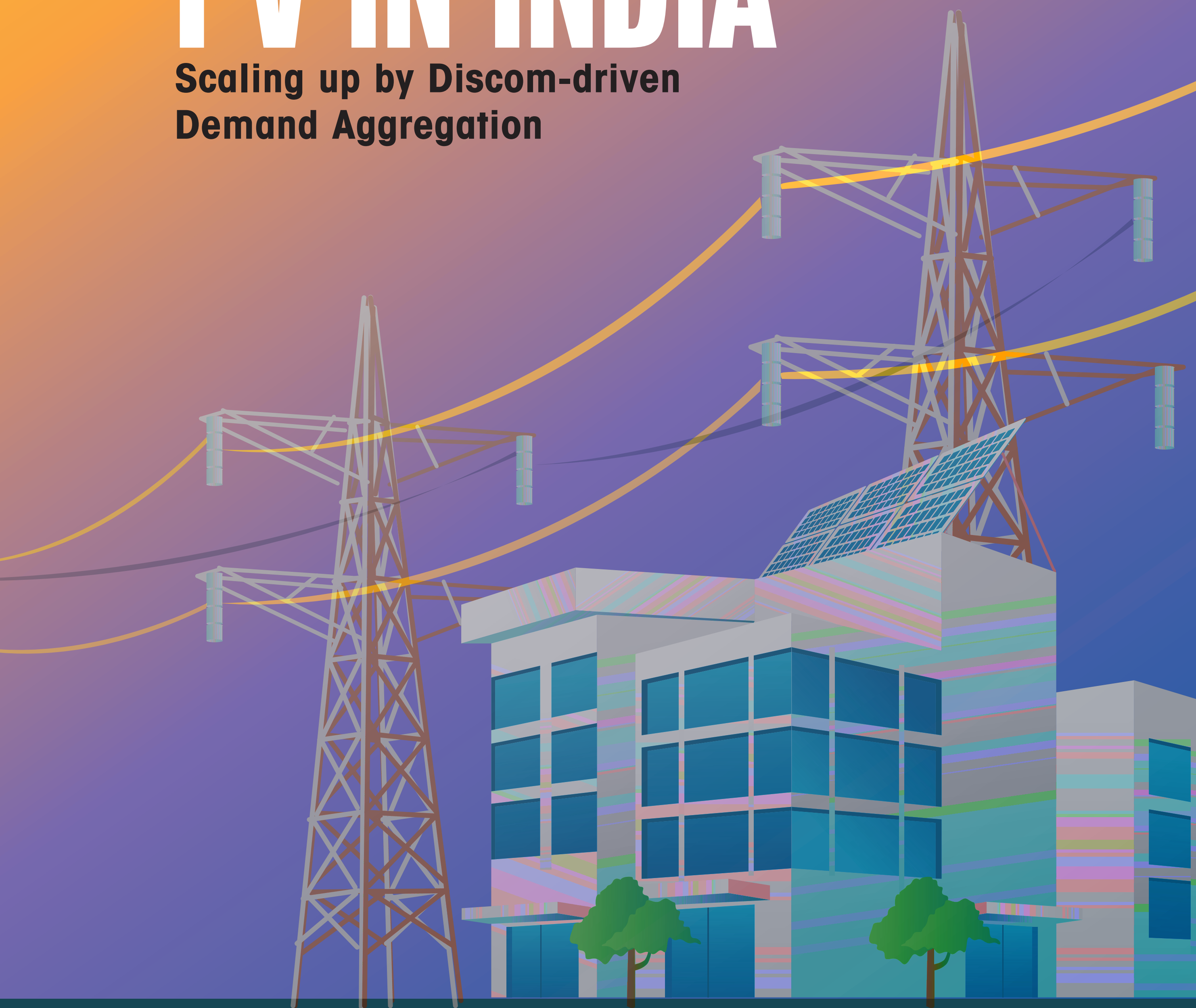
Centre for Science and Environment

ROOFTOP SOLAR PV IN INDIA

Scaling up by Discom-driven Demand Aggregation



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CONTENTS

List of abbreviations

ADB	Asian Development Bank
APEPDL	Eastern Power Distribution Company of Andhra Pradesh Limited
AT&C	Aggregate technical and commercial
BIPV	Building integrated photovoltaic
BLDC	Brushless direct current motor
BRPL	BSES Rajdhani Power Limited
C&I	Commercial and industrial
CAPEX	Capital expenditure
CEA	Central Electricity Authority
CFA	Central financial assistance
CREDA	Chhattisgarh State Renewable Energy Development Agency
CREST	Chandigarh Renewable Energy Science and Technology
CT	Current transformer
DISCOM	Distribution company
DNHPDCL	Dadra Nagar Haveli Power Distribution Corporation Limited
DT	Distribution transformer
EESL	Energy Efficiency Services Limited
EMI	Equated monthly instalment
EOI	Expression of interest
EPC	Engineering Procurement Construction
FIT	Feed-in tariff
FLS	Feeder-level solarization
FoR	Forum of Regulators
FPO	Farmer Producer Organizations
FY	Financial year
GBI	Generation-based incentive
GEDA	Goa Energy Development Agency
GERC	Gujarat Electricity Regulatory Commission
GNM	Group net metering
GOI	Government of India
GPCL	Gujarat Power Corporation Limited

GUVNL	Gujarat Urja Vikas Nigam Limited
HAREDA	Haryana Renewable Energy Development Agency
HPERC	Himachal Pradesh Electricity Regulatory Commission
HPO	Hydropower obligation
HPSEBL	Himachal Pradesh State Electricity Board Limited
IFC	International Finance Corporation
IPGCL	Indraprastha Power Generation Company Limited
IPS	Individual pump solarization
IREDA	Indian Renewable Energy Development Agency Limited
JAKEDA	Jammu and Kashmir Energy Development Agency
JERC	Joint Electricity Regulatory Commission
JREDA	Jharkhand Renewable Energy Development Agency
KSEB	Kerala State Electricity Board
KSEBL	Kerala State Electricity Board Limited
LEDA	Lakshadweep Energy Development Agency
LIDAR	Light Detection and Ranging
LWE	Left-wing extremism
MNRE	Ministry of New and Renewable Energy
MOU	Memorandum of understanding
MPPT	Maximum power point tracking
MPUVNL	Madhya Pradesh Urja Vikas Nigam Limited
MSEDCL	Maharashtra State Electricity Distribution Company Limited
NABARD	National Bank for Agriculture and Rural Development
NDC	Nationally Determined Contribution
NEP	National Electricity Plan
NGO	Non-governmental organization
NPV	Net present value
O&M	Operation and maintenance
OERC	Odisha Electricity Regulatory Commission
OPEX	Operational expenditure
OREDA	Odisha Renewable Energy Development Agency
P2P	Peer to peer

PBI	Procurement-based incentive
PFC	Power Finance Corporation
PLI	Production-linked incentive
PPA	Power Purchase Agreement
PPP	Public–private partnership
RDSS	Revamped Distribution Sector Scheme
REC	Rural Electrification Corporation
RESCO	Renewable Energy Service Company
RFP	Request for Proposal
RFQ	Request for Qualification
RPO	Renewable Purchase Obligation
RREC	Rajasthan Renewable Energy Corporation
RTS PV	Rooftop solar photo voltaic
SAM	System advisor model
SDG	Sustainable Development Goal
SECI	Solar Energy Corporation of India
SEPP	Solar energy power plants
SERC	State Electricity Regulatory Commission
SMC	Surat Municipal Corporation
SNA	State Nodal Agencies
SNO	State Nodal Officer
SPG	Solar power generator
SPV	Special Purpose Vehicle
SPV	Solar photovoltaic
T&D	Transmission and distribution
TANGEDCO	Tamil Nadu Generation and Distribution Corporation Limited
TEDA	Tamil Nadu Energy Development Agency
TNERC	Tamil Nadu Electricity Regulatory Commission
TSERC	Telangana State Electricity Regulatory Commission
UNFCCC	United Nations Framework Convention on Climate Change
UPNEDA	Uttar Pradesh New and Renewable Energy Development Agency
UT	Union Territory

VGF	Viability gap funding
VNM	Virtual net metering
WBSEDCL	West Bengal State Electricity Distribution Company Limited
WPO	Wind power obligation
WUA	Water Use Associations

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GW	Gigawatt
kW	Kilowatt
MWp	Megawatt peak
kWp	Kilowatt peak
BU	Billion units
kWh	Kilowatt hour

EXECUTIVE SUMMARY

The rooftop solar PV segment is one of the fastest-growing sectors across the world. It has the ability to provide reliable power for both rural and urban consumers, scale up investments through multiple investors, empower energy end-users and enhance their energy security issues while helping utilities address critical transmission and distribution losses.

The contribution of the residential sector to rooftop solar photovoltaic (RTS PV) is very low as compared to ground-mounted solar photovoltaic (PV) due to various complexities surrounding the sector. Challenges of rooftop rights, financial credit worthiness of rooftop owners and small size of the RTS PV system that make it unattractive for third-party investors or renewable energy service companies (RESCOs) are some of the reasons for not considering the residential sector suitable for RESCO-based RTS PV. Based on the enormous potential presented by residential RTS PV in India, however, and progressive developments in the segment, it becomes imperative to increase the penetration of rooftop solar PV in the residential segment to improve the share of generation of clean energy feeding into the grid and to mitigate climate change risks due to emissions from fossil-fuel-based generation of electricity.

The Ministry of New and Renewable Energy (MNRE) had set aside a target of 100 GW of solar energy by 2022. The 100 GW was subdivided into 60 GW of utility-scale solar and 40 GW of rooftop solar. The ministry extended the deadline for Phase-II of the Rooftop Solar Programme from the original deadline of December 2022 to 2026, without any financial implication, i.e. within the originally approved total outlay of Rs 118.14 billion for both components of the programme, incentives to distribution companies and Central financial assistance to the residential sector.

Though India has made significant progress in installation of ground-mounted solar—and more than 55 GW has been installed against the target of 60 GW—the progress for solar rooftop projects is only 10.9 GW (as of July 2023) against the target of 40 GW. In order to address the situation, public–private partnership (PPP) projects could be arranged in which the developers would make the investment. The investment would be recovered by the sale of power to the consumers in the next 25 years.

The Government of India sanctioned on August 20, 2019, Phase II of the Grid-Connected Rooftop and Small Solar Power Plants Programme[1] in order to achieve a cumulative capacity of 40 GW of rooftop solar plants by 2022. To implement this, in the second phase of the programme, DISCOMs and their local offices were made nodal points.

An important objectives of the second phase of the government programme was to generate a supplementary rooftop solar capacity of 38 GW by December 31, 2022 in the country. This was to be achieved by incentivizing DISCOMs—4 GW for residential areas would be done through Central Financial Assistance (CFA) and 34 GW for other sectors such as government, Public Sector Undertakings (PSUs), social, private, commercial, industrial and autonomous. To implement the second phase of the solar energy programme, DISCOMs have the option of taking aid from State Nodal Agencies (SNAs) involved in the advancement of renewable energy in their respective zones or areas.

In such a scenario, sourcing power from renewables becomes inevitable. This is also in sync with India's long-term goals. According to the updated Nationally Determined Contributions (NDCs) submitted to the United Nations Framework Convention on Climate Change (UNFCCC) in August 2022, India set ambitious targets to reduce the emissions Intensity of its GDP by 45 per cent by 2030 from the 2005 level and produce 50 per cent cumulative electric power installed capacity from energy resources based on non-fossil fuels by 2030.[2] Though India missed its target of 175 GW of renewable energy target by 2022, it continues to expand its renewable energy capacity. A target capacity of 500 GW by 2030 through non-fossil fuels was announced at CoP 26 by the Prime Minister of India. The National Electricity Plan 2023 emphasizes significant solar and wind capacity addition—of about 365 GW and 122 GW respectively—which India is planning to add by 2031–32.

DISCOMs can play a pivotal role in turning the rooftop sector. However, due to limited resources and capacities, the sector is yet to witness a proactive role of DISCOMs as enabler, facilitator and offtaker of solar power from RTS PV. As pointed out earlier, residential RTS PV has been the laggard amongst the defined RTS PV segments. While the RTS PV sector itself has achieved about 27 per cent of the envisaged target of 40 GW, the residential sector has contributed only 20 per cent to the overall 27 per cent target achieved despite offering a huge estimated potential.

Against a backdrop of several policies to promote RTS PV both at the Central and state levels, along with multiple schemes and incentives, the progress so far in the sector does not manifest such a supportive environment. It implies a disconnect between the policies and implementation—with various components—and stakeholders are not finding level playing fields to work in tandem.

This report attempts to underline various challenges and issues around RTS PV, with special focus on maximizing the residential rooftop space driven by DISCOMs. It also tries to understand the business case for DISCOMs to pursue RTS PV among urban and rural residential households. It is structured with the objective of providing readers all the important elements required for deployment of the rooftop solar PV programme for residential end-users. The report addresses the concerns of all the important stakeholders, including policymakers and regulators, distribution companies, state nodal agencies and bankers. Correspondingly, it addresses key topics encompassing the various business models, policies and regulations, technological standards, and financing.

1

ROOFTOP SOLAR PV

- DESPITE MISSING THE 2022 TARGET, THE CENTRAL GOVERNMENT IS WORKING TOWARDS INCREASING ITS RENEWABLE ENERGY CAPACITY.
- STATES HAVE TAKEN NUMEROUS MEASURES TO INCREASE THE SHARE OF ROOFTOP SOLAR PV THROUGH VARIOUS POLICIES AND REGULATIONS.
- TO SUPPORT RTS PV BUSINESS MODELS, EACH STATE HAS ANNOUNCED REGULATION FOR RTS PV IN INDIA.
- THESE REGULATIONS INCLUDE GUIDELINES FOR DEVELOPERS FOR INSTALLATION OF RTS PV SYSTEMS AND RESTRICTIONS ON THE MAXIMUM SIZE AND INSTALLED CAPACITY OF ROOFTOP PV SYSTEM IN ASSOCIATION WITH DISTRIBUTION TRANSFORMER CAPACITY.

India had an ambitious target of achieving 175 GW of renewable energy generation by 2022. This included 100 GW of generation from solar photovoltaic (PV), with 40 GW of the contribution from rooftop solar PV (RTS) projects.

The developments to achieve the target have been slow despite an engaging policy and economics surrounding it. Despite missing the 2022 target, the Indian government is working towards increasing its renewable energy capacity. The Government of India has decided to invite renewable energy bids of 50 GW capacity for the next five years, i.e. from FY 2023–24 to FY 2027–28.[3] Since the commissioning time of renewable energy projects is around 18–24 months, the bid plan will add 250 GW of renewable energy to assure achievement of 500 GW by 2030.

India's aggregate rooftop solar PV capacity by July 31, 2023 was 10.9 GW. The current total renewable energy capacity of India (as on July 31, 2023) stands at 130.9 GW, which includes 71.1 GW of solar power, 43.9 GW of wind power, 4.9 GW of small hydropower, and 10.8 GW of bio-power.[4] Determining business verticals and developing newer and more effective strategies to drive rooftop solar PV adoption nationwide is crucial.

The Forum of Regulators,[5] in their report, stressed the importance of the necessity to encourage and implement new models and strategies for installing rooftop solar PV systems and the role of utilities in their uptake. The utilities can help in the uptake of rooftop solar PV and provide support to aggregate the demand through the perspective of a developer or a financer.

The demand aggregation approach can be divided into the following three categories:

1. Collection or aggregation of the interest from the end-users;
2. Viability/suitability analysis; and
3. Implementation of the rooftop solar PV programme.

For a utility to take on the role of developer or financer, it should first recognize the need for demand aggregation. As a developer, the utility would find out the requirements of end-users and aggregate their demands thereon. It would take requisite action by involving suitable dealers to deploy rooftop solar PV systems on the rooftops of designated end-users. As a financer, the utility would fund, own and work on rooftop solar PV programmes by subletting the rooftops of end-users based on workability rights.

SCALING UP SOLAR PV MODULES

The Union Cabinet approved the Production-Linked Incentive (PLI) scheme for the National Programme on High Efficiency Solar PV modules for achieving manufacturing capacity of gigawatt (GW) scale in high-efficiency solar PV modules on April 7, 2021. The outlay for this scheme was initially Rs 4,500 crore (Tranche I), and the Ministry issued the guidelines for the PLI scheme on the National Programme on High Efficiency Solar PV Modules on April 28, 2021.

Under this tranche, the Indian Renewable Energy Development Agency Limited (IREDA), the implementing agency on behalf of MNRE for the PLI scheme (Tranche I), issued the bid documents for the selection of manufacturers for setting up manufacturing capacities for high-efficiency solar PV modules. In response, 18 bids corresponding to a solar PV manufacturing capacity of 54,809 MW were received and Letters of Award were issued by IREDA to three successful bidders for setting up 8,737 MW capacity of fully integrated solar PV module manufacturing units within the PLI scheme outlay of Rs 4,500 crore.

To establish a larger manufacturing base for solar PV modules, an additional allocation of Rs 19,500 crore (Tranche II) for PLI for the manufacture of high-efficiency modules with priority to fully integrated manufacturing units from polysilicon to solar PV modules was announced in the Budget 2022–23 on February 1, 2022.

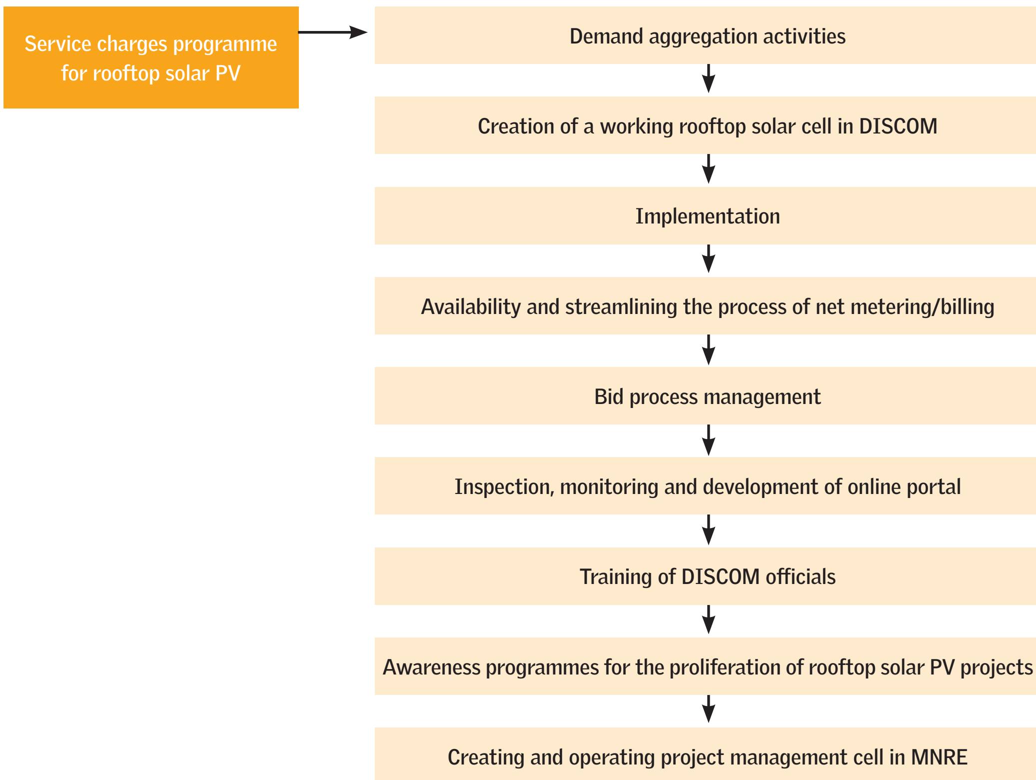
The budget allocated for the solar power sector in 2023–24 is Rs 7,327 crore, which includes grid, off-grid and PM-KUSUM projects. This is a rise of 48 per cent from the allocation of the previous year (2022–23) of Rs 4,979 crore.

Among the advantages of the demand aggregation programme, it can lower operation cost and end-user investment cost, which rose during the COVID-19 due to the curtailment of movement and restrictions on operating hours. Phase II of the grid-connected rooftop solar PV discusses the role of utilities in implementing the rooftop solar programmes and the outlay of the Central Financial Assistance scheme to residential users based on the specifications laid out by the government. About 3 per cent[6] of the allocated fund for CFA has been assigned towards service charges of the programme (see *Figure 1: Service charges programme for the rooftop solar PV programme*). This covers the following:

1. Demand aggregation activities;
2. Creation of a working rooftop solar cell in DISCOMs;
3. Management of the bid process;
4. Implementation;
5. Availability and streamlining the process of net metering/billing;
6. Inspection, monitoring and development of online portal;
7. Training of DISCOM officials;
8. Awareness programmes for proliferation of rooftop solar PV projects; and
9. Creating and operating the project management cell in MNRE.*

* This topic has been covered in detail in Section 3 of the report.

Figure 1: Service charges programme for the rooftop solar PV programme



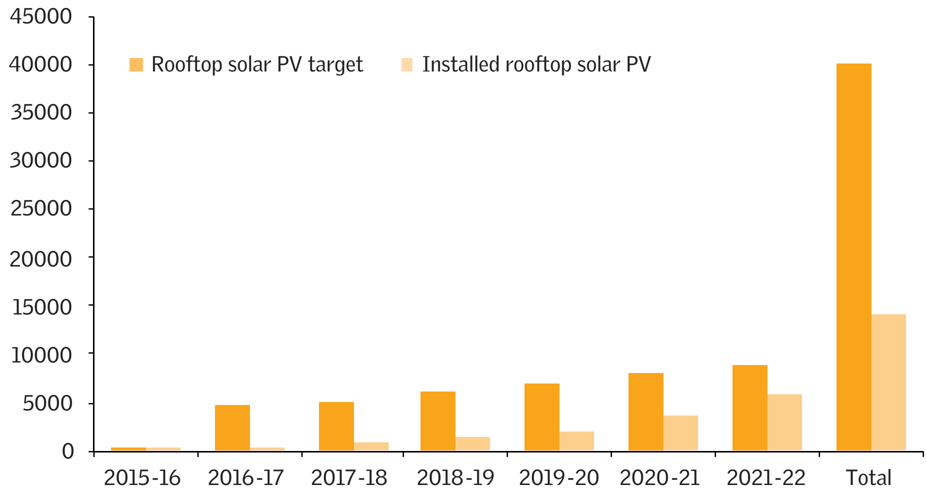
Rooftop solar (RTS) PV systems

Grid-connected non-conventional energy generation has evolved significantly over the past few years, with emphasis now on clean, green and sustainable energy generation. The Electricity Act 2003, with its provisions for renewable energy, has encouraged market competition through the adoption of non-conventional energy resources in India (see *Graph 1: YoY target for rooftop solar PV installation*).

The Government of India has suggested specific state-wise goals based on their available solar resources, energy demand and the subsequent solar energy requirement to achieve the equivalent Renewable Purchase Obligation (RPO) (see *Graph 2: State-wise rooftop solar PV goals (in MW)*.

