs. For instance, states like Uttar Pradesh and Tamil Nadu restrict net-metering for corporate consumers

besides levying other grid charges; some states restrict net-metering under OPEX models.

Only a few states have provisions for group-net metering and virtual-net metering with limited surplus energy generation banking. This leads towards sub-optimal utilisation of RTS business models and prevents DISCOMs from viewing RTS as conventional energy generating assets.

Although intended to give DISCOMs flexibility in choosing business models, such fragmented policies have led to inconsistent energy accounting practices and near-term regulatory hurdles. Behind-the-meter storage options are also largely unregulated, and there is no defined mechanism for consumers installing systems beyond sanctioned capacity. In the case of non-compliance to RPO's there are no penalties levied.[6] Additionally, their compliance is non-uniform amongst states. With the delayed implementation of time variable tariffs (time-of-day) and applicability on residential consumers remains unclear giving no real incentive to the DISCOMs to facilitate RESCO models with on-site battery storage.

2. ***Operational and technical***: With proliferation of RTS systems, there are various programme administration costs, such as energy accounting and billing for consumers under different metering infrastructure, lack of a real-time monitoring system for generation and forecasting excess demand, procedural changes, and coordination with multiple entities. DISCOMs also cite lack of manpower towards handling RTS-related issues, especially for demand aggregation for RESCO/OPEX projects. On the technical front, there are barriers in terms of sub-station transformer sizing and loading, requirement of reactive power support, voltage frequency and power quality management. With increasing RTS systems, managing peak loads becomes more difficult. Lastly, an increase in RTS capacities from a particular distribution sub-station requires additional capacity enhancement for increased pooling capacity.[7]
3. ***Financial implications***: Revenue losses are the most recurring concerns from increased RTS penetration, which happens mainly on two fronts. DISCOMs continue to procure power (thus, incurring fixed charges) from existing PPAs signed; secondly, the shift of high paying corporate consumers which heavily cross-subsidise for residential and agricultural segments continue to reduce revenue generation from DISCOMs. Typically, the highest paying consumers are opting to shift towards RTS, which reduces the available pool of consumers on which cross-subsidies could be applied.

   In terms of metering arrangements, there is sufficient consensus of DISCOM's inclination towards gross-metering, than net-metering and its sub-categories. This is due to lower purchase costs from gross injected power, as compared to net-meter where they have to incur costs nearly equivalent to average power purchase costs (APPC). Stress from revenue loss cascades through the entire value chain, further deteriorating the aggrieving financial health of DISCOMs which are already reeling under losses.

Consumer categories

The biggest factor towards shifting towards RESCO/OPEX is elimination of upfront capital investment costs while continuing to use energy as a service. Since the solar RTS markets are heavily CAPEX-driven, most consumers have limited interpretation of OPEX models. This is more pronounced in the case of residential consumers. The nature of rentals and leasing of buildings in India is a factor which influences RTS installations in both residential and corporate segments. Existing grid tariff rates which are heavily subsidised for low electricity-consuming residential consumers reduces further incentives of households to view RTS as a long-term shift.

1. ***Trust and awareness***: While the perception around solar has considerably improved in India, the same is not true for OPEX/RESCO models. Most consumers are unaware of the existence of alternate business models, except for CAPEX. The private corporate consumers are more likely to shift to OPEX/RESCO, if not for existing technicalities such as reluctance of developers and ability to seek appropriate credit restricts participation. Also, the long-term commitment nature of RESCO projects extending up to 25 years also creates apprehensions. Consumers are doubtful of a solar installation firm which itself has been in business for five to seven years, assuring services till 25 years. The project proposition does not instill confidence in consumers to sign long-term PPAs, especially consumers in the group-residential and small businesses segments. Simultaneously the developers also feel hesitant to install RESCO projects on customers other than profitable C&I and government institutional categories.

   Currently, the RTS programmes are very urban-centric, and as the pace of implementation gathers, similar apprehensions are expected in the rural and peri-urban areas as well. In addition, usually urban centres have higher loaded capacities on the sub-station transformers, as compared to rural areas. In these cases, even the traditional CAPEX route also may not be very successful, since this shall require immediate upgrades in transformer pooling stations.