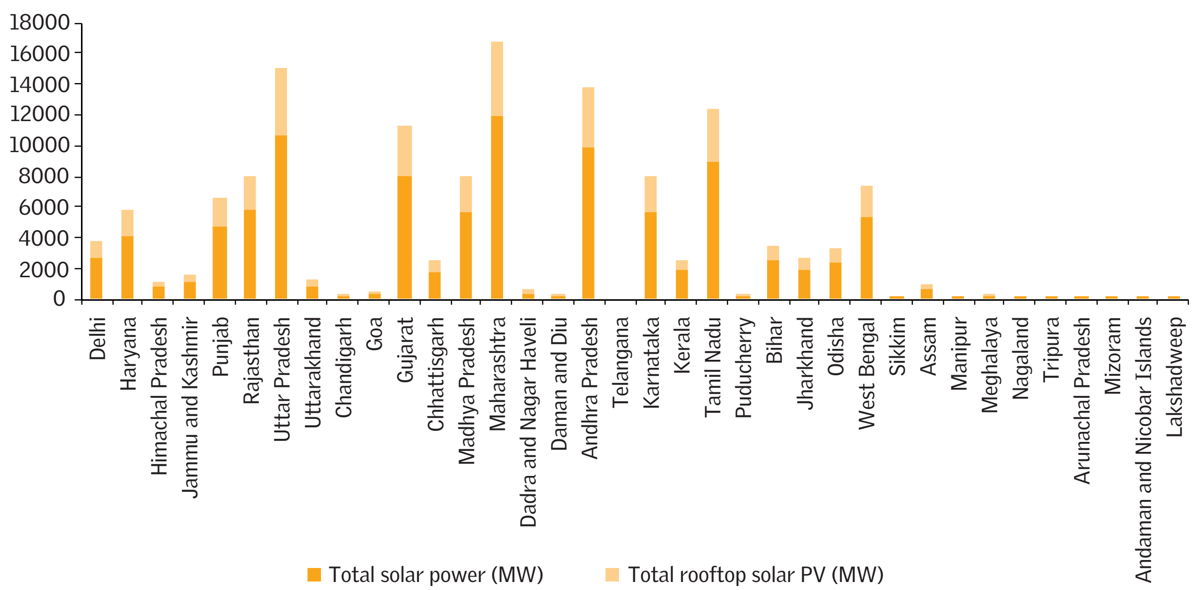
Gujarat tops from the Indian states, with the highest installed capacity of 2,842 MW, followed by Maharashtra with 1,667 MW, Karnataka with 1,562 MW, Rajasthan with 997 MW, and Haryana with 471 MW, thus comprising more than half of the total rooftop solar PV installations in the country (as on July 31, 2023).

Graph 1: YoY target for installation of rooftop solar PV (in MW)



Source: Ministry of New and Renewable Energy (MNRE)

Graph 2: State-wise rooftop solar PV goals (in MW)



Note: Phase II of the Grid-connected Rooftop Solar Programme with a target to achieve a cumulative installed capacity of 40 GW has been extended to 2026.[7]

Source: MNRE[8]

The states have taken numerous measures to increase the share of rooftop solar PV through policies and regulations comprising the respective state government' allocations of subsidies and net metering initiatives across various end-user groups. The measures would help increase the uptake of grid-connected rooftop solar PV nationwide. The maximum uptake has been among commercial and industrial (C&I) end-users. This can be attributed to low costs of installations leading to low solar costs.

Developments in achieving the rooftop solar PV goals have been fairly slow despite a favourable policy and an engaging financial market. The total installed capacity of rooftop solar PV as of July 31, 2023 is 10.9 GW.[9] The tardy pace of growth can be due to various reasons, including:

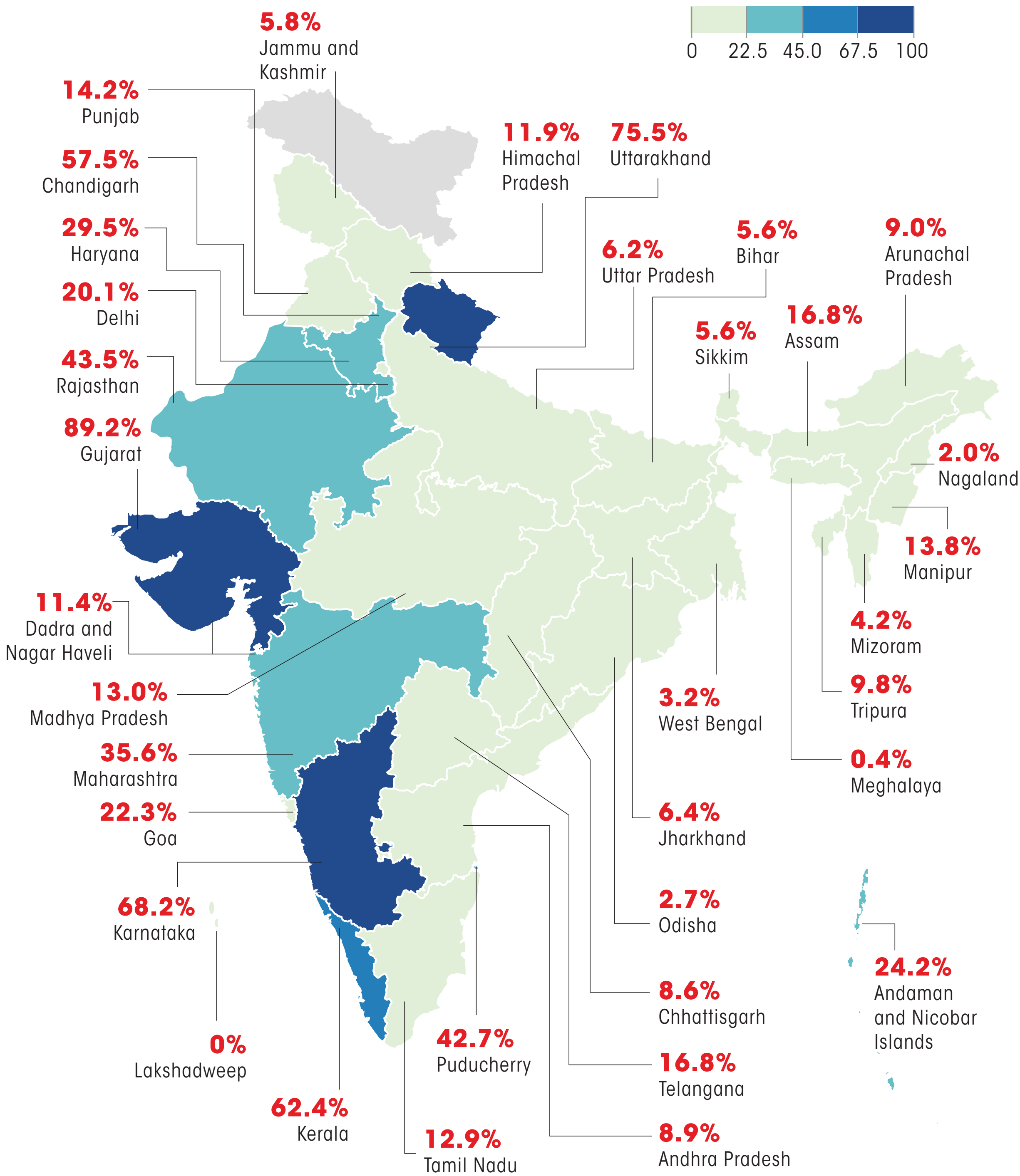
- Financial inaccessibility,
- Lack of interest by utilities, and
- Inaccessibility to suitable project developers, to name a few.

The majority of states are struggling to achieve the envisaged targets as about 24 states out of 35 with RTS targets have been able to add only one-fifth of the targeted capacity. These states need to learn from the top achievers such as Gujarat, which, on another extreme, has been able to mobilize the sector to singly contribute 26 per cent of total RTS installed capacity in the country with about 90 per cent of target realization with its dynamic and supportive policies. Chandigarh, Kerala, Karnataka and Uttarakhand have demonstrated a proactive approach which has resulted in the form of a modest outcome, with an achievement rate as low as 57 per cent and as high as 75 per cent accounting for nearly one-fourth of the total RTS capacity addition. It is also worth acknowledging the efforts of states such as Haryana, Maharashtra, Puducherry and Rajasthan, which have collectively contributed about 30 per cent to the total national RTS capacity so far with an average target achievement rate of 38 per cent. Overall national achievement rate versus allocated target is, however, not highly encouraging (see *Map 1: Percentage of RTS PV capacity target achieved*).

Rooftop solar PV policy of states

Various state governments have undertaken initiatives for the deployment of rooftop solar PV such as additional subsidies and demand aggregation for the installation of rooftop solar PV on a large scale (see *Table 1: Roles and responsibilities of the stakeholders under Phase II guidelines and Table 2: State-wise rooftop solar PV regulations*). Some of them have been elaborated state-wise in the following:

Map 1: Percentage of RTS PV capacity target achieved



*As on July 31, 2023; Source: CSE analysis

Table 1: Roles and responsibilities of stakeholders under Phase II guidelines

S. no.	Ministry of New and Renewable Energy	Utility	Empanelled vendors
1.	Allocate capacity for the ensuing year to different DISCOMs on the basis of demand, capacity required for fulfilment of solar RPO	Create a rooftop solar cell at each division level headed by the Executive Engineer and the respective Sub-Divisional Officer acting as nodal officer for implementation of RTS projects	Install RTS plant within the timeframe decided by the utilities
2.	Release funds to the utilities for disbursement of CFA to the vendors installing RTS plant in the residential sector.	Develop dedicated online portal for grid connected RTS projects. This portal shall be integrated with MNRE's Solar Photovoltaic Installation (SPIN) portal	Use of only indigenously manufactured solar PV panels (both cells and modules) for projects covered under CFA
3.	CFA would be reimbursed for the capacity installed from time to time without any need to wait for the entire sanctioned capacity. Funds may be released on receipt of Project Installation Reports in prescribed formats on SPIN portal.	Empanelment of agencies for design, supply, installation, testing and commissioning of RTS system in residential premises	Establishment of vendors for supply and installation of the RTS in each district.
4.	Release eligible incentive to the utilities based on their performance in the last financial year	Notify time-bound procedure for implementation of the programme	Service centres to provide services to the RTS PV owners within the timelines decided by the utilities, free of cost for first five years (warranty period) of commissioning of the RTS.
5.	Physical sample inspection of the installed RTS PV plants for which CFA or incentive has been claimed by the utilities.	Notify cost of metering arrangements, related connectivity components and other charges and ensure availability of appropriate meters	
6	To provide necessary assistance to utilities pertaining to portal development and its integration with SPIN portal, capacity building, updation of billing software.	Undertake capacity building programmes	
7	Undertake capacity building and public awareness campaigns through print and electronic media	Submit the cumulative capacity of grid-connected RTS plants (in MWp) installed in their distribution area on March 31, 2019 for calculating the applicable incentive.	

Table 2: State-wise rooftop solar PV regulations

S. no.	State	Fixed installed capacity of RTS PV	Fixed installed capacity of RTS PV for net metering	Maximum installed capacity of the system (as a per cent of sanctioned load)	Maximum installed capacity of system (as a per cent of DT capacity)
1.	Delhi	>1 kWp, 5 kWp–5 MWp—for group and virtual net metering	>1kWp, 5 kWp–5 MWp - for group and virtual net metering	100 per cent	Not less than 20 per cent
2.	Haryana	>1 kWp	1 kWp–500 kWp	100 per cent	50 per cent
3.	Punjab	1 kWp–1 MWp	1 kWp–500 kWp	70 per cent	30 per cent
4.	Chhattisgarh	From 1 kWp up to permissible limit according to the system	1 kWp–500 kWp	100 per cent	100 per cent
5.	Madhya Pradesh	1 kWp–1 MWp	1 kWp–500 kWp	100 per cent	30 per cent
6.	Gujarat	1 kWp–1 MWp	1 kWp–1 MWp	100 per cent	50 per cent
7.	Rajasthan	1 kWp–1 MWp	1 kWp–500 kWp	80 per cent	100 per cent
8.	Himachal Pradesh	1 kWp–1 MWp	1 kWp–1 MWp	80 per cent	30 per cent
9.	Uttar Pradesh	1 kWp–2 MWp	1 kWp–2 MWp	100 per cent	100 per cent
10.	Maharashtra	1 kWp–1 MWp	1 kWp–1 MWp	100 per cent	70 per cent
11.	Telangana	1 kWp–1 MWp	1 kWp–1 MWp	80 per cent	50 per cent
12.	Tamil Nadu	> 1 kW	> 1 kW	100 per cent	90 per cent
13.	Karnataka	1 kWp–1 MWp	1 kWp–500 kWp	100 per cent	80 per cent
14.	Andhra Pradesh	1 kWp–1 MWp	1 kWp–1 MWp	100 per cent	80 per cent for LT
15.	Odisha	1 kW–1 MWp	1 kWp–500 kWp—group net metering 5 kWp–500 kWp—virtual net metering	100 per cent	75 per cent
16.	West Bengal	> 1kWp	1 kWp–5 kWp	100 per cent	
17.	Bihar	1 kWp – 1 MWp	1 kWp–1 MWp	80 per cent	80 per cent
18.	Andaman and Nicobar islands (UT)	1 kWp–500 kWp	5 kWp–500 kWp—group and virtual net metering	100 per cent	75 per cent
19.	Jharkhand	1 kWp–2 MWp	1 kWp–2 MWp	100 per cent	100 per cent
20.	Kerala	1 kWp–1 MWp	1 kWp–100 kWp		75 per cent
21.	Jammu and Kashmir	1 kWp–1 MWp	1 kWp–1 MWp	50 per cent	20 per cent
22.	Sikkim	1 kWp–1 MWp	1 kWp–1 MWp	80 per cent	

1. Delhi Solar Policy

A generation-based incentive (GBI) of Rs 2 per unit on solar energy generated between FY 2017 and FY 2019 was provided by the Delhi government according to Delhi Solar Policy 2016 vide no. 205 dated September 28, 2015. The GBI has been extended for five years from FY 2020. The demand aggregation was done by Indraprastha Power Generation Company Limited (IPGCL) for Energy Efficiency and Renewable Energy Management Centre which is the state nodal agency for Delhi in 2018 and 2019 from government buildings, residential owners and housing societies. The eligibility criteria was 1,100 kilowatt-hour (kWh) solar energy units generated per annum per kilowatt-peak (kWp) for GBI, with the upper limit of 1,500 kWh per annum per kWp. Expressions of Interest (EoI) were invited from the residential owners and housing societies by the Indraprastha Power Generation Co. Ltd (IPGCL) for the installation of rooftop solar PV. A feasibility analysis of the rooftop was undertaken and subsequently a tender was issued for aggregated power of 40 MW for residential owners and housing societies of which 35 MW was for pre-identified buildings and 5 MW was for the open category in which the selected project developer was authorized for identification of the site and installation of the rooftop solar PV at a price identified through the bidding process. The installation and commissioning of the rooftop solar PV was done by IPGCL (see *Table 3: Tenders issued by IPGCL for various categories of users*).

A Draft Solar Policy 2022 was circulated for comments on January 4, 2023 with a vision to establish Delhi as a leading state in solar adoption and reduce its reliance on conventional fossil-fuel energy. The Delhi Solar Policy 2022 envisages achieving the following targets by 2025–26:[10]

The Draft Solar Policy specified:

a. A total of 6,000 MW of installed solar capacity, which shall include 750 MW of rooftop solar within the state and 5,250 MW of utility scale solar from outside the state.

Table 3: Tenders issued by IPGCL for various categories of users

Scheme	Capacity and date of publication	User category	Installed capacity
MNRE Phase I	21.5 MW (June 13, 2019)	Government	16.5 MW
MNRE Phase I	35 MW tendered category, 5 MW open category (December 10, 2018)	Residential	15.5 MW
MNRE Phase II	24 MW tendered category, 6 MW open category (February 28, 2020)	Residential	2.119 MW

Source: Data analysed and collected from IPGCL

b. A total of 25 per cent of Delhi's annual electricity demand shall be met through solar energy.

The Draft Solar Policy includes the following models for end-users with rooftop constraints:

a. **Group Net Metering (GNM)**: For consumers with multiple buildings and service connections, constrained roof space in one property or electricity service connection can benefit from any excess solar energy generated on any other property (one or more), provided these connections are in the same DISCOM territory. DISCOMs shall facilitate this via Group Net Metering (GNM).

b. **Community Solar**: Under Community Solar, consumers who do not have a suitable roof for installing a solar system (e.g. residential consumers who live in apartments, consumers with small or shaded rooftops) will be able to benefit from solar energy through the facility of Community Solar. Individual consumers can be owners, with benefit, of a larger solar system.

c. **Peer to Peer:** Under Peer to Peer (P2P), energy-trading consumers who are planning to or have already adopted solar will have the opportunity to sell their excess electricity generation from their rooftops in real time via a P2P energy trading platform.

Customers who do not have sufficient capital to invest in a rooftop solar system can avail of innovative schemes under the Renewable Energy Service Company (RESCO) model. Apart from net metering benefits, MNRE capital subsidy for group housing societies/residential consumers and Delhi's GBI will be available for all eligible consumers who adopt RESCO model. Under the hybrid RESCO model, the net-metering agreement between the consumer and DISCOM, with a PPA agreement between a RESCO developer and the DISCOM, is combined. The model has significant benefits for consumers as they can adopt RTS without any upfront cost, receive net-metering benefits under one bill from the DISCOM and also slide to a lower tariff slab. This model is also beneficial for developers as they sign a PPA with the DISCOM with assured offtake and payment security.

Additional benefits for group housing societies/residential consumers

The following are additional benefits for group housing societies/residential consumers:

a. Capital subsidy by MNRE of 40 per cent for residential systems up to 3 kW

Table 4: GBI applicable under Draft Solar Policy 2022

Type of consumer	Monthly GBI (Rs per kWh)
Residential: Maximum up to 3kW	3
Residential: Above 3 kW, and up to10kW	2
Group housing societies/Residential Welfare Associations: Up to 500 kW (at 10 kW per house)	2
Commercial and industrial (for the first 200 MW deployed)	1

Source: Draft Solar Policy 2022

and 20 per cent for residential systems above 3 kW and up to 10kW until December 31, 2022 or as extended/amended by MNRE from time to time.

b. Capital subsidy by MNRE of 20 per cent for group housing societies and residential welfare associations with systems up to 500 kW (at 10 kW per house) until December 31, 2022 or as extended/amended by MNRE from time to time.

c. Reduced upfront cost of mounting structures for RTS for residential consumers via capital subsidy.

GBI payments will be valid for five years from the date of commissioning of the system, provided the system is commissioned within the operative period of the Policy (see *Table 4: GBI applicable under draft solar policy*).

2. Goa Solar Policy

The government of Goa published an amendment to the Goa State Solar Policy 2017 on February 7, 2019,[11] with the Goa Energy Development Agency (GEDA) being designated as the State Nodal Agency. The government of Goa will offer a combined subsidy by the Centre and state of 50 per cent, which includes a Central share of 40 per cent and state share of 10 per cent for 1–3 kWp of the capital cost of the rooftop solar PV system, or the benchmark cost provided by the MNRE or the cost derived through tendering process by GEDA, whichever is lowest. The residential owners and the residential welfare association can only avail of the benefits of CFA for the installation of the rooftop solar PV. The state subsidy will be released upon the completion of six months of solar energy being injected into the grid.

3. Puducherry Solar Policy

The Puducherry solar policy was launched in 2015 to make solar energy a mainstream energy source by the year 2025 in the union territory. The Government of Puducherry rolled out a notice for the installation of rooftop solar PV plants on September 16, 2022.[12] The Electricity Department Puducherry is the implementing agency under the phase II guidelines of MNRE. A Central Financial Assistance/ subsidy of up to 40 per cent for rooftop solar systems up to 3 kWp can be availed for residential buildings and for incremental capacity above 3 kWp the CFA would be limited to 20 per cent on the rates arrived through competitive bidding or MNRE benchmark cost, whichever is lower. Under Phase-II of the Grid Connected Solar Programme by the Ministry of New and Renewable Energy (MNRE), the Electricity Department selected five vendors for installation of additional rooftop solar power plants of 5 MW in 2021–22 in the residential sector in the UT (see *Table 5: Subsidy applicable under MNRE Phase II guidelines*).

4. Dadra and Nagar Haveli Renewable Energy Policy

The Renewable Energy Policy 2018[13] was launched with an aim to supply 24x7 uninterrupted power supply to all the category of users in the territory. The Dadra Nagar Haveli Power Distribution Corporation Limited (DNHPDCL) has been appointed as the State Nodal Agency. An addition of 45 MW of target rooftop capacity was allocated for 2021–22. A subsidy of 30 per cent on the cost of the solar system can be availed of from the Ministry of New and Renewable Energy (MNRE) through the State Nodal Agency for domestic end-users.

5. Daman and Diu Renewable Energy Policy

Under the Renewable Energy Policy 2018,[14] the Electricity Department of Daman and Diu has been appointed as the State Nodal Agency and is responsible for the installation and monitoring of the rooftop solar PV plant (see *Table 6: Subsidy to domestic end-users*).

Table 5: Subsidy applicable under MNRE Phase II guidelines

Plant capacity	Applicable subsidy
Up to 3 kW	Rs 14,588 per kW
Above 3 kW and up to 10 kW	Rs 14,588 per kW for the first 3 KWp and thereafter Rs 7,294 per KWp
Above 10 kW	Rs 94,822 fixed

Source: Electricity Department, Government of Puducherry

Table 6: Subsidy to domestic end-users

Plant capacity	Applicable subsidy (in Rs)
1 kWp	10,000
2 kWp	20,000
3 kWp	30,000
4 kWp	40,000
5 kWp	50,000

Note: The subsidy will be offered when the plant is located at the point of consumption. No incentive will be provided to the plant with capacity more than 5 kW at a single location.

Source: Official Gazette, Daman and Diu

6. Andaman and Nicobar Islands

The Electricity Department is responsible for the generation in the islands. An MoU has been signed with Solar Energy Corporation of India (SECI) for the development of 1 MWp of rooftop solar plant on government buildings in Port Blair. The Joint Electricity Regulatory Commission (JERC) had notified solar net metering regulations, i.e. Solar Tariff and Net metering Regulation 2015 on May 8, 2015 to accelerate the deployment of rooftop solar PV in the UT. The owners of residential buildings/community, institutional and non-commercial establishments, who are users of Electricity Department and are interested in the installation of rooftop solar plant, shall be provided subsidy of 70 per cent on the benchmark price fixed by MNRE. The remaining 30 per cent of the benchmark price and the actual project cost has to be borne by the user. A 4 MW of target rooftop solar PV capacity addition had been allocated for the year 2021–22.

7. Chandigarh Solar Policy

The Joint Electricity Regulatory Commission for the State of Goa and Union Territories (JERC) had notified the Solar Tariff and Net Metering Regulation 2015 on May 8, 2015 based on which any resident can install and sell solar power @ Rs 8.51 per unit (kW hr) from a solar plant without subsidy and @Rs 6.14 per unit with a capital subsidy of 30 per cent. The Chandigarh Renewable Energy Science and Technology (CREST) is the implementing agency for MNRE schemes and renewable energy projects in Chandigarh. CREST has empanelled 27 solar plant installers/aggregators along with rates from whom any resident can install a solar PV plant and can avail a subsidy of 30 per cent.

8. Lakshadweep Solar Policy

MNRE has fixed a target to achieve 10 MW of rooftop solar PV by 2022. LEDA (Lakshadweep Energy Development Agency) had made an initial assessment that the Roof area is sufficient to install 1 MW roof top solar PV plant[15] in the island capital. The possibility to get a third party installing the plant and the department having a Power Purchase agreement (PPA) with them at the tariff rate fixed by JERC is being explored with the help of the Solar Energy Corporation of India (SECI).

9. Jharkhand Solar Policy

The state government notified the Jharkhand Solar Policy 2022[16] on July 5, 2022 for promotion of the rooftop solar programme, with a cumulative target of 250 MW till 2027. A subsidy of 60 per cent (up to 3 kW for annual income less than Rs 3 lakh) and 80 per cent (3–10 kW for annual income less than Rs 3 lakh) has been offered by the state government. The Jharkhand Renewable Energy Development

Agency (JREDA) is the implementing agency for the rooftop solar PV projects and may develop innovative mechanisms for the deployment of the projects.

Under the Anchored Procurement Model, the implementing agency acts as an aggregator and collects interests from consumers for procurement of solar energy through rooftop solar. The implementing agency then bids out the aggregated capacity to discover the lowest rate. The PPA is signed between the developers and interested consumers. Under the Community Solar models for low-paying consumers the developer will install systems under CAPEX and OPEX modes. DISCOM would facilitate the metering and billing for such installations as per the regulatory provisions by Jharkhand State Electricity Regulatory Commission (JSERC). The Solar Policy allows residential consumers to subscribe to solar power at a predetermined tariff. The roof owner gets a rent for utilization of their rooftop.

10. Jammu and Kashmir Solar Policy

The Grid Interactive Rooftop Solar Photo Voltaic Power Plants based on Net Metering 2016 was notified on February 21, 2017. The Jammu and Kashmir Energy Development Agency (JAKEDA) has been designated as the nodal agency to undertake the solar rooftop programme in the state for the domestic, social, government, institutional, and industrial and commercial sectors through grid interconnectivity and sale of power to the State Utility (DISCOM) on the basis of net metering. The electricity generated from small power plants for self-consumption, sale to third party or sale to licensees shall be liable to pay 4 paisa[17] per unit under Jammu and Kashmir Electricity Duty Act 1963.

11. Meghalaya Solar Policy

The Rooftop Solar Grid Interactive Systems based on Net Metering Regulations, 2015[18] was published on February 25, 2015. A maximum cumulative capacity of 1 MW shall be allowed to eligible end-users under net metering, on a yearly basis, in the area of supply of the distribution licensee. The distribution licensee shall provide a net metering arrangement as long as the total capacity (in MW) does not exceed the target capacity determined.

12. Kerala Solar Policy

The Soura Solar Subsidy Scheme 2022 was launched by the Kerala State Electricity Board for providing subsidy for installing Solar Panels on Rooftops. Under Model 1 (Kerala Model) the end-user pays only a part of the total implementation cost of the solar panel while the other part is borne by the Kerala State Electricity Board Limited (KSEBL). This model is eligible for a solar PV capacity of 2 kWp or 3 kWp and the following three options can be availed based on the monthly energy consumption

Table 7: Return based on monthly energy consumption for Model 1

Average monthly consumption (units)	End-user contribution (per cent of cost)	Return (per cent of plant generation)
Up to 120	12 per cent (max. Rs 6,200 per kWp)	25 per cent
Up to 150	20 per cent (max. Rs 11,000 per kWp)	40 per cent
Up to 200	25 per cent (max. Rs 14,000 per kWp)	50 per cent

Source: Kerala State Electricity Board

Table 8: Subsidy based on plant capacity for Model 2

Plant capacity (kWp)	Subsidy (per cent of cost*)
Up to 3 kWp	40 per cent
4–10 kWp	40 per cent for first 3 kWp, 20 per cent for each additional kWp
Above 10 kWp	26 per cent for 10 kWp and nil for rest

Note: * Maximum cost of plant as per notification of MNRE is Rs 54,000 per kWp

Source: Kerala State Electricity Board

(see *Table 7: Return based on monthly energy consumption for Model 1* and *Table 8: Subsidy based on plant capacity for Model 2*).

Under Model 2 (normal subsidy model) if an end user wishes to install the plant investing the whole amount with low subsidy, they can choose this option. The end user will be eligible to consume the entire energy generated from the solar plant and can claim up to 40 per cent of the plant cost as subsidy based on the solar PV plant capacity. The minimum plant required is 2 kWp for this model and the following subsidies can be availed based on the plant capacity.

13. Odisha Solar Policy

The Odisha Renewable Energy Policy, 2016 sets a target of 2,200 MW of additional solar generation by 2022. The Odisha Renewable Energy Development Agency (OREDA) is the state nodal agency responsible for the installation of rooftop solar PV. Under the Odisha Renewable Energy Policy 2022 published on November 30, 2022, solar parks with a minimum capacity of 25 MW have been promoted. OREDA will aggregate the demand from various government departments and conduct bids to facilitate the deployment of rooftop solar PV on government buildings. All the state DISCOMs would procure the power at the tariff determined by the Odisha Electricity Regulatory Commission (OERC). The subsidies will be provided to rooftop consumers according to the guidelines of the central or state government. The policy would promote the solarization of existing irrigation pumps under the Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan (PM-KUSUM) programme. The government plans to deploy technologically advanced solutions like agri-PV to allow maximum land utilization by combining agricultural production with energy generation on the same land.

14. West Bengal Solar Policy

There are currently two types of subsidies available to existing end-users based on the following categories:

a. Government subsidy scheme for domestic consumers: Group housing societies (GHS)/residential welfare associations (RWA) and individual residents under the domestic category within the West Bengal State Electricity Distribution Company Limited (WBSEDCL) jurisdiction area.

b. Net metering of the Agriculture Consumers under KUSUM-C Subsidy Scheme: This scheme is applicable for existing agriculture consumers under five divisions, i.e. Arambagh, Kalna, Memari, Burdwan North and Burdwan South (see *Table 9: Central Financial Assistance to residential sector* and *Table 10: Cost of installation of solar PV system*).

In case the existing consumer is not eligible for any of the aforesaid subsidy schemes or does not want to avail any subsidy, they can apply for a solar PV connection under the non-subsidy category; provided contractual load of their connection is 1 KW or above. Consumers will have to install a solar PV system at their own cost and will also have to bear all required charges, i.e. application fee, cost of

Table 9: Central Financial Assistance to residential sector

S. no.	Capacity of GRTSPV plan	L1 price in Wp (watt peak) including GST including cost of net meter in Rs	MNRE benchmark cost in Rs/ Wp	**Subsidy
1	1 kWp	51.19	51.1	@ 40 per cent of MNRE benchmark cost
2	>1 kWp to 2 kWp	47.06	46.98	@ 40 per cent of MNRE benchmark cost
3	>2 kWp to 3 kWp	45.84	45.76	@ 40 per cent of MNRE benchmark cost
4	>3 kWp to 5 kWp	44.72	44.64	@ 40 per cent of first 3 kW and 20 per cent of rest capacity
5	>5 kWp to 6 kWp	44.72	44.64	@ 40 per cent of first 3 kW and 20 per cent of rest capacity
6	>6 kWp to 10 kWp	44.72	44.64	@ 40 per cent of first 3 kW and 20 per cent of rest capacity
7	>10 kWp to 100 kWp	41.71	41.64	20 per cent of MNRE benchmark cost *
8	>100 kWp to 500 kWp	39.15	39.08	20 per cent of MNRE benchmark cost *

*CFA @ 20 per cent for GHS/RWA capacity up to 500 kWp (limited to 10 kWp per house and total up to 500 kWp)

Source: West Bengal State Electricity Distribution Company Limited

Table 10: Cost of installation of solar PV system

S. no.	Division name	Rate (in Rs)
1	Arambagh	3,89,775.53
2	Kalna	4,00,432.50
3	Memari	3,68,454.38
4	Burdwan North	3,89,855.25
5	Burdwan South	4,00,432.50
Consumer contribution: 40 per cent of above cost will be collected from the consumer through "quotation" according to the location of their service connection.		
Subsidy: 30 per cent will be provided by the state government and 30 per cent will be provided by the Central government.		

Source: West Bengal State Electricity Distribution Company Limited

Table 11: Solar power projects up to 2026–27

Particulars	Capacity
Utility scale solar projects/parks	14,000 megawatt
Solar rooftop (residential)	4,500 megawatt
Solar rooftop (non-residential institutions)	1,500 megawatt
Distributed solar generation (PM KUSUM component C1 and C2)	2,000 megawatt
Employment generation/skill development	30,000 (number)

Source: Uttar Pradesh New and Renewable Energy Development Agency (UPNEDA)

alteration of service (if required), cost of consumption meter, generation meter and modem.[19] The net-billing or net-metering facility can be availed of by such consumers depending upon the tariff category of the consumer and contractual load of their connection as per the guidelines of the said procedure.

15. Uttar Pradesh Solar Policy

The Uttar Pradesh Solar Energy Policy 2022 aims to implement 22 GW of solar power projects up to 2026–27 (see *Table 11: Solar power projects up to 2026–27*).

UPNEDA is the nodal agency for implementation of this policy. To promote installation of grid-connected rooftop systems under the net metering arrangement in private residential sector, a Saurya Uttar Pradesh Yojna[20] is proposed to be implemented during the policy period. Under this, the state government will provide a subsidy of Rs 15,000/kW to a maximum limit of subsidy Rs 30,000 per consumer. The subsidy will be provided in addition to central financial assistance available from the Government of India.

Under PM KUSUM C-1, solarization of installed on-grid pumps will be carried out under MNRE PM KUSUM Yojna component (C-1) in the state. The state

Government will give a 70 per cent subsidy to Scheduled Tribe, Vantangia and Musahar caste farmers. This subsidy will be in addition to subsidy available from the Central government. The state government will give an additional 60 per cent subsidy to other farmers. Under PM KUSUM C-2 the state government will provide a maximum Viability Gap Funding (VGF) of Rs 50 lakh per megawatt in addition to subsidy being provided by Central government. Project allocation will be through competitive bidding (VGF/tariff based) according to the guidelines of MNRE/state government.

16. Andhra Pradesh Solar Policy

In 2019, Andhra Pradesh issued new solar policy with a target of a minimum addition of total solar power capacity of 5,000 MW in the next five years. The Eastern Power Distribution Company of Andhra Pradesh Limited (APEPDL) had proposed a DISCOM-driven solar rooftop programme, approved by the Andhra Pradesh state government and comprising two models. Model 1 is to be a customer-owned solar rooftop PV programme with net metering. The equated monthly instalment (EMI) will be partly shared by the DISCOM on a net present value (NPV) basis. The model will be for consumers with monthly consumption of 140–200 units. Rooftop solar PV systems will be of capacity 1–1.5 kW. The DISCOM will be the facilitator who aggregates consumer demand by taking signed consent from the consumers. Model 2 is to be for a grid-connected rooftop solar PV programme on developer mode under gross metering. Under this model, a developer will be selected through competitive bidding for the supply of power to APEPDCL for 25 years. The developer will utilize the rooftop spaces of interested consumers.

17. Telangana Solar Policy

Telangana's solar policy came into effect on June 1, 2016. Some of the policy measures undertaken by the state to promote rooftop solar PV are: About 40 per cent subsidy is given for 3 kWp capacity and 20 per cent for 3–10 kWp capacity of the plant. End-users need to spend Rs 52,000 for 1 kWp plant that includes Rs 37,330 for the solar plant, and Rs 2,950 for net metering charges with Rs 18,800 being the subsidy provided. Developers give a warranty of four years on rooftop solar PV panels. Tariff applicable for units generated under Gross Metering at 11 kV and below would be the average cost of service of the DISCOM as determined by Telangana State Electricity Regulatory Commission (TSERC). Subsidy applicable is according to the SECI guidelines.

18. Gujarat Solar Policy

According to Gujarat Electricity Regulatory Commission (GERC) (Net Metering Rooftop Solar PV Grid Interactive Systems) (Third Amendment) Regulations, 2022, net metering will be allowed for rooftop solar PV systems with a capacity of 1 kW–1 MW. Gross metering for rooftop solar PV systems will be permitted for 10 kW–1 MW capacity. Rooftop solar PV projects for residential end-users will be allowed irrespective of the sanctioned load. Solar projects can also be set up by a developer on the rooftop of a residential owner for generation and sale of power to another end-user on the same premises under third-party sale. The developer and end-user must enter a lease or power-sale agreement in such cases. In the case of self-owned and SURYA Gujarat project end-users, DISCOMs must purchase the power at Rs 2.25/kWh for the first five years from the date of commissioning of the project. After that, they should purchase it at 75 per cent of the simple average of the tariff discovered and contracted under the competitive bidding process conducted by Gujarat Urja Vikas Nigam Limited (GUVNL) for non-park-based solar projects in the preceding six months from the project's commercial operation.

19. Maharashtra Solar Policy

According to the Rooftop Solar Programme Phase II scheme, grid-tied solar installations for residential use can receive a fixed amount of Central Financial Assistance (CFA) for each kW of system size. Only residential consumers and housing societies are eligible to avail of the solar plant subsidy under this scheme (see *Table 12: Applicable subsidy based on the system size*).

20. Tamil Nadu Solar Policy

The Tamil Nadu Solar Energy Policy 2019 set a solar energy target of 9,000 MW by 2020, of which 40 per cent, i.e. 3,600 MW is allocated to the end-user category. In March 2019, the Tamil Nadu Electricity Regulatory Commission (TNERC) Order on Rooftop Solar Generation established a formula to determine net feed-in tariff for accounting solar power. Based on that formula the net feed-in tariff value is Rs 2.28 per kWh for solar PV systems commissioned during FY 2019–20. This tariff

Table 12: Applicable subsidy based on the system size

Rooftop solar system capacity	Applicable subsidy (₹)
Up to 3 kW	14,588/kW
Above 3 kW and up to 10 kW	7,294/kW*
Above 10 kW	94,822**
Resident welfare associations (RWA)/ group housing societies (GHS)	Rs 7,294 per kW
	For common facilities up to 500 kWp @ 10 kWp per house, with the upper limit being inclusive of individual rooftop plants already installed by individual residents in that GHS/RWA at the time of installation of RTS for common activity.

Note: * Rs 14,588/kW for the first 3 kW and Rs 7,294/kW for the rest of the capacity up to 10 kW.
**The subsidy amount is fixed for rooftop solar systems above 10 kW capacity.

Source: Maharashtra State Electricity Distribution Company Limited (MSEDCL) is extremely low and represents about 50 per cent of the actual cost of small-scale solar PV energy generation.

For the solarization of government buildings, the Tamil Nadu Energy Development Agency (TEDA) has entered into an agreement with Energy Efficiency Services Limited (EESL) in September 2019[21] for developing at least 50 MW of rooftop solar PV under the Renewable Energy Service Company (RESCO) model. TEDA will be the nodal agency for the programme, and EESL will make the entire investment for the development of the projects. EESL will carry out tendering to select a third party for installation and commissioning. The government departments who are the rooftop owners will make fixed monthly or quarterly payments through TEDA to EESL. As part of the Phase II guidelines of MNRE on rooftop solar, the Tamil Nadu Generation and Distribution Corporation Limited (TANGEDCO) plans to add 5 MW of rooftop solar PV capacity for domestic end users (i.e. utility-driven rooftop solar PV). For the implementation of KUSUM–C scheme in Tamil Nadu, TEDA has been designated as the nodal agency. As part of the scheme, 20,000 pumps with 7.5 HP capacity each will be solarized with an 11 kW grid-connected solar PV system each (Energy Department 2020b). KUSUM–C scheme in Tamil Nadu is expected to add a total distributed solar energy capacity of 220 MW. The solar PV plants will be set up under the RESCO mode. A capital subsidy of 30 per cent will be provided by the Central and the state government. The utility will pay RESCO a fixed tariff for the gross solar energy generated.

21. Haryana Solar Policy

The Rooftop Solar Grid Interactive Systems Based on Net Metering/Gross Metering, Regulations, 2021 was published on July 19, 2021. For the rooftop solar PV, a subsidy of 30 per cent of the benchmark cost has been provided and for farmers on water-pumping systems 90 per cent subsidy is available (see *Table 13: Benchmark cost of grid-connected solar PV).*

22. Madhya Pradesh Solar Policy

The MP government solar PV subsidy is available under the Rooftop Solar Programme Phase II guidelines introduced by MNRE for residential property owners, institutions and social sectors. With a target to achieve 4 GW of residential solar installation by 2024, the Government of India has been offering solar panel subsidies in MP. The recently announced subsidy under the national simplified subsidy scheme offer a fixed amount for each kW of solar system (see *Table 14: Subsidy for solar PV*).

Table 13: Benchmark cost of grid-connected solar PV

System	Government subsidy	Customer price (in Rs)
Up to 3 kW	40 per cent	
Above 3 kW to up to 10 kW	20 per cent	
Above 10 kW	0 per cent	
Cost of 3 kW solar system	Without subsidy	1,80,000
Customer payable amount	With subsidy (–Rs 72,000)	1,08,000
Cost of 5 kW solar system	Without subsidy	3,00,000
3 kW	40 per cent subsidy (3*24,000)	–72,000
2 kW	20 per cent subsidy (2*12,000)	-24,000
Customer payable amount	With subsidy (–96,000)	2,04,000
5 kW generation	Benefits	Rs 7.5/Unit
Daily generation	25 units	187
Monthly generation	625 units	4687
Yearly generation	7,500 units	56, 250
Lifetime generation	1,87,500 units	14,06,250
Return on investment		3.6 years
Income		6.89X
	Installation area	
1	Mono Perc	500 sq. ft
2	Shark 440 W – 540 W	300 sq. ft

Source: Haryana Renewable Energy Development Agency (HAREDA)

Table 14: Subsidy for solar PV

Rooftop solar system capacity	Percentage based on system capacity	Amount (in Rs)
1–3 kW	40 per cent	14,588 per kW
3–10 kW	20 per cent	14,588 per kW for the first 3kW
		7,294 per kW thereafter for the rest
Above 10 kW	–	94,822 fixed
Group housing societies/residential welfare associations (GHS/RWA)	20 per cent for up to 500 kW capacity	–

Source: Ministry of New and Renewable Energy

23. Rajasthan Solar Policy

The Rajasthan Solar Policy 2019 aims to achieve 1,000 MW of rooftop solar PV projects by 2024–25.[22] CFA of up to 40 per cent will be given for rooftop solar PV systems up to 3 kW capacity. For rooftop solar PV systems of capacity above 3 kW and up to 10 kW, the CFA of 40 per cent would be applicable only for the first 3 kW capacity and for capacity above 3 kW the CFA would be limited to 20 per cent. Residential users may install a rooftop solar PV plant of even higher capacity according to their requirement and the respective State Electricity Regulatory Commission (SERC) regulation; however, the CFA would be limited for the first 10 kWp capacity rooftop solar PV plant. Rajasthan Renewable Energy Corporation (RREC) has been designated as the nodal agency for the implementation of rooftop solar PV. The state government will facilitate installation of rooftop PV solar power systems in the state and endeavour to develop 33 district headquarters as Green Energy Cities in the next five years by installing 300 MW of solar rooftop PV systems.

24. Chhattisgarh Solar Policy

The Chhattisgarh Solar Policy 2017–27 was issued by the state government under the National Solar Mission in 2017. Plants with capacity of 10 kW and above will be provided grid connection and the Chhattisgarh State Renewable Energy Development Agency (CREDA) will act as the nodal agency and a single window clearance agency for solar power projects.

25. Himachal Pradesh Solar Policy

The revised Solar Power Policy with amendments was notified on January 24, 2016. Electricity consumers of Himachal Pradesh State Electricity Board Limited (HPSEBL)[23] shall be eligible to install a minimum of 1 kW to a maximum of 5 MW capacity solar PV plants on their building rooftop, which will be connected to grid with bidirectional meters. The consumer will use solar generation for their consumption, and only the drawl from grid to meet the deficit will be billed and surplus generation will be injected in the grid, and the end-user will be paid for this quantum by HPSEBL. Himachal Pradesh Electricity Regulatory Commission (HPERC) has already framed regulations and a fixed tariff of Rs 5 per unit for surplus energy, which is one of the highest tariff in the region, in order to encourage investment. To benefit from the Government of India scheme of equity contribution of Rs 50 lakh per MW, the state encourages farmers and unemployed youth to set up projects in a distributed and dispersed manner from 500 KW to 5 MW, with priority to smaller capacities. This will create capacity of 84 MW, according to Government of India allocations.

26. Uttarakhand Solar Policy

The Uttarakhand government has released a draft solar policy that targets 2,000 MW of installed solar capacity and envisages improving the solar power allocation in utility energy purchases to 18 per cent by 2028. According to the policy, the total solar target to be achieved is 2,000 MW. This includes utility scale of 600 MW, distributed scale of 1,400 MW, residential of 250 MW, commercial and industrial of 750 MW, institutional of 350 MW and agriculture of 50 MW, and the regulations also includes virtual net metering and group net metering. All residential consumers with load of more than 5 kW are mandated to install a rooftop solar on their premises to meet a minimum of 30 per cent of their annual electricity consumption. The subsidy[24] earmarked according to the policy is as follows—for rooftop PV Rs 23,000/kW up to 1 kW and Rs 17,000/kW up to 3 kW, for community solar Rs 8,000/kW for 5–500 kW and for solar villages Rs 15,000/kWh for 50–200 kW.

Factors discouraging offtake of RTS PV

In spite of several dedicated policies for scaling up rooftop in India, including Central- and state-level policies, the sector has not seen the expected growth in terms of capacity addition. The target for ground-mounted solar capacity has been nearly achieved, with 55 GW against the target of 60 GW, while RTS PV has been a laggard with a mere 27 per cent realization of targeted potential. These two targets share the same timeline, which obviously raises fundamental question as to what is wrong. What did the policies miss in understanding the sector? Can it be argued that the policies were not aligned with the implementation goals? Or does the market not see merit and potential in rooftop solar PV? Are certain technical and technological challenges causing the sector to hold back? Is finance a challenge? Are market elements responsible? Is there a disconnect and/or indifference somewhere the along the value chain? And last but not the least, is the grid infrastructure a bottleneck? These questions require in-depth deliberation among stakeholders.

One of the most common factors that has been encountered is lack of transparency and awareness among the consumers regarding the transfer of benefits accrued from rooftop solar in terms of monetary savings or overall energy savings.

Such systems have been seen to be of limited utility and use, especially in rural areas where power outages are very frequent. Due to islanding requirements, rooftop systems generate minimum power or no power at all, depending on the active load during the grid outage. Consumers, either commercial or industrial, depend on DG sets for power backup. They end up running DG sets throughout outage hours as the active load varies within a wide range and solar power kicks in only when the active load is higher than the minimum load criteria for the DG set in sync (for the differential load only). Eventually, consumers in rural areas end up consuming more diesel, which offsets the benefits of the RTS PV. As it happens, a negative perception gets generated around such systems, discouraging other consumers from considering adopting RTS PV.

Another major issue that has been identified and is related to the designing of the RTS PV is that developers and promoters often follow the practice of designing the RTS PV based on three criteria, i.e. availability of suitable space, sanctioned load and associated capping imposed by the policy (of the state). However, the projects that are designed based on these criteria face certain performance issues. RTS PV needs to be designed on the basis of the electrical load distribution throughout the daytime as it varies to a significant extent, especially in commercial premises. This way, the RTS PV capacity can be optimized to meet an average hourly demand, thereby optimizing the size of the DG sets required for syncing to meet islanding requirement. Thus, the minimum load criteria for DG set gets optimized and lets generation of more solar power as compared to the system designed on the basis of peak load or sanctioned load. This is also another discouraging factor for the consumers which developers need to take into account while designing such projects whether as CAPEX or through the RESCO model.

Another discouraging reason for the consumers is the net-metering system itself. Net metering facilitates adjustment of units between import and export of power from and to the grid on a monthly basis. But according to the policy, the adjustment has to be net positive for import from the grid which works well for the benefit of both, i.e. the DISCOM and the consumer as the consumer has to pay for the net units consumed after adjustment. However, it so happens that in certain months or over some of the billing cycles, because of reduction in activities or some other reason, export to the grid is more than the import from the grid, which eventually reflects as net negative units with respect to the import of power from the grid. In such cases, it is seen that the consumer ends up feeding surplus power to the grid without any benefit as it is neither carried forward to the next billing cycle nor is the equivalent amount adjusted against other charges from the utility such as fixed charges etc. The issue can be resolved with the provision of carrying forward the net negative import balance to the next billing cycle or can be adjusted against other charges in the same bill. Also, the mechanism of net billing can be effective in addressing this problem.

It is well known fact that the businesses want to stick to a good paying consumer. Most of the C&I customers are premium consumers for DISCOMs also. Moreover,

Table 15: Problems faced by end-users in uptake of rooftop solar PV

Funding	Utilities	Ministry	Developers
• Longer scrutiny time and conflict resolution • Absence of standards and performance metrics • Small programme size • Lending limitations by banks • Limited technical capacity within FIs required for decision making	• Surplus PPAs signed for conventional sources of energy • Indifference in RPO compliance mandate • Non-availability of training for utilities personnel • Information awareness not available to consumers	• Ambivalent policy for rooftop solar PV • Longer waiting durations for allocation of grants • Limited consumer access to information on subsidies or schemes	• Difficult to select reliable project developers • Lack of performance standards • Uncertainity on installation quality due to price competition • Impediments in the signing of PPA contracts • Lack of transparent O&M mandate

Source: CSE analysis

DISCOMS are supposed to provide seamless access and connectivity to RTS PV to their distribution system in order for the grid to carry more green and clean power. It sometimes is in direct conflict with business interests of DISCOMs and hence challenges regarding interconnection with the distribution network, availability and access to such systems becomes a problem both for the consumers as well as the developers.