2. ***Use and ownership of rooftops***: As per current regulations, it is not mandatory to solely install RTS on rooftops, structures such as balconies, external building facades, etc. are also covered under the RTS regulatory ambit. However, by far, most installations are undertaken on rooftops for ease of location, maintenance, and safety. In order to install RTS, besides having the electricity bill on the consumer's or entity's name, it is also essential to secure unhindered long-term access to rooftops, which are often shared or leased spaces for residential

consumers. There has to be a consensus amongst all the residents in order to install RTS. If one is a tenant, it is even more cumbersome to persuade owners.

Under the current RTS regulatory regime, few states have sanctioned group-net metering to facilitate large residential facilities to switch to solar; however, presence of both formal and informal social networks restrict adoption. For example, convincing a resident group of ten or more people for RTS can be burdensome. Adding a mix of rentiers and owners in it further complicates the situation, since some may not want to opt for RTS and are also reluctant towards committing to long-term PPAs on shared rooftops. This is simplified in the case of C&I and institutional consumers where long-term lease agreements with rooftop rights can be facilitated. But in these cases, as well convincing several institutions together towards adopting solar via an external entity, as witnessed in the MPUVNL's case, is very challenging. Securing financing for such installations is also is very demanding, since banks require proofs of long-term ownership of rooftops. The RTS programmes are largely urban-centric and do not have viable presence in rural areas, with nearly 90 per cent of the capacity being added only in urban areas.

3. ***Presence of existing low tariffs for residential consumers***: The case for shifting towards solar for public and corporate entities is distinct on account of financial savings. However, the residential grid-tied retail tariffs are very concessional and heavily subsidised with few states doling free electricity units up to a certain limit. This is directly contradictory towards nudging shifts to solar RTS, there has to be clearly evidenced cost savings from solar in the residential segment. Nearly 85 per cent of residential consumers are low-energy consuming households, connected below in a single phase in 2–4 kW. The high tariff paying residential consumers are already making rapid shifts towards solar. Targeting this low household consumption households and weaning them away from subsidised power towards clean and relatively inexpensive solar power—within India's complex political-economy of power—is very challenging.

iv) Features of RESCO-based models under PM Surya Ghar residential scheme

In December 2024, MNRE introduced implementation guidelines for PM Surya Ghar Muft Bijli Yojana, under RESCO-utility led aggregation (ULA) models with payment security mechanism built-in, paving the roadmap for installations under RESCO/OPEX modes. It has also permitted state governments/DISCOMs/state-designated entities to innovate on new procurement models with appropriate metering arrangements under RESCO modes. The salient features are as follows:

1. ULA models can be undertaken either by the DISCOMs or state government/

Rooftop solar for a RESCO site for an industrial consumer
Image credit: Clean Tech Solar

state designated entity under two models—utility-owned assets, and consumer-owned assets; with appropriate RESCOs selected through an open, competitive and transparent bidding or matching Feed-in-Tariffs (FiT), as appropriated by the respective state electricity regulatory commission (SERC).

a. Utility-owned: The demand aggregation shall be undertaken by the designated entity and can include several business models under this arrangement, with flexibility for utility to either construct solar RTS installations either by itself (self-investment) or through an EPC RESCO for a fixed period of at least five years. The payments shall be made on behalf of the utility to EPC RESCO, governed by the terms of the PPA between them, with additional scope for sale of excess power to other utilities or DISCOMs and rooftop rentals for the consumers.
b. Consumer owned assets: Besides demand aggregation, the utility provides an additional grant component (apart from the central CFA), with the ownership of the RTS systems resting with the consumers. The projects can be executed under EPC mode, with the payment responsibility resting with the utility, and options to secure some financial contribution not higher than ten per cent of benchmark costs (Rs 5000/kW currently).

2. The proposal for installations under both the outlined models shall be vetted by a technical committee within the MNRE and cleared within 30 days. The

proposal shall highlight provisioning of services for the particular segment and the economic advantages expected, with details on service warranties and liabilities on components. This is provisioned via an online application and monitoring platform which shall be used for the overall proposal timeline.

   a. It also provides for the creation of a technical committee (National Program Implementation Authority, NPIA) which acts as the nodal facilitation and grievance authority for RTS.