Long-term PPAs have two sides, i.e. they are market enablers but prone to disputes ending up in legal battles. While the long-term PPAs ensure project sustainability and availability of power at a reasonable pre-agreed price that is not at all dynamically linked with market, consumers do not wish to be bound by such long-terms commitments as several factors may come into play over such a long period. After a point, consumers too start feeling that the developer has already recovered its investment with a reasonable return, so why continue the PPA. Instead of agreeing to exit and parting ways amicably, parties land up in courts for dispute resolution, which is both costly and time-consuming (see *Table 15: Problems faced by end-users in uptake of rooftop solar PV*).

The low offtake of rooftop solar PV projects makes recognizing advanced working market models necessary to accelerate the uptake. Utility-based demand aggregation is one of the models in which the utility combines the rooftop interests in its area of work and decides on the project developer for the installation of the rooftop solar PV in the aggregated terrace space of the designated end-users.

Every state in India has come up with its net metering policy in accordance with the Electricity Act 2003, which provides the procedure for the installation of the rooftop solar PV in the given state.

According to the new amendments by the government, net metering would be allowed for end-users up to 500 kW[25] load or the sanctioned load, whichever is lower. For sanctioned loads, most of the states limit their capacity to 100 per cent of the sanctioned load while some restrict it to less than 100 per cent. For integrating the generated solar PV energy into the grid, most of the states allow connections up to 50 per cent of the transformer capacity.

2

RESCO MODEL FOR RTS PV

- SOLAR-BASED GENERATION IS PLAYING A PREDOMINANT ROLE IN ACHIEVING RPO TARGETS.

- ONE OF THE CHALLENGING FEATURES IN THE RESCO MODEL IS THE TRANSITION OF THE ROLE OF A DISCOM TO AN ACTIVE RTS PV DEVELOPER AND PRODUCER.

- SINCE THE ROOFTOP SOLAR PV SECTOR IS SMALL AND MORE DISTRIBUTED THAN LARGE-SCALE SOLAR PV, IT REQUIRES ZEAL AND DEDICATION FROM THE UTILITIES TO EVINCE THE INTEREST OF END-USERS IN THE TECHNOLOGY.

- CREATING APPROPRIATE CONSUMER AWARENESS PROGRAMMES BY UTILITIES CAN ACCELERATE ROOFTOP SOLAR PV ADOPTION ACROSS END-USER CATEGORIES.

Business case for DISCOMs

Rooftop solar PV uptake in India can largely be attributed to commercial and industrial (C&I) segment supported by specific policies of the respective states as well as Central government. However, low offtake of rooftop solar PV against the envisaged target of 40 GW indicates that the policies have not been entirely aligned with the interest of multiple stakeholders, resulting in only 10.8 GW of capacity addition, merely 27 per cent achievement of the target. The factors have been discussed in detail in the following chapters.

The residential sector seems neither to be contributing to the RTS PV sector nor was it anticipated to contribute due to various complexities and hurdles. Several analyses suggest significant potential residential sector offers in terms of rooftop space availability, which is not expected to be a challenge to achieve the government's target of 40 GW. Some of the reasons for not considering the residential sector suitable for RESCO-based RTS PV are related to the challenges around rooftop rights, financial credit worthiness of the rooftop owner, and the size of the system which are relatively very small thereby making it unattractive for third-party investors/RESCOs. Also, residential RTS PV projects through own investment/CAPEX models are continuously being deployed, but not in significant numbers. Most of the systems are standalone systems offsetting the grid power demand of the household and sometimes feeding into the grid.

However, looking at the potential of the residential RTS PV and the developments in the C&I segment in rooftop it becomes important to consider scaling of rooftop solar PV in the residential segment to increase the share of generation of clean power feeding into the grid. This requires experimenting with various models, involving multiple stakeholders. Most importantly, distribution companies that have access to every grid-connected household/consumers in their respective jurisdiction of power supply can play the leading role in terms of mobilizing consumers, thereby aggregating potential and demand of rooftop solar PV which would also augment their reliance upon non-conventional sources of energy in terms of procurement and supply, especially in rural areas. DISCOMs can partner with multiple stakeholders such as developers, consumers and financiers to carry out feasibility analyses of such projects followed by project development through appropriate models such as CAPEX, OPEX (RESCO) and DISCOM-facilitated community projects. However, this should make a business case for DISCOM to see the light of the day.

Implementing the RESCO model

There are well-proven models to implement rooftop solar PV such as RESCO, CAPEX and DISCOM-facilitated models. One of the challenging features in the RESCO model is the transition of the role of the DISCOM to an active RTS PV developer and producer. DISCOMs in states such as Gujarat, with strong financial status, should work as producers, developers and financiers. The consumer database of the utilities are equipped with knowledge of T&D losses and rooftop availability. They are up to date about end-user behaviours and they also manage grid interconnections, metering, inspections, billing cycles, and Engineering Procurement Construction (EPC) services.

The solar PV production cost continues to fall, which means that the solar PV market and end-users will find a way to keep RTS PV moving forward regardless of the role played by the utilities. Many of the C&I consumers have installed their own RTS PV, and the utilities are already reeling under the loss of their revenue. The State Electricity Regulatory Commissions and the state governments will not be able to shield the utilities for longer by lowering the installation capacity and the supply of surplus generation to the grid. Market economics will dominate and the earlier the utilities realize this scenario, the more will be their chance at continuity.

a) Identifying the locality

The RESCO model can be deployed across the utilities, but it is preferable to conduct field analysis in some locations or implement in stages as and when field results come. Based on our analysis, the model is not financially suitable in places where the T&D losses are low. Rebate for RTS PV for low-paying end-users, however, results in financial profits in all the areas.

The place for installation should be identified based on the following principles:

i) Availability of rooftop space;
ii) T&D losses; and
iii) Reliability of the power supply in the area

The substations having greater T&D losses should be selected first as they would provide bigger financial profits. Solar PV generation would be pointless if the generated power is not injected to the grid. A cost-effective technological solution needs to be developed to address the challenges in the supply chain.

b) Bidding criteria

The role played by public bidding is mainly necessary for:

i) Eliciting a good feedback from the market;

ii) Selection of the best RESCO; and

iii) Achievement of quality and safety in the RTS PV installations.

If the tender consists of all the information necessary for the submission of a competitive bid, the market feedback is quite strong, with competitive prices. Thus a pre-bid meeting is required along with a site visit. The tender must include standards and safety guidelines for the RESCO to follow during installation.

Apart from the usual details mentioned in the tender document, it should have:

i) Power purchase agreement (PPA) to be signed between the end-user, the RESCO, and the utility;

ii) Rooftop space agreement to be signed by between the financier, the RESCO, the end-user, and the utility; and

iii) Evaluation criteria developed based on the low tariff and technical specifications.

The PPA should mention the mechanism of interconnection, installation capacity parameters, metering, billing cycle, payment mode, and compensation for failure of payment, among others. The rooftop agreement should mention responsibility for each of the party during the programme period.

It may be preferable and favourable for all concerned stakeholders to have a short- to medium-term commitment in the form of validity of the PPA in order for the projects to run smoothly as the projects with longer tenure are more likely to meet disputes of various sorts amongst parties, most likely financial issues.

Also, DISCOMs may choose to enter into a general contract with RESCOs through the single bidding process for the entire jurisdiction in the form of a “rate contract” wherein the selected RESCOs can develop RTS projects anywhere within the jurisdiction of DISCOMs with pre-agreed and uniform pricing. Essentially, a rate contracting arrangement will save the parties from the hassles of several bidding process which otherwise would be followed for every such project, thereby reducing project execution time.

c) Role of the end-users

One of the methods to implementing the RESCO model is through the involvement of the end-user. The role of the end-users are dependent on:

i) Lowering of the electricity bill, and
ii) Compensation for the rooftop space.

Lowering of the electricity bill is based on the sharing of financial gains by the utilities. There many ways to achieve this. For example,

i) A certain proportion of the energy generated is free of cost for the rooftop space owner,
ii) Multiple tariffs can be set for energy utilized from RTS PV and the grid, and
iii) A predetermined tariff can be set for the surplus energy supplied to the grid after the rooftop space owner's own consumption.

For compensation of rooftop spaces, it can be included as rebate in the electricity bill or it can be paid separately on a monthly basis by the RESCO to the rooftop owner. Efforts should be made to involve the end-user from the very beginning. They can be invited to the substation or local office of the utility through any mode of advertisement, and all the details of the RTS PV such as the exemptions in the electricity bill and the type of compensation for rooftop space adopted should be explained through example and with calculations. The level of penetration of the RTS PV in a locality directly depends on the end-user involvement in the project.

d) Capacity building of the utility officials

The utility field officials are the focal point of contact for end-users and for RESCOs post signing the agreement. It is thus imperative to explain to utility field officials the processes involved during the award of RTS PV, installation of RTS PV, responsibilities of utilities, RESCOs, end-users, interconnection methodology and the arrangements of PPAs and rooftop space agreements. Workshops should be conducted for capacity building of field officials.

e) Supervision of the project

The project should be observed based on the following points:

i) Per kW energy generation of the total installed capacity of the RTS PV;
ii) Energy generation as a percentage of the total residential consumption;
iii) Lowering of the electricity bill of the end-user;
iv) Lowering of the T&D losses;
v) Financial benefits to the utility;
vi) Reliability and quality of the power supply in terms of System Average

Interruption Duration Index (SAIDI) and System Average Interruption Frequency Index (SAIFI);

vii) Reactive power, harmonics and power factors; and

viii) Accidental or safety events.

Each utility has its own guidelines for procurement. If generation tariff is considered as the only criteria, unrealistic bids may be submitted and the contract may even be awarded, but the project fails to take off.

DISCOM-driven RESCO models for end-users

Stakeholder consultations were held in Delhi and based on market analysis to understand why the existing rooftop solar PV models have not been very successful for low-paying end-users, the following conclusions were derived:

Low-paying end-users have limited capability to invest in upfront costs in rooftop solar PV. Therefore, gross-metering and net-metering schemes are not being availed of by them.

Considering the security of long-term contract, RESCOs have ranked the low-paying end-users as "low". The tariffs of rooftop solar PV power are relatively high as compared to the subsidized power that the low-paying end-users receive. Both these scenarios make the RESCO model unappealing for such end-users.

The eventual alternative is the DISCOM-based model, but DISCOMs do not want to inherently fund in the system. They are debt ridden, with a weak financial position. One of the challenges faced by the Indian power sector is the compelling issue of Aggregate Technical and Commercial Losses (AT&C), which is lowered by RTS PV as generation and consumption are co-located. Places where AT&C losses are high can deploy RTS PV.

In the third party or the RESCO model, the renewable energy service company invests its funds in solar PV projects and sells power to the owner/end-user at a price that is lower than the grid charges with a profit margin. This model is also called OPEX as the owner/end-user pays for the operation cost of the system over several years. The third party refers to the relationship of the RESCO with the owner and the utility as the third party. The key benefit of this model is that the RESCO bears the technical risk and the end-user does not have to make capital investment in the project.

Financing options in a RESCO model

Financing options in a RESCO model include:

a. Power purchase agreement (PPA)

Under this model, a power purchase agreement is signed between the owner of the rooftop and the owner of the system/RESCO, based on the arrangement of the connection. The system design needs to consider the C&I consumer as their load varies during the day. Assessment of the operational load should be included as part of the PPA. The project lenders or the financial institutions need to take into consideration factors before financing any project which includes a well-drafted PPA taking into account the analysis of the project, and the installation and commercial terms. The rate contracting, benchmark IRR, capital cost and the various cost components need to be fixed based on the system design in the PPA so that the tariff models remains same for a particular system capacity.

b. Gross metering

Under this model, a portion of the earnings that is accrued through the export of energy from the system to the grid is split with the owner of the rooftop for leasing the rooftop space with the project owner. The project developer would generate earnings through the export of solar power from the RTS PV to the DISCOM at a price determined by the regulatory commission of the state (see *Figure 2: Gross metering*).

Figure 2: Gross metering

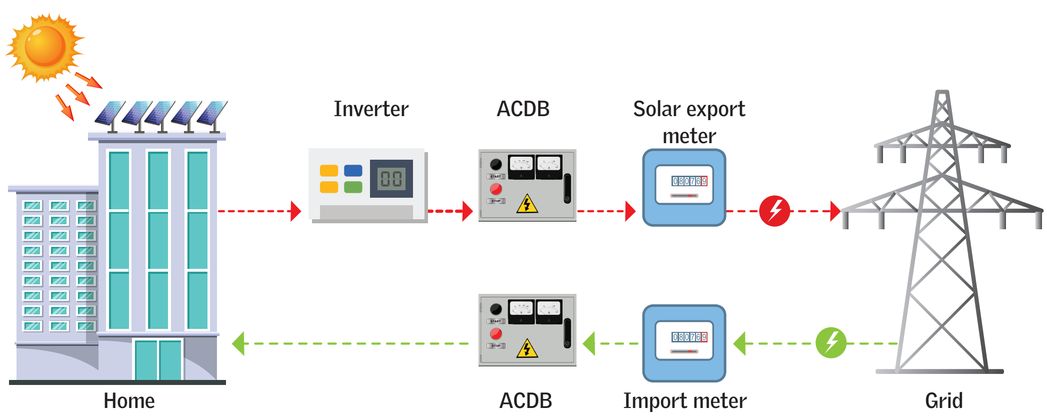
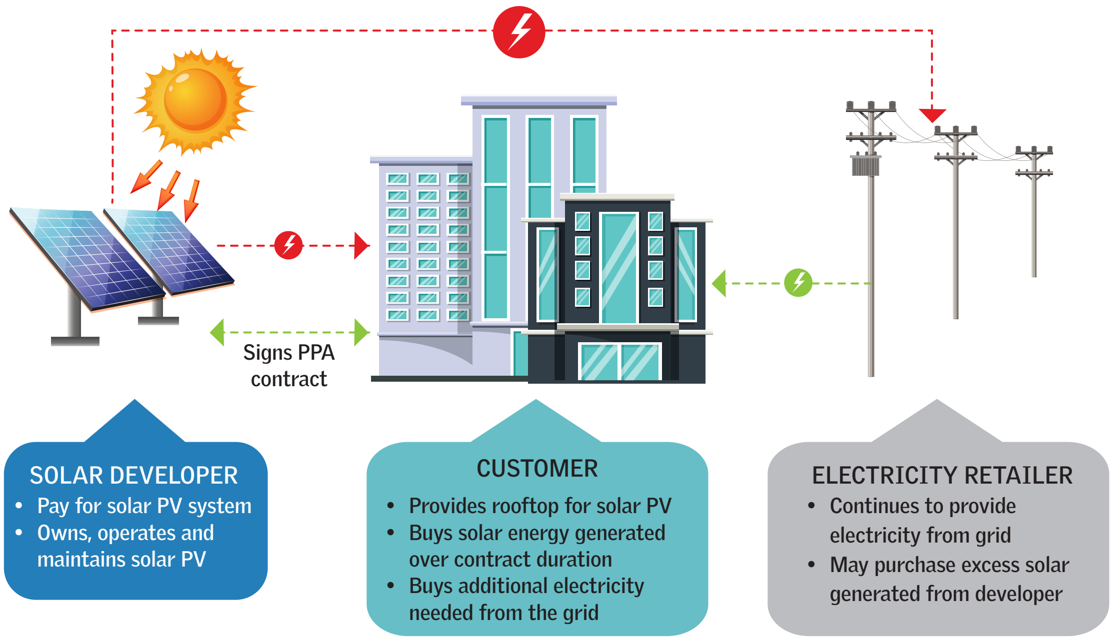


Figure 3: Lease model



c. Leasing model

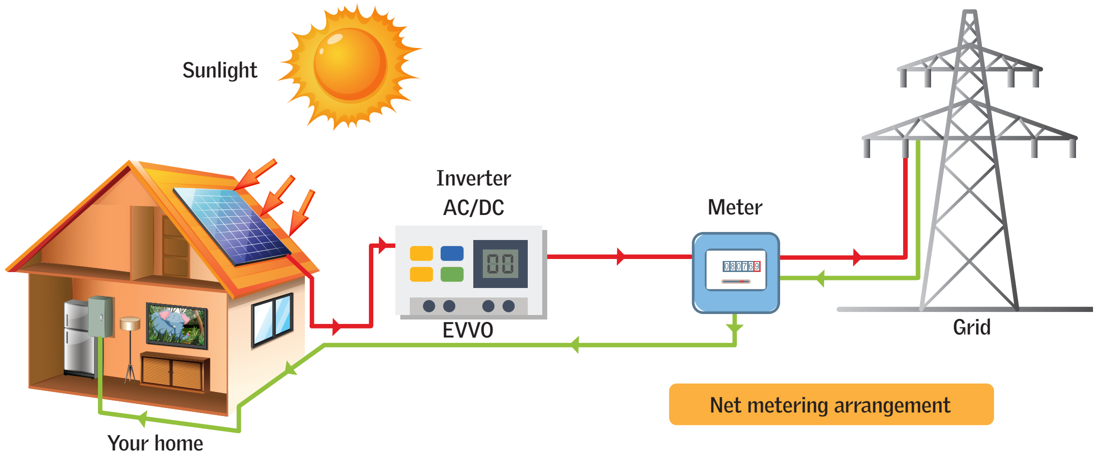
This model is in its initial stage in India and is less common among the developers and the end-users mainly due to issues such as reneging on payments, less tax benefits, low equity returns and ownership problems. Under this model, the consumer leases the RTS PV system from the developer and provides its payment over a period of time. The lease can be for either financial or operational purposes. On completion of the lease timeframe, the resource is transferred to the end-user (see *Figure 3: Lease model).*

d. Net metering

Under this model the electricity produced by the RTS PV installed at the end-user's rooftop is used to meet their energy demands. The developer is encouraged by the income from the rooftop owner according to the agreement. By avoiding the purchase of power from the utility, savings are accrued. The sale of excess power produced within the settlement time is a source of income for the system developer.

The state of Tamil Nadu has included network charges for the prosumers, which means for the per unit of electricity generated by solar in addition to the existing billing mechanism, prosumers have to pay a specific charge which is as high as Rs 1.48 for C&I consumers. This is a big challenge as the prosumers have to pay additional charges.

Figure 4: Net metering



The processing time and approval stages in certain states is quite lengthy and a time-consuming process which further deters end-users from installing RTS PV on their rooftops (see *Figure 4: Net metering*).

e. Group net metering

In this model excess energy generated through RTS PV is exported to the grid through a net meter and the exported energy is adjusted in more than one electricity connection of the same end-user located within the same distribution licensee's area of supply. It is usually not practised as it is available to the end-user with many connections.

f. Zero export model

In many parts of India, net metering is not provided to all the consumers. In such a scenario, the end-user may prefer to opt for the zero-export model. This type of grid-type model includes supplementary current transformers (CTs) to monitor the consumption of the end-users. The solar power generated is made equivalent to the consumption requirement through suitable adjustment of Maximum Power Point Tracking (MPPT) to minimize the export of solar power to the grid. It is necessary to lower the export to the grid as the normal energy meter would read the solar power exported as consumption. Consumers with energy requirements that are more than the net metering capacity as specified by the state regulations could avail benefit through this model. The consumers have the option of importing energy from the grid if required, but it is not allowed to export energy to the grid. As it indicates, the model is self-defeating with regard to achieving the objective of maximizing generation of cleaner power. In a recent and welcome development dated August 30, 2023, the Rajasthan Electricity Regulatory Commission (RERC) announced a regulation to facilitate the transfer of benefits of exporting excess/ surplus solar power through adjustments of credits over the next billing cycles, which otherwise would lapse under the current regulation as the surplus power cannot be carried forward to subsequent billing cycles.

g. Net billing

Under this model, energy is exported to the grid at a lower rate than the net-billing system. For example, if the government charges Rs 8 per unit for energy imported from the utility grid, the consumer will be paid Rs 3 per unit for the energy exported to the grid. The savings accrued are lower than in net metering but higher than in gross metering (see *Figure 5: Net billing*).

An important parameter affecting the cost of power supply is T&D losses. The higher the T&D losses, the higher will be the cost of power supplied to end-users. For solar rooftop PV, the generation and consumption points are co-located, so there are no T&D losses. This acts as an added advantage when compared with energy based on fossil fuels for supplying power to end-users (see *Table 16: RTS PV projects in various stages of implementation based on RESCO model*).

Figure 5: Net billing

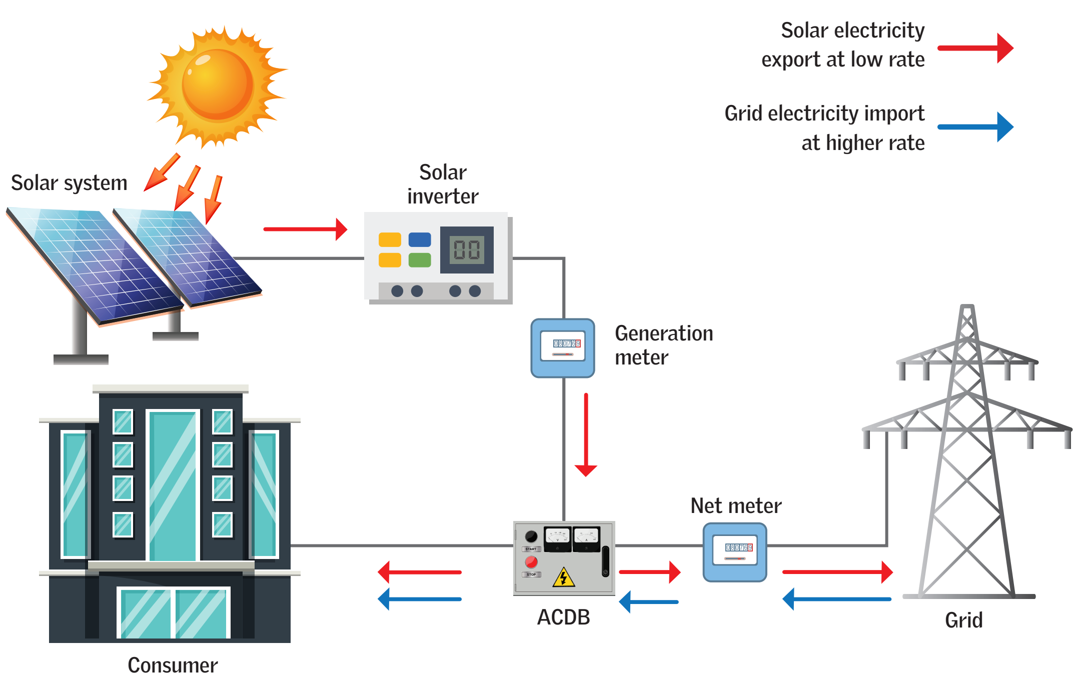


Table 16: RTS PV projects in various stages of implementation based on RESCO model

State	Implementing agency	Description of project
Rajasthan	Jaipur Vidyut Vitran Nigam Limited	A tender has been issued for installation and commissioning of 347 MW of solar projects under component C of the PM KUSUM (Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan) Programme.
Rajasthan	Jodhpur Vidyut Vitran Nigam	The Jodhpur Vidyut Vitran Nigam (JVVNL) has called for bids to develop 31.02 MW grid-connected solar projects under 'Component C' of the PM-KUSUM meant for the solarization of power grids.
Rajasthan	Rajasthan Electronics and Instruments Limited	Rajasthan Electronics and Instruments Limited has issued a tender for 50 MWp grid-connected rooftop and small ground-mounted solar power plants for government buildings in different states/Union Territories of India under the Renewable Energy Service Company (RESCO) model.
Delhi	Municipal Corporation of Delhi	The Municipal Corporation of Delhi (MCD) has inked a Memorandum of Understanding (MoU) with the Solar Energy Corporation of India (SECI) and NTPC (National Thermal Power Corporation to set up 10–15 MW rooftop solar PV on all buildings of MCD.
Odisha	Odisha Renewable Energy Development Agency	Seven medical colleges and 32 district headquarters hospitals (DHHs) across the state of Odisha will get rooftop solar PV installations. Under the renewable energy service company (RESCO) programme of the Odisha Renewable Energy Development Agency (OREDA), healthcare facilities and hospitals will be mounted with rooftop solar PV systems.
Gujarat	Surat Municipal Corporation	Surat Municipal Corporation has floated two grid-connected solar tenders. Both tenders have a capacity of 2 MW. One is for a solar plant to be installed on the BRTS route to Narmad University, and the other one will be in the Central Mall in Surat through the RESCO model.
Maharashtra	Maharashtra Energy Development Agency	Maharashtra Energy Development Agency (MEDA) has invited expressions of interest (EoI) for discovering the tariff for the 10 MW Grid-Connected Rooftop Solar PV Systems under the RESCO model.
Delhi	Indraprastha Power Generation Co Ltd	Delhi government-owned utility firm Indraprastha Power Generation Co Ltd (IPGCL) has notified the selection of L1 bidders for the grid-interactive rooftop solar PV power plant under RESCO-A, RESCO-B and RESCO-C for 35 MW of rooftop solar PV projects in the state of Delhi.
Madhya Pradesh	Madhya Pradesh Urja Vikas Nigam Ltd	Madhya Pradesh, via the RESCO model, is implementing 26 MW of multiple rooftop solar programmes in the state.

Source: CSE analysis from various sources

Utility-led rooftop solar PV models

It is necessary to promote new and innovative business models for facilitating the uptake of rooftop solar PV on a large scale for suitable end-users, especially in urban areas with low rooftop space or accessibility issues for rooftops (see *Table 17: Utility-led Demand Aggregation Programme approaches* and *Table 18: Stakeholder advantage in utility-led demand aggregation*). The Forum of

Table 17: Utility-led Demand Aggregation Programme approaches

	Facilitation approach	Investment approach
Role of utility	Procurement • Aggregates roofs from consumers and conducts initial site surveys • Structures projects • Carries out bidding for aggregated capacity • Develops bidding documents and contracts • Invites bids • Assesses and selects the bidder from the received bids • Facilitates signing of standardized contracts Execution • Supervises progress • Carries out regular quality checks Operation • Supervises operations and maintenance (O&M) on behalf of consumers	Procurement • Aggregates roofs from consumers and carries out the initial site survey Execution • Builds plants through contracted engineering, procurement and construction (EPC) company Operations • Carries out O&M (back-to-back O&M contracts can be arranged)

Source: National Portal for Rooftop Solar

Table 18: Stakeholder advantage in utility-led demand aggregation

	Facilitation approach	Investment approach
Consumers	• Reduction in cost of system/services due to economies of scale due to aggregation • Better performance due to DISCOM-led supervision at the commissioning stage • Reduced risks of default on services from developer/RESCO • Standardized contract facilitated and vetted by utility protects consumer interest.	• Reduction in cost of system/services due to economies of scale due to aggregation • Ensured availability of O&M services by utility throughout the project life
EPC organization/ RESCO	• Attractive project sizing • Consumer acquisition cost is greatly lowered • Lower cost of procurement • Recurring revenue through utility reduces collection costs and risks • Opportunity for developing more projects in various clusters through single rate contract for a bundled capacity. It will help avoid entering into multiple contracts/agreements/PPAs	• Reduced consumer acquisition cost • Lower cost of procurement/ sale • More payment security
DISCOM	• Earns facilitation fee • May achieve benefit by development of rooftop clusters in congested areas in a planned manner • Indirectly helps in postponing the network augmentation for increased load due to localized generation and consumption from rooftop projects	• Project returns • Higher control on the assets • All benefits as in case of facilitation will also be available
Funding agencies	• Low rates of transaction • Low risks due to technology • Reduced risk on investment due to DISCOM being the offtaker	• Low rates of transaction • Low risks due to technology • Guaranteed project take off

Source: National Portal for Solar Rooftop

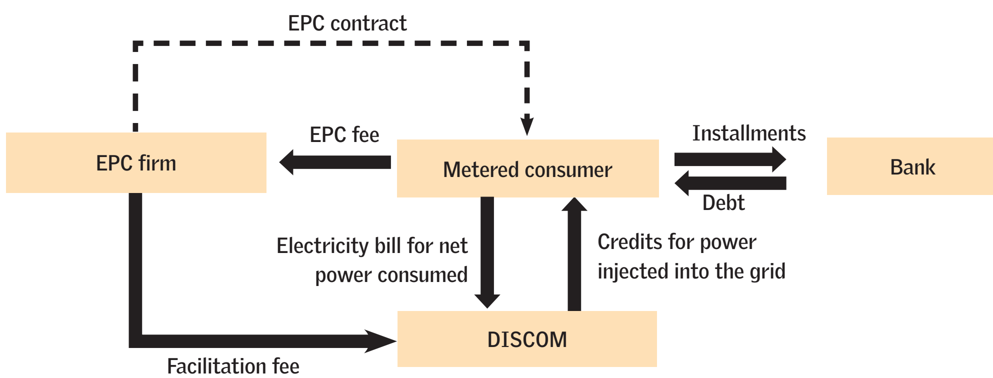
Regulators 2019 report Metering Regulation and Accounting Framework for Grid Connected Rooftop Solar PV in India have identified the following models:

1. Consumer-owned (the utility-only aggregates)
2. Consumer-owned (utility aggregates and acts as an engineering, procurement and construction (EPC) company
3. Third-party owned (the utility aggregates and acts as a trader between the RESCO and the consumer)
4. Utility-owned (utility aggregates and acts as RESCO)

1. Consumer-owned (utility-only aggregates)

In the model, the utility aggregates by identifying the demand for rooftop solar PV in its distribution area. The end-users who are interested in the installation of rooftop solar PV contact the utility. Once the demand aggregation has been done, the utility starts the reverse bidding process to provide the EPC services to the demand aggregated. The EPC service providers who were selected sign contracts with the interested end-users. The utility charges a facilitation fee from the selected bidder for demand aggregation. The utility signs a project management service agreement with the end-users for monitoring the system till it is interconnected with the grid. It is the responsibility of the end-user to bear the complete capital expenditure (see *Figure 6: Consumer-owned (utility-only aggregates*).

Figure 6: Consumer-owned (utility-only aggregates)



Source: National Portal for Rooftop Solar

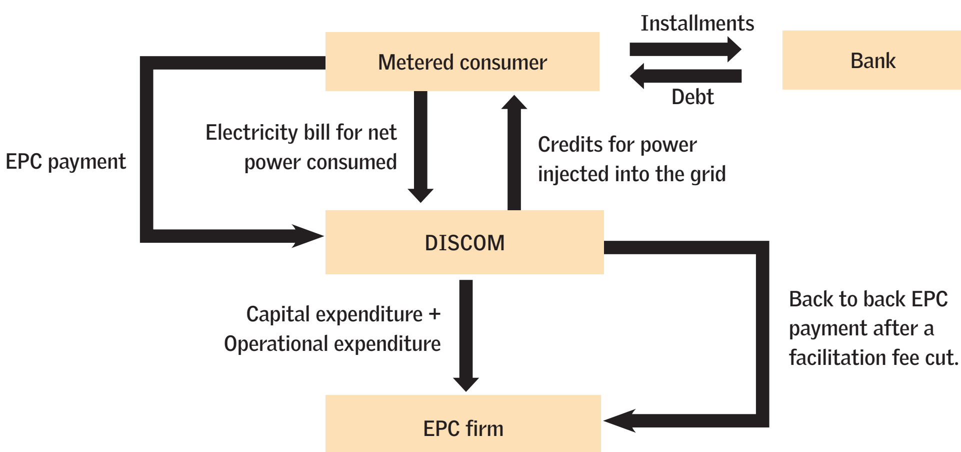
2. Consumer-owned (utility aggregates and acts as an EPC)

In the model, the EPC contract is signed between the utility and the end-user for installing the rooftop solar PV. The utility then signs an additional agreement with the selected EPC player selected through the process of reverse bidding. The utility is paid the EPC services fee by the end-user. It then transfers the fees to the EPC firm at a margin. The utility is paid a one-time facilitation fee and earns a margin on the back to back EPC agreements (see *Figure 7: Consumer-owned [utility aggregates and acts as an EPC]*).

3. Third-party owned (utility aggregates and acts as a trader between the RESCO and the consumer)

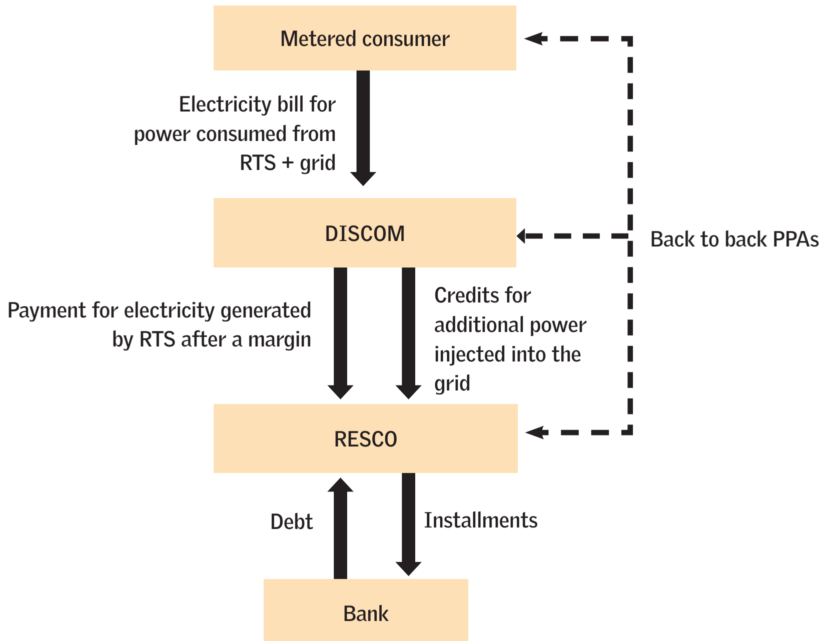
In this model, the utility aggregates the demand in the distribution area while another RESCO identified invests, based on the reverse bidding process, in the project. The payment is routed through the utility. The utility signs Power Purchase Agreements (PPAs) with the end user and the RESCO. The RESCO and the utility sign a PPA in which the utility will purchase the power generated by the rooftop solar PV. The consumer and the utility sign a PPA for the energy produced by the RESCO. The utility charges a trading margin as fees for facilitating trading operations (see *Figure 8: Third-party owned (utility aggregates and acts as a trader between the RESCO and the consumer*).

Figure 7: Consumer-owned (utility aggregates and acts as an EPC)



Source: National Portal for Rooftop Solar

Figure 8: Third-party owned (utility aggregates and acts as a trader between the RESCO and the consumer)



Source: National Portal for Rooftop Solar

4. Utility-owned (utility aggregates and acts as RESCO)

In the model, the utility aggregates the demand and acts as a RESCO for the demand aggregated by installing the rooftop solar PV on the end-user's premises. The utility installs, owns and operates the rooftop solar PV. The utility and the end-user sign a PPA. An agreement is signed between the EPC firm and the utility (see *Figure 9: Utility-owned (utility aggregates and acts as RESCO)* and *Figure 10: Examples of utility-led rooftop solar PV models*).

1. Anchored procurement

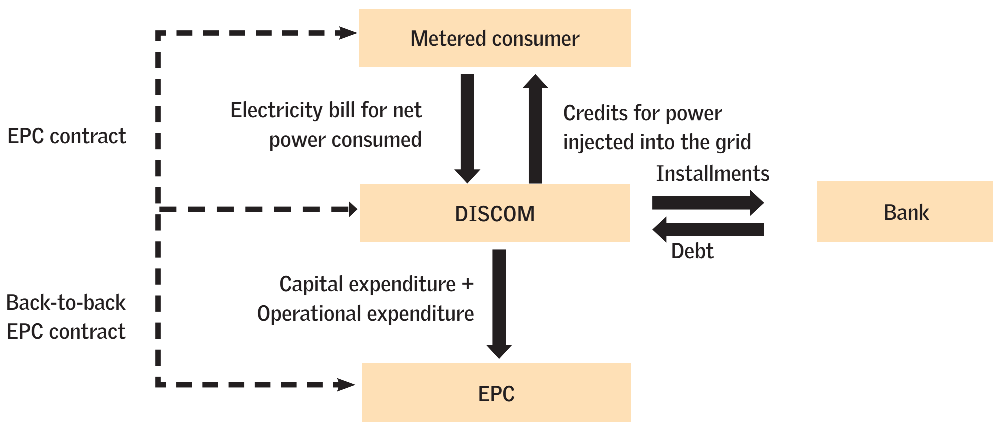
Residential and institutional end-users show more interest in securing rooftop solar PV services through DISCOMs as they have an established relationship with them. This model is suitable for end-users who want to develop rooftop solar PV projects through the CAPEX mode.

Anchored procurement can be divided into the following approaches:

a. Facilitated procurement

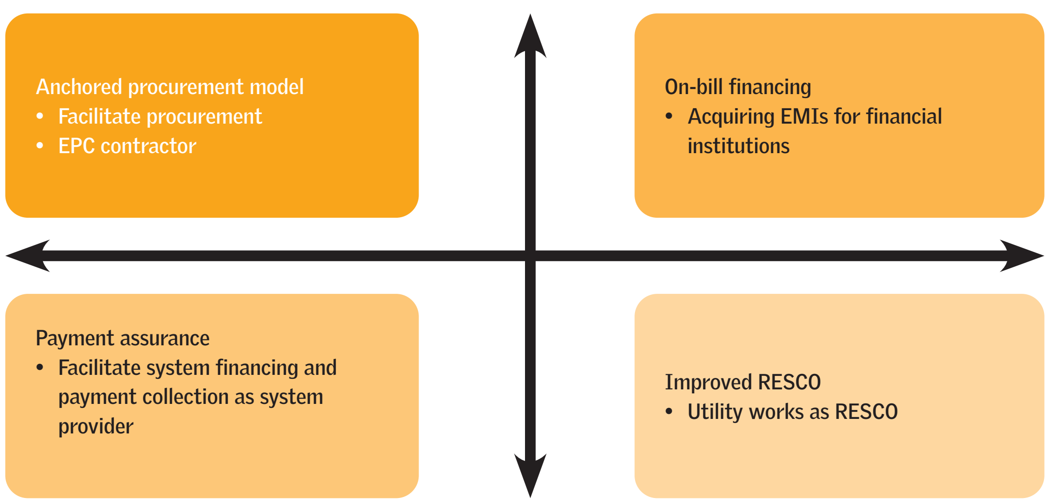
Under this model, the utility acts as a single point for the end-users to procure the services from a third party assessed by the utility. The utility registers the end-

Figure 9: Utility-owned (utility aggregates and acts as RESCO)



Source: National Portal for Rooftop Solar

Figure 10: Examples of utility-led rooftop solar PV models



users who wish to set up rooftop solar PV (aggregation of the end-users) and signs a Project Management Service Agreement (projects the services to be offered to the end-users by the utility and through the utility by the developer). On finalizing the bidder, the end-users sign an agreement with the selected developer. The utility gathers a facilitation fee from the project developer. The utility working for the end-user allows the facilitation and the implementation of the rooftop solar PV. Some of the benefits of the model are economies of scale, better quality of systems due to utility defined standards and better O&M services, faster installations and reduced transaction costs as well as lower payment risks to the developer.

b. EPC contractor

Under this model, the utility signs an engineering, procurement and construction (EPC) agreement with the end-user for the engineering, installation and commissioning of the rooftop solar PV projects. The utility can if required sign a back-to-back agreement with the developer. The developers are identified through a competitive bidding process to develop the aggregated capacity. This model allows better enforcement of contract, quality control and timely installations.

2. On-bill financing

Under this model, the utility acts as the intermediary between the end-user and the financial institutions with the cost of financing lower due to preferential rates available to the end-user, reduced risks and reduced transaction costs. This model includes three stakeholders, i.e. the utility, the financer/lender and the end-user. The DISCOMs aid the end-users by promoting access to finance. The utility collects the EMIs usually through the electricity bills on the loans that have been taken up by the end-users for the rooftop solar PV plants. The EMIs are transferred to the financial institutions for a small service charge by the DISCOMs.

This model can be combined with the anchor procurement model allowing end-users ease of finance, selection of developers through the bidding process, and ensuring system quality through timely implementation.

3. Improved RESCO

Under this model the DISCOM owns and funds rooftop solar PV from developers and provides power to the end-users. The end-users do not own the plant but take up long-term PPA to procure the power from the DISCOM at a pre-determined tariff. Such a RESCO model based on the utility provides increased security of the contract, helps in aggregation and provides economies of scale. This model can be divided into:

a. Utility-based rooftop solar PV

The utility under this model invests in capital cost to install rooftop solar PV on the end-user's building. The end-users buy the energy generated and lease their rooftop space to the DISCOM for the project lifetime. As the DISCOMs aggregate and purchase large capacity upfront, the costs are lowered on account of economies of scale. The DISCOM aggregates the demand of the end-users and provides end-users with an arrangement at a reduced tariff rates than the market.

b. RESCO-owned rooftop solar PV

Under this model, the DISCOM determines the end-users and aggregates the demand while providing them power procured through preferred RESCO. The DISCOMs sign a PPA with the RESCO and an agreement between the end-users for the sale of the power. The end-users lease their rooftop to the DISCOM, who sub-leases it to the RESCO. The energy generated is sold to the DISCOM by the RESCO which is then sold to the end-user by the DISCOM. The DISCOM enacts the role of the power trader and facilitator. Power is purchased from the RESCO at a predetermined tariff (through bidding process) and is sold to the end-user inclusive of the transaction costs.

4. Payment assurance

Under this model, the DISCOMs neither fund nor own the plant. They act as a facilitating agency between the end-users and the rest of the stakeholders, i.e. the financer and the RESCO. The DISCOMs collects the electricity generation charges from its consumers and then pay the rooftop solar PV developer a token. The risk of payment for developer is lowered in this model while reducing the financing cost as well.

Measures to accelerate deployment of rooftop solar PV

Rooftop solar PV has been predominantly installed in the country under the end-user-based Capital Expenditure (CAPEX) model or the developer-based Operational Expenditure (OPEX). The **CAPEX** model involves installation of the complete solar PV by suitable engineering, procurement and construction (EPC) organization, and on the complete execution of the project it is handed over to the end-user. In this model, the investment cost is derived from the end-user consuming the energy and the Central and state government through subsidies wherever relevant. The operation and maintenance of the solar PV project are taken care of by the EPC organization based on the terms and conditions agreed upon in the annual maintenance contract (see *Figure 11: Risks of OPEX and CAPEX models*).

The OPEX model is managed by the developer in the form of a Renewable Energy Service Company (RESCO) that owns and invests in the solar PV project while the end-user pays for the energy generated. The end-user and the developer are bound

Figure 11: Risks of OPEX and CAPEX models

CAPEX

- Apprehension among end-users and banks in investing in projects
- Lack of knowledge by end-users
- Funding options are limited

OPEX

- State government constraints on the RESCO model
- Large rooftop areas favoured by project developers
- Funding options are limited

Figure 12: Advantages of the Demand Aggregation Programme

State government bodies	• Lowering of subsidies to residential, agribusiness, and below-poverty-line end-users • Low dependence on conventional sources of energy
Banks/funding agencies	• Low transaction prices • Adherence to strict deadlines • Suitable arrangement in the contract allowing appropriate operation and maintenance
Utilities	• Low transmission and distribution loss • Low tariffs of power purchase • Retaining end-user • Reduction in T&D losses
Developers	• Reduction in costs on demand aggregated • Easy process of authorization of regulations • Convenient funding
End-users	• Reduction of cost in electricity bill • Minimum upfront cost and low costs of operation • Confirming to standard system practices

by a Power Purchase Agreement (PPA), usually for a long-term period of 25 years and includes the cost of generation from the solar PV plant.

The utilities have been quite concerned about the loss on the returns from the Commercial and Industrial (C&I) group and thus are unwilling to support rooftop solar PV. Creating appropriate consumer awareness programmes by utilities can accelerate rooftop solar PV adoption across the end-user categories. In turn, they can capitalize on the chance to stabilize the losses incurred owing to subsidies. This measure would ensure the lowering of the transmission and distribution losses and the tariff rates to the end-user post subsidies.

Since the rooftop solar PV sector is small and more distributed than large-scale solar PV, it requires zeal and dedication from the utilities to evince the interest of the end-users in the technology. A dedicated role of utilities and programmes such as Demand Aggregation can improve the market dynamics and help alleviate various challenges that project developers face (see *Figure 12: Advantages of the Demand Aggregation Programme*).*

* This topic has been covered in detail in Section 3 of the report.

3

DEMAND AGGREGATION

- UTILITIES ARE AUTHORIZED TO IDENTIFY THE INTERESTS OF END-USERS, DECIDE THE BUSINESS MODEL AND DEVELOP FINANCIAL DEALS.
- THE FIRST ROOFTOP SOLAR PV DEMAND AGGREGATION WAS ESTABLISHED BY THE GUJARAT GOVERNMENT IN GANDHINAGAR BY THE INTERNATIONAL FINANCE CORPORATION (IFC) IN PUBLIC–PRIVATE PARTNERSHIP (PPP) MODE IN 2010.
- THIS BUILD-OWN-OPERATE MODEL WAS USED FOR INSTALLATION OF ROOFTOP SOLAR PV PROJECTS, AND THE POWER GENERATED FROM THE PROJECTS WAS SOLD TO THE UTILITY.
- THE PILOT PROJECT OF GANDHINAGAR WAS RECREATED IN OTHER CITIES OF GUJARAT, WITH A TOTAL AGGREGATED DEMAND OF 25 MW.
- UNDER PHASE III OF THE OFF-GRID AND DECENTRALIZED SOLAR PV APPLICATIONS PROGRAMME, A TARGET OF 118 MW HAS BEEN FIXED, EXCLUDING SOLAR PUMPS, WHICH ARE TO BE INSTALLED UNDER THE PM KUSUM SCHEME, AND SOLAR HOME LIGHTS, WHICH ARE BEING IMPLEMENTED UNDER THE SAUBHAGYA SCHEME OF THE MINISTRY OF POWER.

Mechanism of demand aggregation

The process of demand aggregation of rooftop solar PV involves inviting interest from the end-users, site assessment of rooftop of end-users, installation of the rooftop solar PV, and operation and maintenance of the plant (see *Figure 13: Mechanism of demand aggregation*).

Procedures in rooftop solar PV demand aggregation

Rooftop solar PV demand aggregation includes planning activities such as technical analysis, economic evaluation and monitoring of the project *(see Figure 14: Demand aggregation activities*)

A. Pre-programme planning

The utility is an important stakeholder providing support in the installation of rooftop solar PV. Knowledge and understanding of rooftop solar PV is a necessity for higher managerial officials as well as for field technicians. Skill training for field officials in various aspects of rooftop solar PV is required as they are the responsible individuals for the site assessment, installation and inspection and operation and maintenance of the project. The training for the skill development should be customized based on the requisite of the utility and the target official (see *Table 19: Utility training programmes for skill development*).