3. The NPIA shall also onboard vendors (service providers/project developers) via a bank guarantee of 25 lakhs for registration for a pan-India operating license. In case a state entity registers itself as RESCO, the financial guarantee component shall be waived off. The tariff arrangement shall rest between the consumer and RESCO who shall also undertake relevant O&M for the duration of the project period. There are provisions for inspection and application of penalties on non-application of service rules and procedures.
4. In order to address payment security mechanisms there is a provision of a Rs 100 crore corpus fund to be managed and administered by NPIA. This shall entail in the form a bilateral agreement between the NPIA and the state designated entity for regular payment to RESCO. With time-bound procedures for payment, billing cycles, application of penalties amongst others.
5. Application of CFA for up to 3 kW systems under relevant metering arrangement by the DISCOM, can also be implemented under funds and CSR, etc.

Discussion

The guidelines for implementing the RESCO model under PM Surya Ghar: Muft Bijli Yojana provide flexibility in terms of business models—utility-led aggregation models (as a Super RESCO/ULA), RESCOs with rooftop rental, among others. The incorporation of a Rs 100 crore fund for payment security assurance is also encouraging. However, the guidelines are silent in terms of collating mechanisms for aggregating demand under RESCO. The provision of a technical committee housed within the MNRE is a positive step, but any details towards selection and approval are missing. These raise transaction costs for local developers and it is against the principle of decentralisation. Under ULA models, there is an immense scope of implementation for group-housing societies and high rises with uniquely configured business models. Addressing the payment security mechanism (PSM) for RTS is one of the biggest achievements of these guidelines, which may hopefully spur investment in the sector. The features of the PSM—including automated billing system, dispute resolution, settling of claims within 15 days—shall definitely raise the investor confidence in the RTS markets. Further, we see two segments where improvements could have been made:

- Demand aggregation: The guidelines do not outline a mechanism for aggregating demand or defining bid capacities, this retains the onus of finding new customers on the project developers—which has previously also been contested. Since there is subsidy available, the customers by default may prefer the CAPEX route and the developers may automatically prioritise CAPEX deployment, since it reduces the overall 'costs' incurred by the developer.

Also, no particular beneficiary group under residential segments has been identified (such as housing clusters, high-rise group housing) where it could be especially leveraged. Nor do they set any targets given to state designated entities for new RESCO share, which could have been a percentage of total rooftop installations (e.g. 10–15 per cent of new RTS connections in the service area). The central financial assistance available to DISCOM/SNA can also be routed based on coverage of RESCO.

- Implementation and institutional burden: The method of implementation provisions of a technical committee at MNRE for approval of projects under ULA models. The concerned state designated entity must prepare proposals with budgetary outlays and seek approval of the respective state government. Thereafter, it shall be vetted by the technical committee at MNRE in a time-bound manner. This raises the overall transaction costs of clearances, regulatory approvals, and increases compliance burden on the state designated entities (DISCOM/SNA) who anyways have been gradually aligning and accepting RTS installations. Given the additional administrative and regulatory burden towards creation of proposals, this shall impact the excellent opportunity towards solarising several residential clusters together. The guidelines should promote deployment in group-housing societies and dense residential regions by incentivising decentralised approaches and reducing costs for businesses. Besides, another challenge is limited capacity of agencies (DISCOM/SNA) to invest in capital intensive technologies themselves, whether under model I (ULA owned assets) and model II (consumer owned assets).
- There is also no mechanism deliberated towards reducing off-taker risks, except for payment security defaults. Often, there are other issues such as access rights, O&M scope and duration, and renouncement of existing PPA because of alternative cheaper tariffs. Since these come under contract enforcement clauses, there are no mechanisms mentioned that can be used towards enforcing contracts as per the PPA. Several pieces of evidence have cited this as a key lacking measure, especially in case of residential segments where 'public interest' clauses have to be more detailed. These could be in terms of work completion days, changes in property value, limitations, and liabilities (warranties, timelines, insurance, suspension, or termination). When enforcement mechanisms can be legally enforced, they have a cyclical effect on overall markets, especially for credit enhancement in small and competitive