Figure 13: Mechanism of demand aggregation

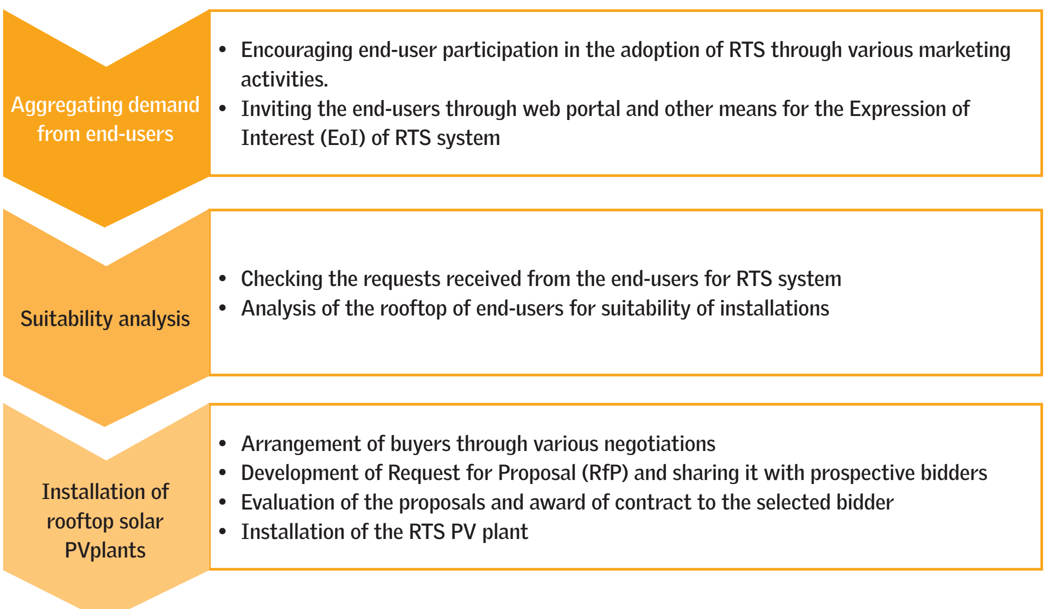


Figure 14: Demand aggregation activities

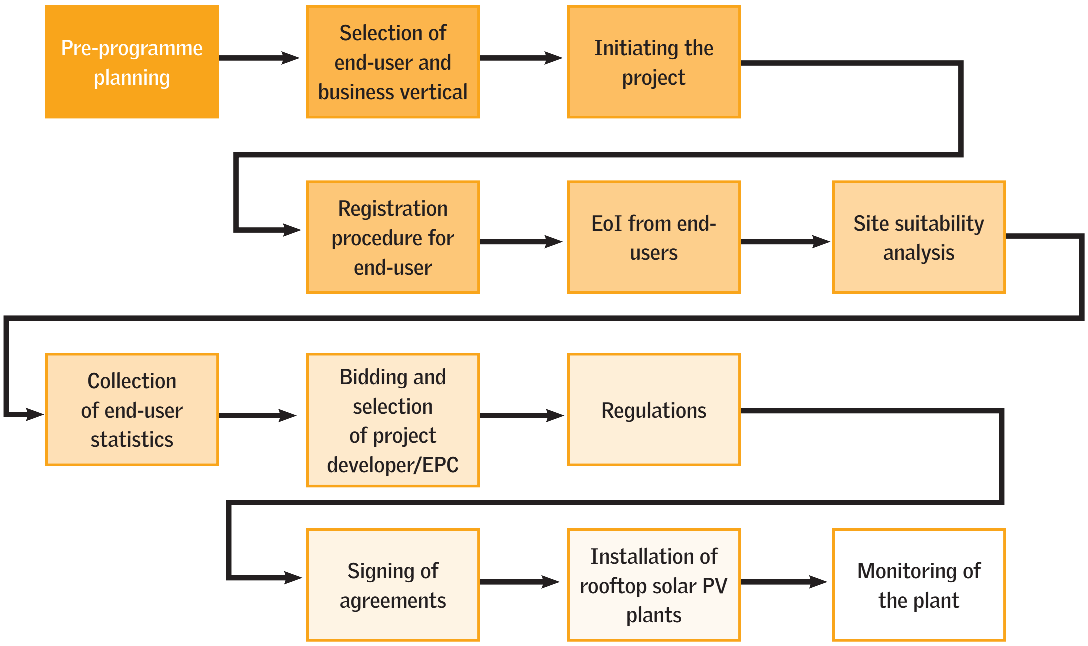


Table 19: Utility training programmes for skill development

Technical modules	Financial and regulatory modules
System components	Ministry of New and Renewable Energy guidelines, Bureau of Indian Standards
Balance of system	State-wise policy and regulations on rooftop solar PV
Net and gross metered system	Grid connectivity standards
Calculations of energy	Energy accounting and settlement for metering
Safety and protection systems	Levelized cost of energy (LCOE) for rooftop solar PV
Inspection of the components	
Tests on installation	
Operation and maintenance of project	

The demand aggregation model includes several stakeholders. In order to monitor appropriate implementation of the programme a committee comprising of the technical team, project development team and a ground team is suggested. The technical team would refer to the queries related to technical aspects of the RTS PV system, evaluation of the bids and the implementation of the RTS PV system. It would comprise the state regulators, senior officials of the utility and the state renewable energy development agency.

The roles and responsibilities of the project development team would include the enrolment of the end-user, analysis and assessment of the aggregated demand, selection of project developers and monitoring of the RTS PV programmes. It would comprise the officials in the technical, commercial and legal departments of the utility.

The ground team would include the engineers of the utility who would be responsible for the site assessment of the project. They would also be responsible for the installation, inspection and monitoring of the rooftop solar PV plants.

B. Selection of end-user and business vertical

It is necessary for the utility to establish the category for the end-user and its model of operation. Some of the measures that need to be taken into consideration are:

a. Deployment of rooftop solar PV can solve the problems of energy shortage. It is advantageous to the C&I users as their day time load is quite high and the local utilization of power would reduce the losses.

b. In case of rooftop solar PV the transmission and distribution (T&D) are less as the power is generated and consumed locally.

c. If the installation of the rooftop solar PV replaces power generator with high variable cost, then marginal power purchase charge is taken into consideration. When multiple utilities are there in a state, the utility cannot choose the generator to procure the power. The state regulators merge all the generators and based on the power demand; each utility is assigned generator. When it is not viable to decide the generators in the future, and evaluate the marginal power purchase charge, average power purchase charge is considered in such cases.

d. High paying end-users favour rooftop solar PV. The utility should utilize this choice as an investor, install rooftop solar PV for the high paying users and sell the power generated to the end-user. The utility should also provide support for the development of rooftop solar PV for the discounted category of the end-users to improve the baseline.

e. The MNRE and the state governments have set up mandates for rooftop solar PV deployment. Utilities who have not been able to achieve the RPO and pushed to purchase the renewable energy certificates (REC) can accrue savings in purchasing the REC through the installation of rooftop solar PV.

C. Initiating the project

One of the challenges for the installation of rooftop solar PV is the lack of understanding of the technology and the suitability of the project by the end-users. Utilities can adopt innovative techniques such as an arrangement for registering the end-users in the utility's portal, conducting a workshop for the end-users to enhance the understanding of the rooftop solar PV installation and the economics of it.

D. Registration procedure for end-user

The demand aggregation from the end-users is done by the utilities when they submit their EoI through online or offline mode of registration. By submitting the EoI, the end-users agrees to the installation of rooftop solar PV and authorizes the utility for feasibility analysis. The utility undertakes empanelment of the project developers and undertakes bid discovery. Based on the business mode, an agreement is signed between the end-user, utility and the project developer. The registration procedure should include terms and conditions for participating in the registration process of the consumers. This registration will be followed by assessment of the demand for aggregation

E. EoI from end-users

For inviting EoI from the end-users, online mode is generally preferred for state level demand aggregation. For society or residential level EoI, offline approach can also be used. In the offline mode, engineers on field duty from the utility go door to door to collect information and to sign the EoI. All the collected and compiled data comprising of the necessary information such as end-user profile, rooftop area and the capacity of the RTS PV systems is shared with the project developers for competitive price discovery for project installation.

F. Site suitability analysis

Site analysis involves the analysis of the rooftops of the end-users and its solar PV potential. The statistics collected in the analysis provides information on the rooftop conditions, and helps better price bid discovery. The site analysis involves the following steps:

i. Whether the rooftop solar PV equipment can be transported to the rooftop of the end-users?

ii. Whether the rooftop of the end-user is flat or at an inclination? In case of an inclination, the direction and angle of inclination needs to be assessed.

iii. The mounting structure for the solar PV modules is planned based on the material of the rooftop. The age of the building structure would help in assessing the feasibility of the plant and in deciding the installation costs.

iv. The area of the rooftop is calculated and the area with shadow (shadow is cast by trees, nearby buildings) is subtracted from it to calculate the shadow free area of rooftop for installation of solar PV modules.

v. The cost of the cables is decided based on the connection points.

vi. Determining the ownership of the building helps in lowering the risk for project developers especially in case of societies.

Once the site assessment is completed, the potential of the rooftop solar PV is assessed. The assessment can be done through physical mode or it can be done using software designer tools such as Helioscope, PVSyst, PVSol and System Advisor Model (SAM). The energy generated includes:

- Size of the PV array or the rated power in kWp
- Peak solar radiation received in peak sun hours
- Total efficiency after including all the losses of the system

Energy generated = Rated power * Total system efficiency * Peak sun hours

- **Size of the PV array or the power generated in kWp** of the rooftop solar PV plant can be estimated using the formula:

  P = (Cm/1000)*(Rcr*Ar/Am)

Where Cm is the per module rated capacity in Wp

Rcr is the rooftop cover ratio. Typically 15 per cent of the rooftop space is kept free for placing the solar modules in an obstacle free zone and with proper gap between them.

Ar is the total rooftop measured area – total shadow free area which is available for the installation of the solar modules in metre^2.

Am is the area of a single solar module in metre^2.

According to thumb rule approximation, for 1 kWp solar PV array 10 metre^2 of shadow free rooftop area space is required.

- **Peak solar radiation received in peak sun hours**
  The global average horizontal irradiance is 4–6 kWh per m^2 in India.[26]

- **Total efficiency** after including all the losses of the system
  Rooftop solar PV system losses is dependent on the system design, selection of the components and the operating temperature of the area. Generally the loss is estimated at around 26 per cent (see *Table 20: Losses in a solar PV plant*).

Other tools are available to gather information that can be utilized to assess the rooftop solar PV potential such as Light Detection and Ranging (LiDAR) and high-resolution satellites.

The information from LiDAR can be accurate to up to 20 cm. The data collected is expensive, and involves labour cost, machine drones and other equipment. The time taken to process data is fairly elaborate, which makes it cumbersome to deploy it in cases where quick repatriation is required. It might also be difficult to obtain permission to fly in some areas, especially if the end-user is near an airport or adjoins a national border region.

The information obtained from satellite is changed every week. The accuracy achieved through satellite imagery is up to 41 cm. Direct retrieval of statistics would cut short the time taken for processing for the data as well as the cost of the analysis.

Table 20: Losses in a solar PV plant

Loss parameters	Loss estimated (per cent)	Efficiency factor
Shading	2	0.98
Inverters	5	0.95
Irradiance	3	0.97
Voltage drop	2	0.98
Tilt angle	1	0.99
Orientation	0	1
Tolerance	3	0.97
Dirt	3	0.97
Temperature	10	0.9

Source: CSE analysis from various online sources

G. *Collection of end-user statistics*

All the information is gathered from end-users through an assessment study of the rooftop and it is made available to project developers so that they can attain the best price discovery for the project.

H. *Bidding and selection of project developer/EPC*

The first step in the selection of a suitable project developer involves drafting of a tender in accordance with the standards followed by the utility. The terms and conditions for the installation of the rooftop solar PV, installation time period, performance metrics, technical specification of the equipment for operation, and the complete bid procedure are defined in the tender. The Ministry of New and Renewable Energy (MNRE) specifies the guidelines for installation under the rooftop solar PV scheme. The demand aggregation includes several settlements in close proximity to each other, the projects are categorized based on the capacity of each rooftop solar PV and the biding region. The benchmark costs[27] for the rooftop solar PV plant is specified by MNRE as on August 18, 2021 and it is based on the individual capacity of the plant (see *Table 21: Benchmark costs for rooftop solar PV*).

Once the tender has been finalized and issued, the utility should arrange for a meeting to resolve the queries pertaining to the bid document.

I. *Regulations*

Each state and Union Territory has specified their own regulations for the rooftop solar PV, with details involving category of the end-user, billing, and energy and metering schemes. There are additional charges associated with rooftop solar PV systems when the utility acts as an investor in a project. The annual return of the utilities are influenced by these charges. The utilities need to file a petition

Table 21: Benchmark costs for rooftop solar PV (Rs per kWp)

Capacity	Benchmark cost	
	General category states/UT	Special category states/UT
Up to 1 kW	51,100	56,210
>1 kW and up to 2 kW	46,980	51,670
>2 kW and up to 3 kW	45,760	50,330
>3 kW and up to 10 kW	44,640	49,100
>10 kW and up to 100 kW	41,640	45,800
>100 kW and up to 500 kW	39,080	42,980

Note: Special category states/UTs includes Northeastern states, including Sikkim, Himachal Pradesh, Uttarakhand, Jammu and Kashmir, Ladakh, Andaman and Nicobar Islands and Lakshadweep Islands with the State Electricity Regulatory Commission (SERC) and the Joint Electricity Regulatory Commission (JERC) for investment sanctions on the following sections of the Electricity Act 2003:[28]

1. Section 86 (Functions of the state commission) (1) The state commission shall discharge the following functions namely:

   (e) "promote co-generation and generation of electricity from renewable sources of energy by providing suitable measures for connectivity with the grid and sale of electricity to any person, and also specify, for purchase of electricity from such sources, a percentage of the total consumption of electricity in the area of a distribution licensee";

2. Section 86 (Functions of the state commission) (1) The state commission shall discharge the following functions namely:

   (b) "regulate electricity purchase and procurement process of distribution licensees including the price at which electricity shall be procured from the generating companies or licensees or from other sources through agreements for purchase of power for distribution and supply within the State";

3. Section 61 (Tariff Regulations) The Appropriate Commission shall, subject to the provisions of this Act, specify the terms and conditions for the determination of tariff, and in doing so, shall be guided by the following, namely:

   (h) "the promotion of co-generation and generation of electricity from renewable sources of energy";

4. Section 62 (Determination of tariff)-(1) The Appropriate Commission shall determine the tariff in accordance with the provisions of this Act for the

   (a) "supply of electricity by a generating company to a distribution Licensee";

5. Section 63 (Determination of tariff by bidding process):
   Notwithstanding anything contained in section 62, the Appropriate Commission shall adopt the tariff if such tariff has been determined through transparent process of bidding in accordance with the guidelines issued by the Central Government.

J. Signing of agreements

In the facilitation mode, the utility acts as a means for the implementation of the rooftop solar PV for the end-users. The project developer signs a contract under the CAPEX mode with the end-user for the installation and commission and operation and maintenance (O&M) of the rooftop solar PV. The project developer signs a power purchase agreement (PPA) with the end-user under the OPEX model for sale of power at predetermined tariff.

In the investment mode, the utility does the installation of the rooftop solar PV. The project developer signs a contract with the utility and the activities of the project developer are executed through the utility. The end-user commits a contract with the utility for right of use of the roof space for the installation and operation of the rooftop solar PV and the end-user receives a rent or initiative for it.

K. Installation of rooftop solar PV plants

The project developer installs the rooftop solar PV on the end-consumer premises within the stipulated time-period. Based on the model adopted, the management of the project is handed over to the utility or the end-user. In the facilitation approach, the utility manages the installation and commissioning and operation and maintenance of the plant. In the investment approach, the utility monitors, operates and does the maintenance of the plant for lifetime of the project.

L. Monitoring of the plant

The investment approach ensures that the project developer does monitors the plant with the submission of system performance and month-wise energy generated reports to the utility at least once every six months.

Classification of Demand Aggregation Programme

Demand aggregation can be done in two ways, i.e. through facilitation or investment approaches. Under the **facilitation approach**, the utility aggregates the various projects and facilitates the procurement of solar PV systems or services paid by the end-user or RESCO. The utility can charge for the services, thereby gaining an additional income for itself. Under the **investment approach**, in addition to aggregating projects, the utility invests in the project's development. The utilities can provide support in financing projects through their association with financial institutions as moneylenders or as collection agencies. The energy generated is acquired by the utility at no cost or sold back to end-users at a fixed rate.

Under the facilitation approach, the utility can fund debts, and aggregate monthly payments from the end-users, providing collaterals to the banks for financing rooftop solar PV projects. Alternatively, the utility can collect the charges from the end-users for electricity consumption using the RESCO model of rooftop solar PV. This would lead to greater cost security for the project developers.

The utility is authorized to identify the interests of the end-users, decide the business model, and develop financial deals. As the capital investment is done by the developer (RESCO), it will bring in more challenges such as the high upfront and transaction costs, and high offtaker risks but also ease the life of the end-users in terms of the monthly pre-determined tariff that they have to pay only for their consumption of electricity and the responsibility of O&M lies on the shoulders of the developer.

Implementing the Demand Aggregation Programmes

Demand aggregation can be a successful endeavour to improve and accelerate the deployment of rooftop solar PV in India. Based on the various consultations done with various stakeholders, some of the strategies that would prove to be favourable among the decision-makers have been suggested as the following:

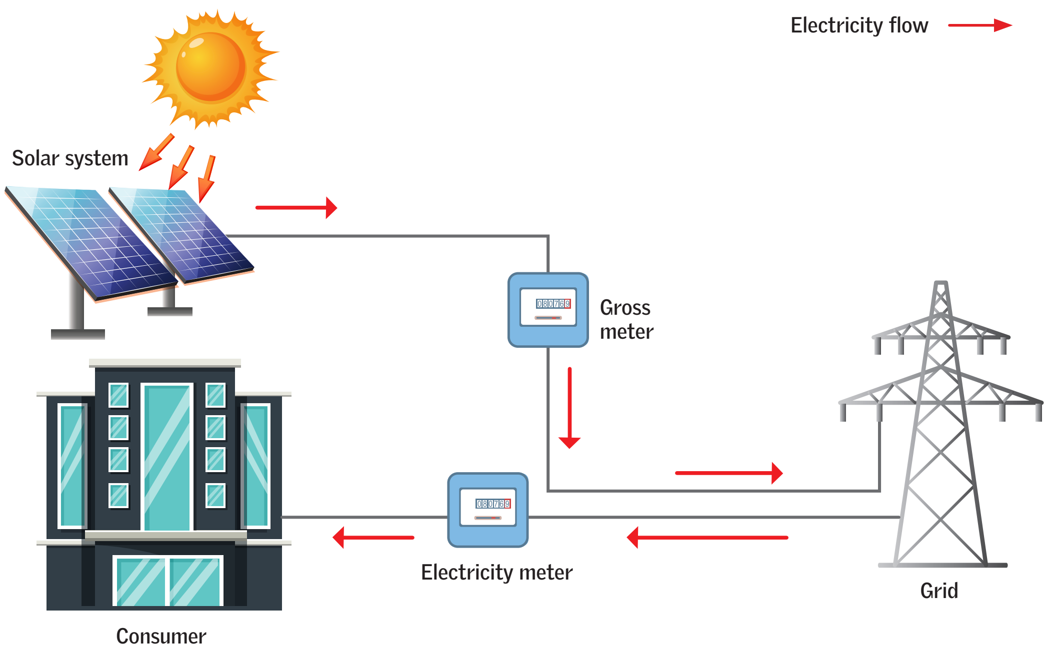
1. Policy level

The rooftop PV goals of states have been issued by the Ministry of New and Renewable Energy (MNRE). District-level solar PV adoption plans are yet to be made. Establishing plans at the district level and the development of steering committees to keep track of the progress can help the states to generate demand and work towards its uniform distribution.

Virtual Net Metering (VNM) policy is a powerful tool to aid demand aggregation at the community level. It is important especially in urban areas where the space for roof is scarce whereas the energy requirement is quite high such as in high-rise apartments. Such specifications in urban areas dictate the necessity of policies in which the end-users can set up a common solar PV plant and share the demand across the city at various points. This is known as solar sharing programme. This will allow the end-user to aggregate the demand in the city (see *Figure 15: Virtual Net Metering*).

It is an innovative business model wherein the power aggregators who are private organizations can aggregate the demand from the end-users and acquire power from different sources such as power exchange, distribution licensees, contracts and agreements. Such power aggregators should also be applicable under Renewable Purchase Obligation (RPO) with incentives provided to increase the rooftop solar PV capacity. Such models would require modifications in the Electricity Act to set a legal precedent to the model.

Figure 15: Virtual net metering



2. Community level

MNRE has assigned states to developing agencies who are in the solar PV domain. Such development firms can form an arrangement within states while working with MNRE and other State Nodal Agencies (SNA) comprising research organization, educational institutions, and non-governmental organizations (NGOs). This arrangement can provide the necessary support to help in demand aggregation, improve understanding and the perception of rooftop solar PV and accelerate its adoption.

3. End-user level

This can be categorized as low-paying and high-paying end-users. For **low-paying end-users**, installation of rooftop solar PV includes cross-subsidized utility rates with subsidies provided by some of the states. The utilities can avail of higher benefits in comparison to the lower returns from the category of end-user post installation. In such cases, the utility can provide financial aid to the end-user category as they do not have access to initial capital investment. This lowers the risk for the bank and allows for easy access to the financing of the project. The energy tariffs are mostly lower than the average cost of supply of the project so the facilitation method is usually favoured for the category of end-user.

For **high-paying end-users**, the energy tariffs are high, so they generally install rooftop solar PV as it has a lower cost than grid power. Commercial and industrial users have limited adoption of rooftop solar PV due to lack of knowledge on the subject. The utilities do the installation and investment in the project to attract and retain the user base. The energy produced is sold to the end-users at a lower rate than the current utility rate.

4. Investment of utility as power producer

In this approach, the utility does the installation and the investment for the rooftop solar PV and takes the energy generated at no charges. The end-users receive discount on the rooftop space utilized. When the discount is calculated in Rs per kilowatt hour, there is no difference in the revenue earned by the utility irrespective of any end-user category. When the discount is calculated in energy credits as percentage of the energy produced, the utility incurs loss in revenue which is higher for high paying end-users. This type of approach is advantageous in areas where there are land issues for the large-scale installation of solar PV projects.

Some of the criterion that should be taken into consideration for Demand Aggregation are losses in distribution, billing efficiency, site accessibility (see *Table 22: Criteria to be taken into consideration for demand aggregation*).

Table 22: Criteria to be taken into consideration for demand aggregation

Criteria for Demand Aggregation	Details
Billing efficiency	At places having low billing efficiency, facilitation method reduces the losses due to low billing income. At places having high billing efficiency, investment method reduces the risks due to cost-benefit.
Losses in distribution	Places incurring high losses in distribution favour the rooftop solar PV installation. Utilization of rooftop solar PV plants lowers the distribution-side losses and also provides support in avoiding the charges due to infrastructure upgradations of the grid.
Site accessibility	Site accessibility is necessary for the installation and maintenance of the rooftop solar PV systems.
Distribution transformer loading	Distribution transformers with bigger loading facility are favoured to lower the daytime peak-load demand.
Interruptions of power	Places where there are less frequent power disruptions are suitable to maximize the output of solar PV generation.
Infrastructure upgradation	Utilities prefer sites where there is no immediate requirement of infrastructure upgradation.

Guidelines for Phase II of the Grid-Connected Rooftop Solar Programme

MNRE had announced the guidelines for implementing Phase-II of the grid-connected rooftop solar programme[29] for achieving a target of 40 GW from rooftop solar PV by 2022 with a Central financial outlay of Rs 118,814 crore. MNRE initiated the Grid Connected Rooftop and Small Solar Power Plant Programme in 2017 with a financial outlay of Rs 5,000 crore for rooftop solar PV projects till 2019–20. Phase I of the scheme faced several challenges including multiple tenders by different organizations, time delays in the installation of the project due to departmental complexities, non-availability of skilled manpower, loosely drafted rooftop solar PV contracts, presence of multiple stakeholders such as state nodal agencies, project developers, DISCOMs, lack of awareness about the project among end-users and lack of uniform regulations.

Phase II guidelines for rooftop solar PV mitigates the challenges faced during the implementation of Phase I of the rooftop solar PV programme and ensures uniformity in implementation through the following ways:

1. Utilities have been assigned as the main implementation medium.
2. Development of single window clearance portal by the utility.
3. Residential sector has been allocated a Central Financial Assistance (CFA) of 40 per cent to promote grid connected rooftop solar PV.
4. Promotion of domestic manufacturing of the solar PV cells and modules.
5. Development of new and sustainable business verticals

(see *Table 23: Component A for setting up of 4 GW of grid-connected rooftop solar projects in residential sector with Central Financial Assistance (CFA), Table 24: Component B for incentives to Electricity Distribution Companies (DISCOMs) based on achievement towards initial 18 GW of grid-connected rooftop solar plants* and *Table 25: Incentive mechanism for rooftop solar PV*).

Existing demand aggregation case studies in India

The first rooftop solar PV demand aggregation was established by the Gujarat government in Gandhinagar[30] by the International Finance Corporation in public–private partnership (PPP) mode in 2010. The quantum aggregated was 5 MW, 80 per cent of which was implemented in predetermined government buildings and the rest in developer-identified private buildings. The project was implemented by Gujarat Power Corporation Limited (GPCL). The build-own-operate model was used for the installation of rooftop solar PV projects and the power generated from the projects was sold to the utility (see *Table 26: Price quoted by bidders for 2.5-MW plant*).

Table 23: Component A for setting up of 4GW of grid-connected rooftop solar projects in residential sector with Central Financial Assistance (CFA)

Component A: Setting up of 4GW of grid-connected rooftop solar projects in residential sector with Central Financial Assistance (CFA)	
Type of residential sector	CFA (as percentage of benchmark cost or cost discovered through competitive process whichever is lower)
Residential sector (maximum up to 3 kW capacity)	40 per cent of benchmark cost**
Residential sector (above 3 kW capacity and up to 10 kW capacity)*	40 per cent up to 3 KW Plus 20 per cent for RTS system above 3 kW and up to 10 kW
Group Housing Societies/Residential Welfare Associations (GHS/RWA) etc. for common facilities up to 500 kWp (@ 10 kWp per house), with the upper limit being inclusive of individual rooftop plants already installed by individual residents in that GHS/RWA at the time of installation of RTS for common activity.	20 per cent

* The residential sector users may install RTS plant of even higher capacity as provisioned by respective State electricity regulations; however, the CFA will be limited up to 10 kWp capacity of RTS plant.
** Benchmark cost may be different in General Category States/UTs and Special Category States/UTs, i.e. Northeastern states including Sikkim, Uttarakhand, Himachal Pradesh, Jammu and Kashmir, Lakshadweep, and Andaman and Nicobar Islands. CFA shall be on benchmark cost of MNRE for the state/ UT or lowest of the costs discovered in the tenders for that state/UT, whichever is lower.

Source: Ministry of New and Renewable Energy (MNRE)

Table 24: Component B for incentives to Electricity Distribution Companies (DISCOMs) based on achievement towards initial 18 GW of grid-connected rooftop solar plants

Component B: Incentives to Electricity Distribution Companies (DISCOMs) based on achievement towards initial 18 GW of grid-connected rooftop solar plants	
Parameter	Incentive to be provided
For installed capacity achieved above 10 per cent and up to 15 per cent over and above of the installed base capacity* within a financial year	5 per cent of the applicable cost** for capacity achieved above 10 per cent of the installed base capacity
For installed capacity achieved beyond 15 per cent over and above of the installed base capacity* within one financial year	5 per cent of the applicable cost** for capacity achieved above 10 per cent and up to 15 per cent of the installed base capacity PLUS 10 per cent of the applicable cost** for capacity achieved beyond 15 per cent of the installed base capacity

* Installed base capacity shall mean the cumulative RTS capacity installed within the jurisdiction of DISCOM at the end of previous financial year. This will include total RTS capacity installed under residential, institutional, social, government, PSU, statutory/ autonomous bodies, private commercial, industrial sectors etc.
** Applicable cost is the applicable benchmark cost of MNRE for a state/UT for mid-range RTS capacity of above 10 kW and up to 100 kW or the lowest of the costs discovered in the tenders for that state/UT in that year, whichever is lower.

Source: Ministry of New and Renewable Energy (MNRE)

Table 25: Incentive mechanism for rooftop solar PV

DISCOMs	Installed base capacity (MW)	Achievement under programme (MW)	Percentage achievement of installed base capacity (per cent)	Capacity eligible for 5 per cent incentives (MW)	Capacity eligible for 10 per cent incentives (MW)
A	100 MW	10 MW	10 per cent	Nil	Nil
B	100 MW	12 MW	12 per cent	2 MW	Nil
C	100 MW	20 MW	20 per cent	5 MW	5 MW
D	100 MW	30 MW	30 per cent	5 MW	15 MW
Note: The capacity eligible for incentives by DISCOMs would cover the entire capacity installed including the capacity installed without CFA and with CFA					

Source: Ministry of New and Renewable Energy (MNRE)

Table 26: Price quoted by bidders for 2.5-MW plant

Developer	Price (Rs per kilowatt-hour)
Azure	11.21
Sun Edison	11.793

Source: International Finance Corporation

The pilot project of Gandhinagar was recreated in other cities of Gujarat, with a total aggregated demand of 25 MW.

The state governments of Odisha and Madhya Pradesh had installed rooftop solar PV projects under the PPP mode, with a total aggregated capacity of 4 MW and 5 MW.

Some of the benefits accrued due to the deployment of rooftop solar PV as part of numerous programmes are:

a. Standardized rooftop solar PV;
b. Growth in the rooftop solar PV sector;
c. Improvements in the fund allocation from various financial institutions;
d. Awareness building among end-users;
e. Boosting the confidence of stakeholders in the rooftop solar PV sector; and
f. Increased deployment of clean energy resources.

Some of the initial demand aggregation programmes installed earlier helped in reduction of the overall cost of solar power.

The role of the aggregator has been categorized based on the facilitation approach and the investment approach. Some of the programmes under the approaches have been discussed in the following:

Facilitation

Surat Smart City Rooftop Solar PV Project

The campaign for the installation of rooftop solar PV in Surat smart city was undertaken by Surat Municipal Corporation (SMC) in 2016. The need of the hour was for the Smart City to meet 10 per cent of its energy requirements through solar energy. SMC was the facilitating agency and initiated the development of the solar guidebook and android application to provide end-users with a one-step platform. Through student volunteers, a campaign activity was conducted for the installation of the rooftop solar PV. The project included planning, consultations with the stakeholders, demand aggregation from selected end-users and communication with the end-users.

The following are detailed activities involved in the programme:

a. Awareness campaign
   i. Campaign activity was conducted through volunteers
   ii. Media, public hoardings were utilized

b. Android application and guidebook
   i. Android application was developed for a single-window platform information for stakeholders
   ii. Solar guidebook was developed for the end-users

c. Site analysis
   i. The details of the rooftop of interested end-users were collected.

d. Trainings and workshops
   i. Workshop were conducted for residential and industrial users as part of the capacity-building process.

e. Implementation
   i. About 11 MW of the total 15 MW capacity implemented was for residential users.

Collab Solar

This project was implemented in 2014 as a collaboration between the World Resources Institute India and Confederation of Indian Industry through the Green Power Market Development Group initiative to aggregate the energy demand from six corporates in Bengaluru.[31]

Some of the activities that were part of the initiative included:

i. Meeting with the potential bidders and creating awareness about the programme;

ii. Collection of statistics and site analysis through door-to-door surveys and site visits;

iii. Preparation and release of request for qualification, and circulating the results to the bidders;

iv. Awareness generation through conducting webinars;

v. Price discovery and negotiation with bidders and selection of the prospective bidders;

vi. Preparation of the request for proposal and circulating the results with the bidders;

vii. Price discovery and negotiation with the bidders; and

viii. Selection of the prospective bidder and signing of contract.

Role of the stakeholders in the project

i. The Confederation of Indian Industry organized two consultation meetings attended by large corporate buyers, clean energy suppliers and officials from Karnataka and released the Request for Qualification (RFQ) and Request for Proposal (RFP) into the market.

ii. The World Resources Institute prepared the questionnaire and presented it among the buyers, conducted site visits to verify the data provided by interested end-users, prepared and circulated RFQ documents and did response analysis, conducted webinars for information sharing and generating awareness to provide all bidders a common point of reference, prepared and circulated the

RFP and evaluation of the same, shared results with the bidders, and anchored the process of contract signing.

It was concluded from the process that the best results were achieved through aggregation between three to five large bidders with a demand of 1 mega unit per annum along with small bidders. Large bidders reduced the financing costs of the project and ensured confidence among the financial institutions to invest in such projects.

Solarise Dwarka

BSES Rajdhani Power Limited (BRPL) partnered with Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ India)[32] under its project Indo-German Solar Energy Partnership (IGSP) to implement the initiative Solarise Dwarka. Solarise Dwarka is an example of the "utility-anchored rooftop programme" for the residential owners of south and west Delhi areas to maximize their potential of rooftop solar PV potential.

Role of BRPL in the project

i. Post-installation inspection for quality assessment and ensure meeting the minimum technical requirements

ii. Providing net metering facilities to the end users.

Role of stakeholders

i. BRPL provided information to the end users for selection of vendors

ii. BRPL conducted suitability analysis at the application stage to check the documents, and for the testing and installation of the solar meter.

The rooftop solar PV installation was done at a single point for each of the residential complexes. BRPL aggregated the interested end-users in its distribution area and the vendors for the rooftop solar PV empanelled by IPGCL, MNRE or SECI. The project was based on the Delhi Electricity Regulatory Commission Net Metering Regulations, 2014 and Delhi Solar Policy 2016 to increase the adoption of rooftop solar PV in the state. In its first phase, the residential complex of Dwarka was targeted with plans to expand it to other nearby areas.

Investment

Madhya Pradesh Urja Vikas Nigam Limited

Bids were invited by Madhya Pradesh Urja Vikas Nigam Limited (MPUVNL) under Madhya Pradesh Resco III. This was the first tender of rooftop solar PV in the country under demand aggregation for Mandideep Industrial Area in Bhopal.

Role of the stakeholder in the project

i. As a bidder MPUVNL undertook all works related to the commissioning and operations for 25 operational years of the plant

ii. As a power generator synchronized the plant with licensee's network under the Madhya Pradesh Policy for Decentralized Renewable Energy Systems, ensured metering and grid connectivity and undertook operation and maintenance (O&M) of the plant up to a period of 25 years from the first part of commissioning or Scheduled Operation date, whichever was earlier;

iii. Acquired insurance for third-party liability covering loss of human life and risks of equipment after work completion;

iv. Maintained conformity to warranty and guarantee clauses and the settlement of issues;

v. Ensured signing of PPA by end-users with the power generators and contributed vacant roof space to the power generators for the installation of the plant.

The selection of the project developer was done based on the reverse e-auction process. About 10.8 MW capacity was involved in this project. The price discovered of Rs 4.61 per unit was less than MPUVNL's price of Rs 7.50 per unit. Around 164 (small, medium and large) industries were to procure solar power under the RESCO model. The industries were put in three groups, each having a capacity of 3.6 MW. This project was implemented as part of the rooftop solar PV programme of the Central government with support from the World Bank.

Kerala State Electricity Board

The government of Kerala started the Soura Scheme in 2018, with technical assistance from Asian Development Bank (ADB), to target the state's installation of ground-mounted and rooftop solar PV plants with an aggregated capacity of 1,000 MWp. The Kerala State Electricity Board (KSEB) developed a Special Purpose Vehicle (SPV) to make it easier to install the project. Bids were invited to empanel EPC contractors and project developers for design, supply, installation, testing and commissioning of grid-tied rooftop solar PV and ground-mounted solar PV plants with an aggregated capacity of 50 MWp under the EPC category and 150 MWp under the tariff category, including O&M of the plant.

Role of stakeholders

1. EPC
   i. Developed installations and other works according to the Central Electricity Authority (CEA) standards,

   ii. Installed net meters and energy meters and developed the distribution infrastructure from the solar production facility to the interconnection section of the solar power equipment and data acquisition and communication system

   iii. Development of plant O&M

   iv. Installed weather monitoring station at the plant for capacity of above 50 kWp

2. State Nodal Officer (SNO)
   i. Helped in providing sanctions and approval from appropriate authorities

   ii. Collected approval of building and land owners for installations of rooftop solar PV

   iii. Assessed the quality and performance of rooftop solar PV plants on behalf of the end users

   iv. Made payments to EPC contractors, thereby providing payment assurance to them

3. End-users
   i. Submission of application for the installation of the rooftop solar PV project and selection of suitable business model

   ii. Signed contract with SNO and KSEB based on the selected business model, and contributed rooftop space to the EPC contractor for installation.

The registration process of the demand aggregation scheme was done through online mode by KSEB in July 2018 and closed on January 31, 2019. A total of 278,257 end-users registered under three business models, namely,

(i) Roof lease model

(ii) Master RESCO model and

(iii)EPC model.

The survey of the residential end users was conducted by KSEB and an android application to gather the details of the survey. Later, a web application was developed to select the best roof space out of 278,264 registrations. Around 70,000 applicants had the best rooftops for solar installations based on the results of the application. KSEB deployed three EPC contractors through a competitive bidding process for installing 46.5 MW rooftop solar PV projects under the aforementioned business models. Till March 2022, about 15.627 MW of rooftop solar capacity has been installed.

Other Demand Aggregation Programmes

The Off-grid Solar PV programme is one of the oldest programme offered by MNRE which aims to provide solar PV based applications in the areas where grid power has not penetrated or cannot be relied on. Various applications such as solar home lighting systems, solar street lighting systems, solar power plants/ packs, solar pumps, solar lanterns, and solar study lamps are covered under this programme.

Under the National Solar Mission, a target of 2000 MWp was fixed for off-grid solar PV applications. Under Phase-I of the Mission (2010–13), a target of 200 MWp was fixed against which 253 MWp was sanctioned. Under Phase-II (2013–17), a target of 500 MWp was fixed against which 713 MWp has been sanctioned. Under Phase-III of the Off-grid and Decentralised Solar PV Applications Programme (2017–22), a target of 118 MW has been fixed, excluding solar pumps—which are to be installed under PM KUSUM Scheme—and solar home lights, which are being implemented under the Saubhagya Scheme of the Ministry of Power (see *Table 27: Status of off-grid solar PV programmes under MNRE*).

i. Pradhan Mantri Kisan Urja Suraksha evam Uthaan Mahabhiyaan (PM-KUSUM)

Standalone solar pumps were associated with the off-grid solar applications till 31st March 2017. The Government of India in 2019 started the Pradhan Mantri Kisan Urja Suraksha evam Utthan Mahabhiyan (PM KUSUM)[33] aimed at installing new standalone pumps in off-grid regions as well as solarising existing grid-connected

Table 27: Status of off-grid solar PV programmes under MNRE

System	No. of units/capacity installed
Solar lamps/lanterns	65,17,180
Solar pumps	2,37,120
Solar street lights	6,71,832
Solar home lighting systems	17,15,639
Solar power plants/packs	212 MWp

Source: Ministry of New and Renewable Energy

pumps. The objective of the KUSUM scheme was to set up 30.8 GW of solar power with a total Central financial aid of Rs 34,422 crore, including service charges to the implementing agencies for the agriculture sector. The components under the PM KUSUM scheme include:

a) **Component-A:** Setting up of 10,000 MW of decentralized ground/stilt-mounted grid connected Solar or other Renewable Energy based Power Plants;

b) **Component-B:** Installation of 20 lakh standalone solar agriculture pumps; and

c) **Component-C:** Solarization of 15 lakh grid-connected agriculture pumps.

a) **Component A:** Under this component, solar-energy-based power plants (SEPP) of capacity 500 kW–2 MW would be set up by individual farmers, groups of farmers, cooperatives, panchayats, farmer producer organizations (FPO), water user associations (WUA), hereinafter referred to Solar Power Generators (SPGs). If the above specified entities are not able to arrange equity required for setting up the SEPP, they can opt for developing the SEPP through developer or even through a local DISCOM that would then be considered as an SPG in this case.

DISCOMs will notify substation-wise surplus capacity, which can be fed from such SEPP to the grid and shall invite applications from interested beneficiaries for setting up the solar energy plants.

The solar power generated will be purchased by DISCOMs at a feed-in-tariff (FiT) determined by the respective State Electricity Regulatory Commissions (SERCs). The DISCOM would be eligible to get Procurement-Based Incentive (PBI) @ Rs 0.40 per unit purchased or Rs 6.6 lakh per MW of capacity installed, whichever is less, for a period of five years from the Commercial Operation Date (COD).

b) **Component B:** Individual farmers will be supported to install standalone solar agriculture pumps of capacity up to 7.5 HP in off-grid areas, where the grid supply is not available.

A CFA of 30 per cent of the benchmark cost or the tender cost, whichever is lower, of the standalone solar agriculture pump will be provided. The state government will give at least a subsidy of 30 per cent; and the remaining—at most 40 per cent—will be provided by the farmer. Bank finance can be availed by farmer, so that farmer has to initially pay only 10 per cent of the cost and remaining up to 30 per cent of the cost as loan.

In the Northeastern States, Sikkim, Jammu and Kashmir, Himachal Pradesh and Uttarakhand, Lakshadweep and the Andaman and Nicobar Islands, a CFA of 50 per cent of the benchmark cost or the tender cost, whichever is lower, of the standalone solar pump will be provided. The state government will give a subsidy of at least 30 per cent; and the remaining—at most 20 per cent—will be provided by the farmer.

c) **Component C: Individual-pump solarization (IPS):** Individual farmers with a grid-connected agriculture pump will be supported to solarize pumps. Solar PV capacity up to two times of pump capacity in kW is allowed under the scheme.

The farmer will be able to use the generated solar power to meet the irrigation needs and the excess solar power will be sold to DISCOMs.

A CFA of 30 per cent of the benchmark cost or the tender cost, whichever is lower, of the solar PV component will be provided. The state government will give a subsidy of at least 30 per cent; the remaining—at most 40 per cent—will be provided by the farmer. Bank finance can be availed of by farmer so that the farmer has to initially pay only 10 per cent of the cost and remaining up to 30 per cent of the cost as loan.

In the Northeastern states, Sikkim, Jammu and Kashmir, Himachal Pradesh and Uttarakhand, Lakshadweep and the Andaman and Nicobar Islands, a CFA of 50 per cent of the benchmark cost or the tender cost, whichever is lower, of the solar PV component will be provided. The state government will give a subsidy of at least 30 per cent; the remaining—at most 20 per cent—will be provided by the farmer.

Component C: Feeder-level solarization (FLS)
The states can instead of individual solar pumps solarize agriculture feeders. Guidelines were issued on December 4, 2020.

Where agriculture feeders are not separated, loan for feeder separation may be taken from NABARD or PFC/REC. Further, assistance for feeder separation may be availed of from the Revamped Distribution Sector Scheme (RDSS) of the Ministry of Power. However, mixed can also be solarized.

Solar plants of capacity that can cater to the requirement of the agriculture load of the selected feeder can be installed through the CAPEX or RESCO mode for a project period of 25 years.

CFA of 30 per cent on the cost of installation of solar power plant (up to Rs 1.05 crore/MW) will be provided. In the Northeastern states, Sikkim, Jammu and Kashmir, Himachal Pradesh and Uttarakhand, Lakshadweep, and the Andaman and Nicobar Islands, however, can avail of a 50 per cent subsidy.

Farmers will get daytime reliable power for irrigation free of cost or at tariffs fixed by their respective states.

ii. **Pradhan Mantri Sahaj Bijli Har Ghar Yojana** (**Saubhagya**)
The government of India launched the Pradhan Mantri Sahaj Bijli Har Ghar Yojana (Saubhagya)[34] scheme in October 2017 to focus on the last-mile connectivity and electricity connections to all the unelectrified households in the country. The outlay for the scheme is Rs 16,320 crore, which includes the Gross Budgetary Support of Rs 12,320 crore. REC is the Nodal Agency for implementation of the scheme.

The Saubhagya scheme aims to achieve:

a) Last-mile connectivity and electricity connection to all unelectrified households in rural areas;

b) Last-mile connectivity and electricity connection to all remaining economically poor unelectrified households in urban areas. Non-poor urban households are excluded from this scheme;

c) Solar photovoltaic (SPV)-based standalone system for unelectrified households located in remote and inaccessible villages or habitations, where grid extension is not feasible or cost effective. Under the scheme, Rs 14,109 crore (including grant of Rs 9,093 crore) has been sanctioned by the Ministry of Power to 26 states/Union Territories, against which Rs 8,840.9 crore (including a grant of Rs 5,408.44 crore) has been released till June 30, 2021. As of March 31, 2019, the country achieved electrification of 262.84 lakh households under Saubhagya (except a minuscule 18,374 households in Left Wing Extremism (LWE) areas of Chhattisgarh)—remarkable progress in a record 18 months. The achievement of universal household electrification, which implies 100 per cent access to electricity has been certified by the Chief Secretaries of States. Further, on the request of seven states (Assam, Chhattisgarh, Jharkhand, Karnataka, Manipur, Rajasthan and Uttar Pradesh), the Ministry of Power accorded time-extension approval to electrify an additional 19.09 lakh unelectrified households, which were unwilling earlier to get electrified and had expressed their willingness before March 2019. A total of 18.85 lakh households have been electrified in respect of the same and the states have reported 100 per cent electrification of all willing households identified before March 31, 2019.

4

ANALYSIS AND RECOMMENDATIONS

- RTS PV CAN LEAD TO SIGNIFICANT SAVINGS IN STATES WHERE T&D LOSSES ARE HIGH.
- THIS ANALYSIS PRESENTS A HIGH-LEVEL APPROACH TOWARD INCREASING RESIDENTIAL RTS CAPACITY, THEREBY INCREASING THE SHARE OF CLEAN POWER IN ACHIEVING 10 PER CENT OF THE DEMAND FOR RESIDENTIAL ELECTRICITY IN 2030 IN A CONSERVATIVE SCENARIO.
- COMMUNITY SOLAR CAN BE A FORM OF AGGREGATION MODEL FOR RESIDENTIAL END-USERS.
- DISCOM-DRIVEN DEMAND AGGREGATION CAN PROVE TO BE A SUCCESSFUL ENDEAVOUR TO IMPROVE AND ACCELERATE DEPLOYMENT OF ROOFTOP SOLAR PV IN INDIA.

Analysis

To understand implications of the residential rooftop solar PV through active interventions of DISCOMS, we have carried out a cost–benefit analysis considering various parameters for DISCOMs operating in 10 select states. The business case has been evaluated by analysing the procurement cost and volume of conventional and solar power specifically to meet the residential power demand and supply by the DISCOMs in these states. The analysis reveals a net per unit cost saving potential for most of the states and indicates towards a favourable business case for RESCO-based solar power projects by DISCOMs.

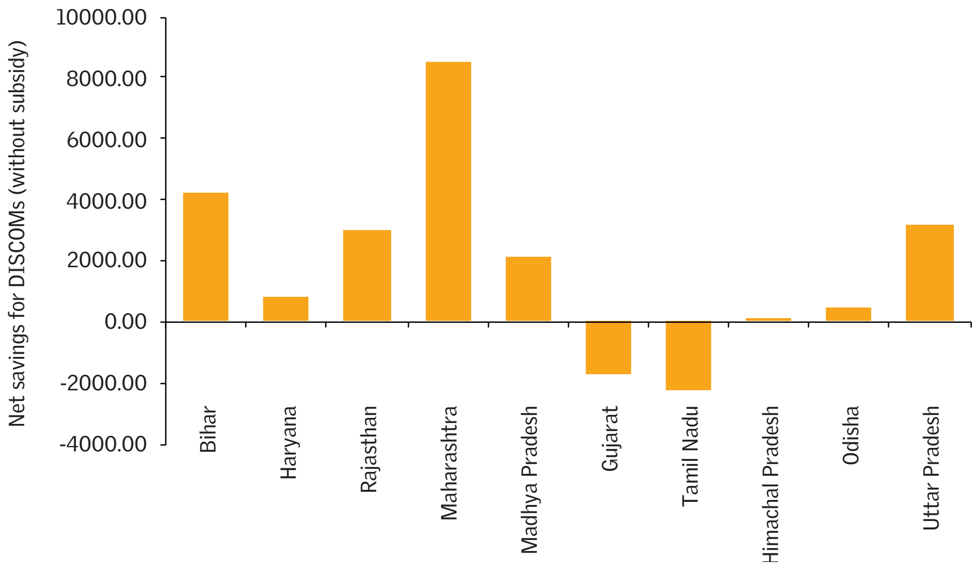
For the financial assessment of the 10 Indian states, the statistics such as procurement cost, volume and tariff of supply to residentials, including losses as reported in the petitions and state regulatory orders, have been considered for FY 2020–21 due to the paucity of data for recent financial years for all the states. The cost–benefit analysis was done considering 10 per cent additional penetration of clean power from RTS PV plant to the residential consumers with and without subsidy from the government. The discussion, however, focusses more on cost savings achieved through RTS PV without subsidy component, assuming a flat RTS PV power procurement cost of Rs 4 per unit. Based on the analysis it can be inferred that DISCOMs will be able to save Rs 0.34–Rs 1.95 per unit through procurement of solar power to meet 10 per cent of the residential electricity demand.