4. Way forward: Resolving implementation hurdles in RESCO-based solar rooftop business models

As per the discussion and analysis presented above, we present a few recommendations towards addressing the systemic challenges of bringing and retaining the legacy problems of RTS. Our recommendations are based on facilitating long-term programme implementation, but addressing immediately doable matters as well. The three most important factors to reform and include are related with policy regulation and institutional governance, markets and services, finance availability. The regulatory leanings guide the sector, market orientations, and finance regulates businesses. The RTS markets require both short and long-term reforms which are presented below, as discussed during our stakeholder consultations, primary, and secondary research on RTS RESCO markets.

i) Strengthening institutional capacity building and policy streamlining:

On demand aggregation (DA): There is a critical need to establish guidelines for creation of demand aggregation (DA) exercises based on specific region and segment—C&I, residential, or institutional. These exercises aim to understand operational, technical and financial parameters such as sanctioned demand load, rooftop size and area, average and annual electricity consumption, local transformer capacity and connectivity level (1,12,233 kV), beneficiary credit history, and repayment ability. This can be undertaken by state designated entities (DISCOMS/SNA), along with civil society organisation via locality-based approach, where clusters are developed with RTS for both residential, corporate and institutional consumers. Sector-based approaches focus on target segment identified, educational institutions, PSUs, or other related facilities. Calculating efficient methods of demand estimation and methods for demand aggregation programmes with fixed timelines should also be proposed which can remove asymmetry in the market. This will support the development of periodic tenders based on aggregated demand and provide greater visibility into bid-linked capacities.

Creation of a national data repository with state-wise data updated on this periodically. By enabling data sharing between agencies, relevant data of the various buildings under different segments can be sanctioned for various customer groups. The data repository should be made public so that relevant beneficiaries can access it and upload their information, such as sanctioned load, rooftop size and average monthly consumptions. It will help tendering agencies and developers access real time information on potential and selection can be made as per clusters.

On improving policy confidence: As evident during our stakeholder consultations and case examples, policy support and guidance is essential during various stages.

- Positive and stable regulatory regimes, ensuring contractual enforcements and execution of payment security mechanisms within the tender are required, while also addressing risks such as contractual (including payment security) as per PPA terms and duration. Ensure clauses in PPAs that include aspects; such as if an EPC is declared insolvent, inclusion of line-item as expenditures towards monthly or quarterly payments for electricity must be mandated, enforcement to ensure instances of rooftop access denial during operational malfunctions aspects. Therefore, there should be a standards setting and an evaluation framework with standards for installations (e.g. track records, PPA standardisation) in order to maintain them as long-time power generating assets. Simultaneously, development of a monitoring framework for such installations must be undertaken.
- Guidelines and tender documents which address these risk components can also be standardised by state regulatory commissions and power procurers. This will bring uniformity in project categorisation, user and segment profiles of beneficiaries, accreditation of RESCO developers by channeling emerging demand for RTS towards RESCO-based models.
- As generation from a large number of distributed renewable energy resources (DER) increases, it is pertinent to include operational and maintenance aspects which cover energy generation and security of installation assets—as demand for ancillary services for load balancing and meeting peak demand becomes challenging with higher number of DERs. There is also a requirement of sufficient studies to study the impact from higher RTS penetration on the grid and scope of immediate and long-term grid augmentation. There is scope of studying various business models and their net-positive impact on the installations which shall give DISCOMS some assurances towards further promoting RTS in their circles.

On improvements in operational aspects of utilities: Given the nature of political-economy in India, the involvement of utilities is essential, since ultimately, they form the most significant aspect in terms of billing, operational interface, and familiarity with the RTS markets. They are also the operators which are the most impacted, therefore, prioritising use cases under utility-centric RESCO models is key. Ideally, utilities should develop their own cost-benefit analysis and extract themselves from marginal power plant procurement and move these requirements towards decentralised solar systems. Given the high sensitivity of the rooftop solar market to policy and regulatory signals, it is imperative to embed robust institutional capacities within both DISCOMs and SNAs. With solar power increasingly becoming more cost-effective than grid-supplied electricity, especially for commercial and industrial consumers, mechanisms such as innovative financing and aggregation models should be promoted to make on-site solar more accessible to entities unable to bear upfront capital costs.

- The role of the utility can be further enhanced and operationalised by positioning it not solely as an implementing agency, but as a *facilitator* within the energy ecosystem. As a facilitator, the utility can unlock new revenue streams by charging service fees for enabling third-party projects and partnerships. This shift can also contribute to cost reductions in power procurement and lower customer acquisition costs. Given their comprehensive access to consumer energy profiles and financial data, utilities are uniquely positioned to assess customer creditworthiness, enabling more efficient and targeted engagement strategies. To mitigate the financial impact of customer migration to RTS, a structured incentive mechanism should be introduced that fairly compensates utilities for potential revenue loss, while encouraging active participation in the rooftop transition. The existing CFA from MNRE to DISCOMS can be enhanced based on the percentage share (in MW) of increase in RTS capacity annually. This can be done via designing of a scheme for utilities to compensate from customer losses from shifts to RTS.
- There is a strong requirement of capacity building at institutional levels (especially DISCOMS and SNA) towards technical estimations and inculcating new opportunities. This includes technical skill development activities of DISCOM staff, so that multiple areas under RTS can be covered. Studies undertake cost-benefit analysis towards increasing solar and from shifting of consumers based on particular business models. There is perceptible evidence in terms of lowered cost of procurement from solar, compared with tariffs under average billing rate and revenue realisation, as well as to average power purchase costs (APPC).

  To remain relevant and financially viable, DISCOMs must proactively engage with the evolving energy landscape. The next phase of growth in DRE

RTS will be closely linked with behind-the-meter storage, electric vehicle (EV) charging infrastructure, and associated increases in demand, which places greater emphasis on existing distribution and transmission systems. Often, these increased loads can be managed locally within the balancing area through targeted load studies. Therefore, for utilities, it makes sound business sense to invest in network improvements and infrastructure upgrades, including measures to prevent congestion. Since RTS systems have the potential to ease pressure on distribution infrastructure and delay the need for large capital investments, their impact should be factored into utilities' overall cost-benefit analyses.

- **Long-term regulatory perspective:** As wholesale demand grows, electricity exchanges must be promoted. There is an increasing need for backup and flexible energy resources. Generators should be available for dispatch rather than remaining on standby, ensuring that sufficient capacity is maintained. Flexible generation assets, which often operate within the distribution market, can be aggregated by DISCOMs. Additionally, mechanisms such as smart tariffs, time-of-use pricing, and curtailment error management can support better grid flexibility and efficiency.

ii) Markets development by providing investment and advisory support services

To improve uptake within RTS RESCO, there is a need for market development and advisory services which deepen the market penetration of this model. Conventional CAPEX restricts users without directly available upfront payments, which may suffice for smaller capacities (mostly residential, and small government or institutional). Most beneficiary consumers do not need to maintain and operate systems after fixed periods; these activities are best left to project developers. It also locks significant capital (more than 40 lakhs) for a long term, instead of availing an energy-based service model from the RTS. Approaching via cluster identification, reduction and facilitation of project developers, creation of a market for distributed energy resources (DERs) with value added services (power exchange, ancillary services) alongside policy stability will ensure financial spending on the sector and improving its implementation.

- **Clusterisation of new RTS projects**: Identification and solarising clusters such as group-housing societies, special economic zones (SEZ), public sector units (PSU), industrial segments (food processing, textiles, manufacturing) etc. can enable demand aggregation for cluster-based RTS installations under ULA models. For example, *Operational Guidelines for Saturation of Government Buildings with Rooftop Solar* under the PM-Surya Ghar: Muft Bijli Yojana offers a framework that can be replicated for other sectors. State-level cluster identification exercises, including community solar for grouped institutions, can help develop viable RTS markets. By developing a regional presence with inclusion of rural and peri-urban areas which have largely been untouched—areas with often the highest distribution and transmission losses—can also reduce power procurement costs for DISCOMs. As mentioned above, a mechanism developed by DISCOMs to earn a facilitation fee can suitably offset anticipated revenue losses from DISCOMs.

- **Reducing risks in RTS markets**: Project developers face multiple risks in the markets. Enabling a risk assessment matrix with inputs on DA mechanism, contractual obligations, payment defaults can help balance and reduce overall risks. A key concern remains contract stability, particularly in the commercial and industrial (C&I) segment, where consumers may switch to lower-tariff solar options as module and technology costs continue to fall. Ensuring historical payment verification and assessing consumer creditworthiness can help de-risk investments and provide alternative market development for O&M service providers as well and create further jobs in the markets. As recommended, with the development of standards and evaluation criteria by independent agencies and think tanks can also reduce overall transactional costs and improve service delivery timelines.
- **Enabling existing market mechanisms in RTS:** The rooftop solar markets also can be used to provide long-term alternate services for revenue maximisation such as development of market exchanges for short-term power, including initiation of virtual power plants (VPP)-led aggregation, provision of time delivery tariffs (Time-of-day), including day charges to incentivise consumer-led consciousness. As rollout of DERs are evident, combining ancillary services provision of RTS with storage allows participative rules for distribution system operators (DSO) with RTS and allows electricity trading from aggregated rooftops. Combined with VPP, it allows coordinating and extracting maximum resources embedded within distribution systems. The nature of distribution of electricity is rapidly changing and RTS (DER) offers to meet emerging wholesale demand from flexible resources.

Currently, there is no publicly available collated data on rooftop generation and overall CUF percentages. While individual consumers and concerned DISCOMs have data on generation status and related parameters, the same is not available within public domains. As adoption rises, making this data public shall also expand the markets by provisioning newer services for system upgrades, developing Resource Adequacy Plans in order to understand the overall quantum of energy generation from RTS, and estimate the overall peak demand gap as per-capita electricity consumption rises. It shall also spur investment into allied services mentioned above (VPPA and energy exchanges) and therefore should be fast-tracked with each Utility declaring the total installed capacity (GW), number of consumers, and quantum of energy generation which shall help fostering a transparent market ecosystem.

iii) Creating financial structures to boost credit-lending in the RTS RESCO market

Stakeholder consultations highlight that in order to spur investment in the RTS markets and scale RESCO business models, there is a pressing need to address gaps in financing, credit extensions and assessments, and risk sharing and allocation. This can be enabled with a comprehensive and standardised credit evaluation methodology, which is able to determine interest rates for long-term capital borrowing by creating standardised loan products (based on PPA approvals, execution of previous projects, etc.), based on segment types (standardised as per size and consumer category), data repository with financial and operational performance of project developers. Such documentation shall reduce bankers' due diligence and negotiation times for extending loans, which can be mainly done through:

- **Credit extension mechanisms**: To facilitate credit extension to renewable energy developers, a standardised developer rating system should be established. This would involve assessing the credit profiles of both lenders and consumers and creating a comprehensive data repository that includes financial status, repayment histories, and operational track records. Such a repository will help in better risk assessment and categorisation of developers, ensuring credit availability across all developer sizes—small, medium, and large. A robust payment security mechanism must be instituted, coupled with reduced compliance costs, to promote investor confidence and mitigate risks, especially in emerging models like RESCO. Additionally, enabling credit extension for innovative installations such as carports, balcony solar systems, and façade-integrated PV will support broader deployment of distributed renewable energy (DRE).
- **Creating standardisation in credit extension services:** Standardisation of business models, Power Purchase Agreement (PPA) types, loan products, and required documentation is essential to streamline due diligence and reduce negotiation time for banks and financial institutions. Creating uniform templates and procedures for loans will increase transparency, efficiency, and bankability of DRE projects. The lack of standardised credit selection criteria—particularly for commercial and industrial (C&I) offtakers with limited credit histories—poses a significant barrier. Establishing norms and data-driven tools for evaluating these offtakers, especially in relation to their performance under PPAs, will help financial institutions confidently underwrite loans and

improve loan recovery prospects. Moreover, a centralised data room containing PPA documents, financials, and risk profiles can enable transparent bidding processes and informed risk allocation.

- **Creating a domestic low-cost debt financing ecosystem**: Banks need mechanisms to offer long-term, low-cost debt financing, especially through concessional and commercial sources during the early aggregation phase and during the mobilisation phases when civil and installation work is underway, which can be a blend of concessional and debt financing. Mechanisms such as the securitisation of PPA documents can be introduced to enhance liquidity. However, given their limited risk capacity, banks alone cannot shoulder the entire financial structure. Hence, collaboration with credit rating agencies is essential to vet new market entrants, such as for developing a credit-rating system for project developers, while including their bankability, project execution history, technical competence and also for off-takers such as PPA termination compensation, transfer of rights in case of insolvency etc. By reducing contractual and offtaker risk through longer-term PPAs and standardised risk assessments, the sector can attract institutional investors and scale effectively.

5. Annexure

The rooftop solar systems are integrated electricity generating solutions which can be installed in a decentralised manner on potential rooftops. These systems are typically grid-connected and with suitable grid connecting arrangements can export excess generated electricity units. The rooftop solar PV (RTS) are cost-efficient solutions which can bring immense savings in electricity consumption bills and positively contribute towards power sector decarbonisation. The rooftop segment has immense potential both in urban and rural areas, besides scope for installation in commercial, industrial, government-owned buildings, private residences, group-housing societies and other dwellings.

Table 7: Benefits outlook from rooftop solar

Construction[8]	
Primary energy supply	Solar energy available freely with no direct environmental costs for electricity generation
Site access	Often located at sites of consumption they do not require additional investment or infrastructure for construction and maintenance
Modularity	Can be designed in various configurations and expanded if increase in consumption.
Operations and maintenance	
Mature technology	Easy operations and maintenance, reliable and proven technology
Peak generation	Ability to match periods of peak daytime demand with electricity generation matching the load curve during the day
Grid interaction	Can be created grid interactive and off-grid for host of applications
Ownership	Self-owned or community/utility owned with a range of available business models.
Direct impact	
Investment	Potential to offset additional costs for creation of transmission and distribution infrastructure in near and long term
Costs	Highly subsidised as a long-term generating asset which offsets their initial costs. Fuel savings from opportunity cost of using other fuels.
Environmental externality	Extremely positive for the environment as creates no direct pollution and other impacts are outweighed by environmental benefits.

Source: ADB and author's description

Table 8: Role of various stakeholders in supporting RTS RESCO in India

Banks/Financial institutions • Providing subsidised project financing/lending terms • Supporting new and existing business models • Identifying customers/ developera (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 Government** • 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

Source: Guidebook for Utilities Led Business Models, ADB

Note on methodology

The stakeholders surveyed were officials and representatives of state nodal agencies, reputed project developers, institutions of national significance, etc. to gain an understanding on the implementation hurdles and regulatory lacunae in RTS RESCO markets. Discussions followed towards refining approach towards identifying most recurring yet resolved issues in piece-meal approaches. Each of the presented challenges were then mapped on parameters such as: ease of implementation, replication and scaling potential, financial and regulatory viability within existing guidelines. Later as per each stakeholder they were clubbed towards understanding the issues most relevant to that particular group. These discussions were conducted from April-June 2025 alongside site visits.

6. References

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This report examines the growth, challenges, and future potential of rooftop solar (RTS) in India, with a focus on RESCO/OPEX business models. It highlights the role of rooftop solar in reducing electricity costs for consumers, improving DISCOM revenues, and contributing to climate change mitigation. While the commercial and industrial sector has driven most of the capacity growth, the newly launched PM Surya Ghar scheme is expected to accelerate adoption in the residential sector.

The report identifies key barriers to scaling RESCO models—including financing constraints, demand aggregation, contract enforcement, and lack of suitable business models—and emphasises the critical role of utilities in overcoming these challenges. It proposes reforms in policy, governance, and financial structures to enable sustainable growth of the rooftop solar sector and ensure long-term investor and consumer confidence.

Centre for Science and Environment
41, Tughlakabad Institutional Area, New Delhi 110 062
Phone: 91-11-40616000 Fax: 91-11-29955879
E-mail: cse@cseindia.org Website: www.cseindia.org