From the analysis it can be inferred that the states find subsidies provided by the government beneficial. If Gujarat and Tamil Nadu, two of the analysed states, don't avail of any subsidy when the cost of power supplied to residential owners is 23 per cent of the actual cost, they do not show benefit due to penetration of RTS PV. The merit of a DISCOM depends on three important factors—the cost of power purchase, cost of power supplied to residential end-users and transmission and distribution (T&D) losses.

The following scenarios try to understand the factors for the states in which RTS PV does not result in significant savings over conventional power:

Scenario I: The tariff for the residential end-users is quite low—at Rs 3.64 and Rs 3.27 respectively—in the case of Gujarat and Tamil Nadu due to which net savings for DISCOMs without subsidy is very low and does not result in significant savings for the DISCOMs. When the tariff for the residential end-users is increased by 23 per cent, net savings to DISCOMs increase marginally for these two states (see *Graph 3: Annual net savings (in Rs million) by RTS PV without subsidy for states in India*).

Graph 3: Annual net savings (in Rs million) by RTS PV without subsidy for states in India



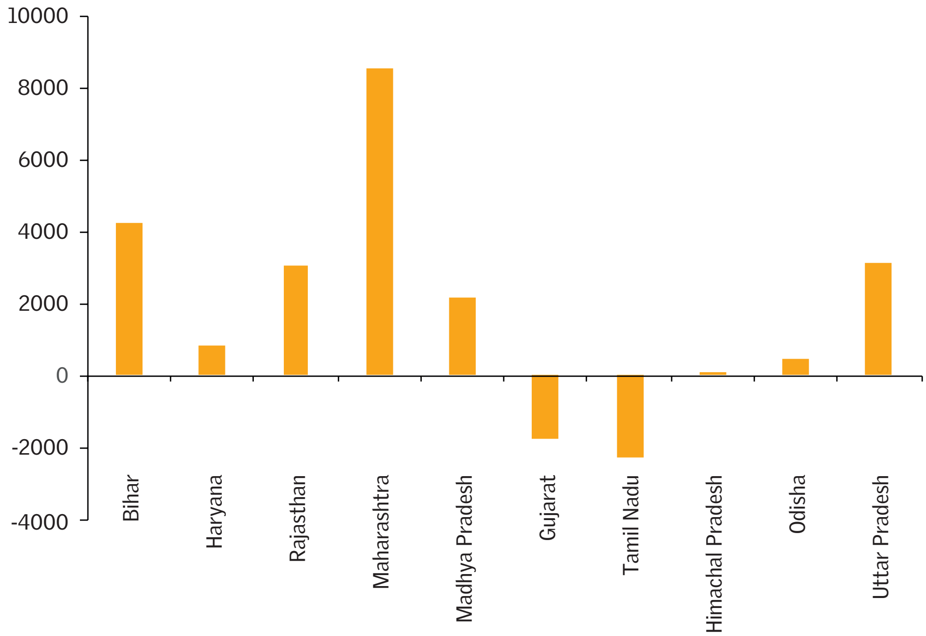
Source: CSE analysis

Scenario II: T&D losses are appreciably low in the case of Maharashtra, at 11 per cent. When T&D losses are increased by 5 per cent from the actual, net savings for DISCOM for both Gujarat and Tamil Nadu increase from the actual losses reported as 14 per cent and 16 per cent, respectively. This implies that RTS PV can lead to significant savings in states where T&D losses are reportedly high (see *Graph 4: Annual net savings [in Rs million] for DISCOMs [without subsidy] when T&D loss is 5 per cent of the actual loss*).

Scenario III: The cost of power purchase is the lowest—at Rs 2.49 per unit in case of Himachal Pradesh—coupled with a comparatively small volume of power supplied to residential consumers. Power procured from RTS PV still results in net savings to DISCOMs, factoring in the T&D losses. The low cost of power procurement in the state can be attributed to the surplus power generation from its various hydropower plants while the consumption of the energy is lower in terms of gross volume (see *Graph 5: Annual savings [in Rs million] for DISCOMs [without subsidy] when cost of power supplied to residential end-users is 23 per cent of actual cost*).

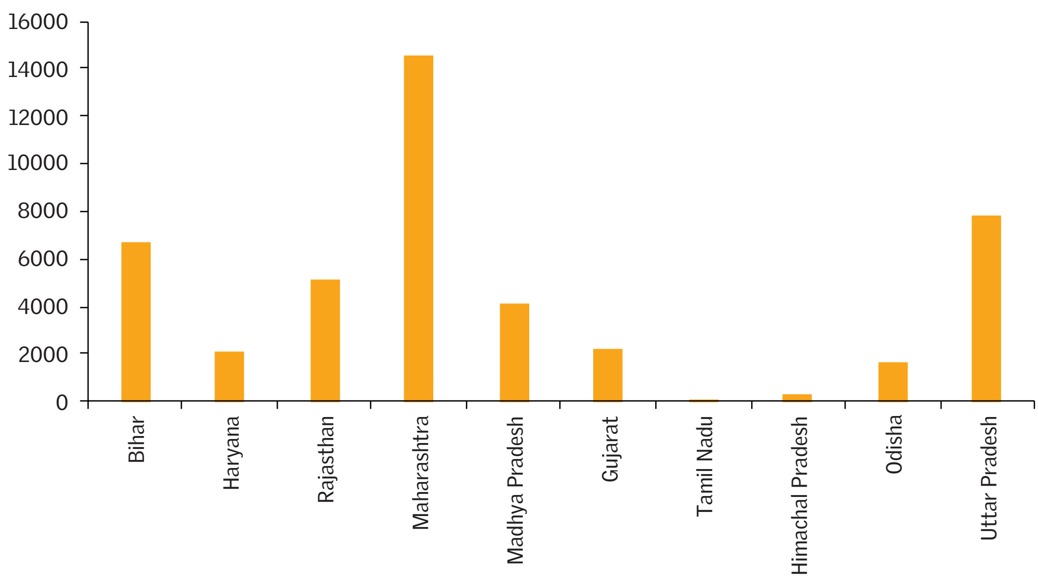
The states of Gujarat and Tamil Nadu can implement RTS PV in the residential areas as it can be commercially successful for these states. It is recommended that the deployment of RTS PV should be done in areas where the T&D losses are high.

Graph 4: Annual net savings (in Rs million) for DISCOMs (without subsidy) when T&D loss is 5 per cent of the actual loss



Source: CSE analysis

Graph 5: Annual savings (in Rs million) for DISCOMs (without subsidy) when cost of power supplied to residential end-users is 23 per cent of actual cost



Source: CSE analysis

Based on the analysis, the DISCOMs can calculate the maximum value of the T&D loss beyond which the RTS PV can be beneficial for them.

The per unit savings of the DISCOMs increase as T&D losses in the region increase. The RTS PV penetration level, however, increases the total savings for the DISCOMs.

Financially, the savings of the DISCOMs can be useful in many ways, e.g. lowering the consumer tariff, lowering the cross-subsidy, lowering the direct subsidy and profit sharing with end-users among others.

If we take the case of Odisha, the government provided a subsidy of Rs 0.10/kWh for low tension (LT) consumers. By substituting 10 per cent of the LT consumers with RTS PV, the government of Odisha can lower the direct subsidy provided to its DISCOMs by Rs 488 million. One of the important benefits of deploying RTS PV for low-paying end-users is the lowering of transmission and distribution (T&D) losses in areas that have been difficult for the utility to manage as the systems would facilitate local generation and distribution incurring less losses as compared to the total T&D loss for the DISCOM representing the entire jurisdiction.

Contributions from residential rooftop solar PV

India is still far behind the target set by the Government of India of achieving 40 gigawatt (GW) of rooftop solar PV installation by 2022. The year of achieving the RTS PV installation target has recently been revised by the government to 2026; the capacity however remains unchanged. There have been numerous new technologies that have been introduced to lower energy consumption such as light-emitting diode (LEDs) and brushless direct current motor (BLDC), which would help in improving grid resiliency. When the grid is unidirectional, power can be injected by only one generator such as thermal power plants. Now with the generation from RTS PV being fed to the grid, the grid can accept power from both fossil-based generations and clean power. But the grid is still largely unidirectional in nature, and is expected to become bidirectional in the future.

Urban areas include a large number of residential buildings and structures that can generate a lot of clean power. With the introduction of new solar PV panel technologies such as building integrated photovoltaics (BIPV)—which can work effectively with more clean power generated from the building injected into the grid through net-metering technology—more clean energy can be fed into the grid. This would lead to an overall increased generation of clean energy share from the residential sector, with reduced consumption from the grid.

Residential RTS PV has a nominal share, with about 2 GW accounting for about 20 per cent of the overall RTS PV capacity. This does not indicate a confidence in the residential sector itself, which in the first place is fraught with several challenges. This report argues basis cost–benefit analysis for DISCOM-driven residential RTS PV in the 10 selected states that the residential rooftops can contribute about 29 GW of residential RTS PV by 2030 even if the most conservative approach is followed. The analysis assumes an overall 10 per cent additional supply of clean power to the residential consumers both urban and rural to be achieved by the end of 2030.

As per the analysis, beginning with 0.15 per cent of total rural households (which approximately is about 200 million) connecting to residential rooftop systems and increasing the household coverage by additional 0.15 per cent every year, the DISCOMs will be able to add about 8GW of residential RTS capacity from rural residential rooftops alone by 2030, with an average rural residential RTS installed capacity of 1 kilowatt peak (kWp).

Similarly, DISCOMs in these 10 states can maximize utilization of available rooftop spaces in urban areas for RTS with 0.15 per cent conversion and adding additional 0.15 per cent in the subsequent year of total urban households (approximately 100 million). Secondary information available in the public domain suggests current coverage of urban residential rooftop is only 0.4 per cent (about 400,000 households), with an average RTS capacity of 5 kWp. It would translate to a total capacity addition of about 21 GW of RTS from urban residential rooftop by the end 0f 2030.

In terms of clean power generation, states will be able to achieve 10 per cent share of RTS power in the overall residential electricity demand in 2030 (estimated with a 5 per cent annual increase in the residential power demand). In the first year (2024), DISCOMS in the selected 10 states can add 1,054 megawatt (MW) reaching a total residential RTS capacity of 29 GW by 2030, with a combined (urban and rural) compound annual growth rate (CAGR) of 20 per cent.

The analysis presents a high-level approach towards increasing residential RTS capacity, thereby increasing the share of clean power in meting out the residential electricity demand by 10 per cent in 2030 in a very conservative scenario. Beginning with a contribution of a mere 1.3 per cent in 2024, residential RTS capacity can rise steadily by 1–2 per cent every subsequent year until it reaches 10 per cent by 2030.

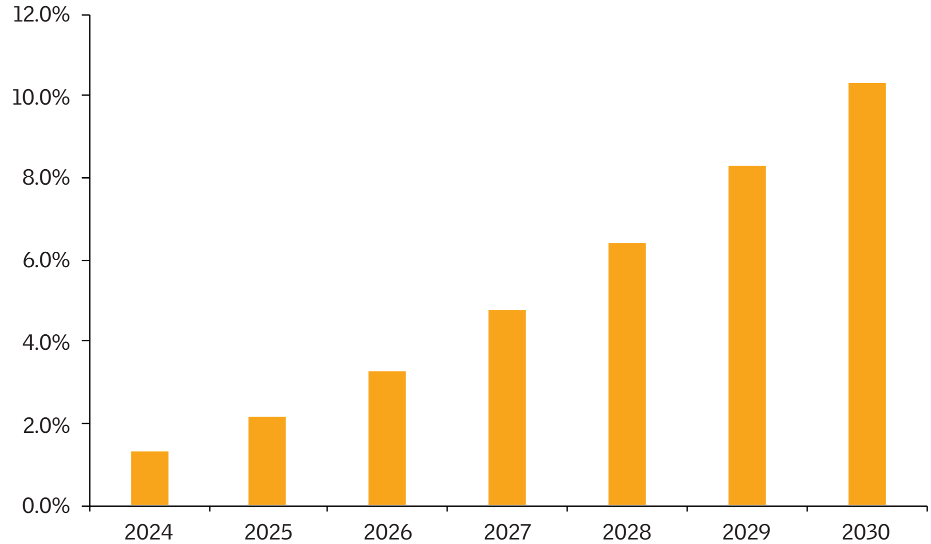
It is, however, also imperative to suggest an indicative approach towards achieving the target. In terms of the number of rural households that would be required to be connected with RTS in the first year cumulatively in all these 10 states is about 300,000, i.e. about 30,000 rural household to be connected to RTS in every state. At the DISCOM level, the number is reduced further to 7,500 per DISCOM assuming four DISCOMS operate in every state, which in terms of RTS capacity translates to 7.5 MW. This seems a reasonable target to be achieved considering the spread of DISCOMs territory, which usually comprises 10 districts. 7.5 MW of RTS can be achieved, distributing the total capacity across 10 districts with about 750 kWp size in each district. Similarly, in urban settlements, DISCOMs can begin with a cumulative rooftop capacity of 2 MWp in the first year and make a steady progress thereupon.

In a more aggressive scenario, DISCOMs will have to be more proactive to reach a 10 per cent share of solar power to meet the residential demand in the very first year. This would require a capacity addition of an overall 18 GW in the very first year at 3 per cent household penetration for RTS in both urban and rural areas. By the end of 2030, however, states will be able to generate solar power from RTS equivalent to double the residential electricity demand. In all likelihood, it presents a very difficult target to achieve with the limited resources and capacities DISCOMs may have in pursuing RTS.

In a conservative scenario, residential RTS PV can contribute significantly towards the RTS PV target of 40 GW envisaged to be achieved by 2026. By the end of the target year 2026, the 10 selected states can add a total residential RTS capacity of 16 GW, making the total residential RTS capacity of 18 GW, including 2 GW capacity that has been achieved so far. This implies a contribution of 45 per cent to the overall RTS target to catch up with the contribution of C&I—which leads with an 80 per cent contribution—against a current contribution of only 20 per cent .

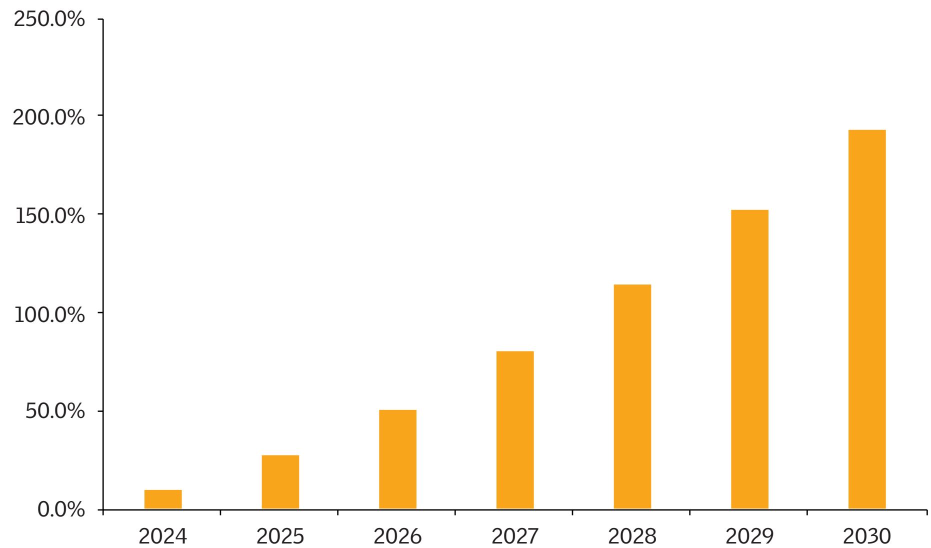
The territory of a DISCOM usually comprises around 10 districts. 7.5 MW of RTS can be achieved distributing the total capacity across 10 districts of about 750 kWp size in each district. Similarly, in urban settlements, DISCOMs can begin with a cumulative rooftop capacity of 2 MWp in the first year and make steady progress thereupon (see *Graph 6: Year-wise share of solar power in residential supply from RTS PV with an annual 0.15 per cent household penetration [urban and rural]* and *Graph 7: Year-wise share of solar power in residential supply from RTS PV with an annual 3 per cent household penetration [urban and rural]*).

Graph 6: Year-wise share of solar power in residential supply from RTS PV with an annual 0.15 per cent household penetration (urban and rural)



Source: CSE analysis

Graph 7: Year-wise share of solar power in residential supply from RTS PV with an annual 3 per cent household penetration (urban and rural)



Source: CSE analysis

When we take an incremental growth rate of 3 per cent from the residential sector, the projected increase in the contribution from RTS PV by 2030 works out to 193 per cent. Achieving a percentage share of 50 per cent of solar power from RTS PV in urban and the rural areas by 2026 would mean achieving half of the required capacity of 40 GW by 2026 and injection of more clean power into the grid.

A cluster-based approach would help in increasing the uptake of the RTS PV in areas which have similar characteristics in the units such as similar geographical location, similar technology deployed in the location, similar development issues. The collection of information and understanding of the issues in such cases tend to become easier and more resource efficient. This leads to more conclusive takeaways from such an approach. The electricity consumption in a cluster shows the potential that rooftop solar PV systems have in such units to reduce the expenses incurred in meeting their electricity/energy demand.

To compute the percentage of penetration of residential RTS PV, a bottom-up approach was considered. This involved making an assumption about the number of households in rural and the urban areas, energy consumption through solar PV and the annual household conversion rate.

Methodology for understanding the business case

It was necessary to have statistics for the same year for all the ten states in order to do a relevant assessment. The analysis done here takes FY 2020–21 as the base year. More recent statistics were available for a few states but not for all the ten states mostly due to lags in orders on the annual revenue requirement (ARR) and consequences of the COVID-19 outbreak. The main purpose of doing the analysis was to calculate the financial gains of the utility and to comprehend the perception of end-users. The current financial gains and losses can be computed easily by using the current data and it will not modify the results of validation.

Much of the statistics were taken from the ARR orders of the individual states. The statistics were augmented by the ARR petitions filed by the state utilities, and the annual reports of the state utilities. The statistics used include energy sales, quantum of power purchase, cost of power purchase, transmission and distribution losses, direct subsidy and tariff schedule.

The cost of generation from RTS PV for residential end-users has been assumed to be Rs 4/kWh for FY 2020–21.

To calculate the benefit or loss of rooftop solar PV to the utilities, states and end-users, the power purchase cost (PPC) was calculated as follows:

PPC = Total approved quantum of energy/Cost incurred in power procrument

Many renewable-rich states in India such as Tamil Nadu, Uttar Pradesh and Odisha are not able to meet their RPO targets. RESCO-based RTS PV would help the utilities to achieve their RPO targets. In order to bridge the gap in fulfilling the RPO targets, DISCOMs resort to buying Renewable Energy Certificates (RECs). RTS PV in the RESCO model would help the utilities in achieving their RPO targets, thereby reducing the need of the RECs.

According to the Electricity Act 2003, Renewable Purchase Obligation (RPO) is a mechanism in which the obligated entities have a mandate to purchase a minimum requirement of their total power consumption from non-conventional sources of energy such as solar and wind. They have been classified as solar and other non-solar RPO. For FY 2023, the government has mandated RPO compliance of 24.61 per cent and for FY 2024 it has been set at 27.08 per cent.

With regard to the contribution of various RE sources in meeting RPO compliances in 2022–23, according to data provided by MNRE, 46 per cent of total RE supply of 354 BU in the country is generated by large hydropower plants. Reliance on solar power has increased significantly—replacing wind as the most reliable source of renewable power in the country—with an overall generation of about 102 BU in the financial year. Recent years have seen a very sluggish growth in wind sector in terms of capacity addition as well as generation evidently reflecting its contribution of about 20 per cent to the total RE generation and supply.

As discussed above, solar-based generation plays a predominant role in achieving RPO targets. This makes a compelling case for states to pursue and scale up solar, maximizing the potential for ground-mounted and rooftop solar PV. For now, growth in the ground-mounted segment seems to be on track, with more than 90 per cent achievement of the target envisaged. However, rooftop solar PV needs ample support.

Key takeaways

community solar can be a form of aggregation model for residential end-users in which the technology is standardized, and the investor-backed utility can manage a larger, comprehensive community-based renewable energy programme to meet the increasing demands of the end-users.

DISCOMs benefit from monetizing the solar PV interest in the energy market, serving their consumers with turnkey solar tools, and gaining unique data and information about the solar PV activity in their service territory. The DISCOMs could even in theory bid into the energy marketplace themselves by offering on-bill financing for residential solar PV systems and create an additional revenue stream. Such online energy marketplaces are extensible to other energy products and services, such as heating and air conditioning systems and home electric vehicle charging stations. These types of partnerships allow DISCOMs to bring more choice to their consumers, improve consumer satisfaction, and simplify consumer protection while delivering value addition to their businesses.

Some of the key takeaways from the chapters discussed in detail in the report have been highlighted below:

Section 1: Rooftop solar PV

- The Government of India has suggested specific state-wise goals based on their available solar resources, energy demand, and the subsequent solar energy requirement to achieve the equivalent Renewable Purchase Obligation (RPO).

- The states have taken numerous measures to increase the share of rooftop solar PV through policies and regulations comprising the respective state government's allocations of subsidies and net metering initiatives across various end-user groups.

- One of the most common factors encountered is a lack of transparency and awareness among consumers regarding the transfer of benefits accrued from rooftop solar in terms of monetary or overall energy savings.

Section 2: RESCO model for RTS PV

- In the third party or the RESCO model, the renewable energy service company invests its funds in solar PV projects and sells power to the owner/end-user at a price that is lower than the grid charges with a profit margin.

- Low-paying end-users have limited capability to invest in upfront costs in rooftop solar PV. Therefore, gross-metering and net-metering schemes are not being availed of by them.

- It is necessary to promote new and innovative business models for facilitating the uptake of rooftop solar PV on a large scale for suitable end-users, especially in urban areas with low rooftop space or accessibility issues for rooftops.

Section 3: Demand aggregation

- Demand aggregation can be a successful endeavor to improve and accelerate the deployment of rooftop solar PV in India.

- Some of the initial demand aggregation programmes installed earlier helped in the reduction of the overall cost of solar power.

- The process of demand aggregation of rooftop solar PV involves inviting interest from the end-users, site assessment of rooftop of end-users, installation of the rooftop solar PV, and operation and maintenance of the plant.

Section 4: Analysis and recommendations

- The per unit savings of the DISCOMs increase as T&D losses in the region increase. The RTS PV penetration level, however, increases the total savings for the DISCOMs.

- Financially, the savings of the DISCOMs can be useful in many ways, e.g. lowering the consumer tariff, lowering the cross-subsidy, lowering the direct subsidy and profit sharing with end-users among others.

- A cluster-based approach would help in increasing the uptake of the RTS PV in areas which have similar characteristics in the units such as similar geographical location, similar technology deployed in the location, similar development issues.

Conclusion

The potential of the residential rooftop solar PV market in India is huge. Of the total installed capacity, about 30 per cent is contributed by renewable energy while rooftop solar PV has contributed only about 13 per cent. To improve the share of rooftop solar PV for residential owners, it is necessary to bring about several policy-related changes in the country.

One intervention required is streamlining of RTS PV-related policies across states, with options provided to consumers to select the model feasible to them on the basis of a techno-economic assessment of the various parameters associated with RTS PV. All the reforms under new regulations and policies should be applicable to new RTS PV projects only for the ease of consumers. The Government of India has issued investments to drive the RTS PV market. Under the guidelines for

Component B of Phase-II of the grid-connected rooftop solar PV programme, incentives have been provided to DISCOMs on the basis of the achievement towards the initial 18 GW of grid-connected rooftop solar plants.

Under the Electricity Amendment Bill 2022, which was issued recently, many significant ongoing measures have been planned such as specifying the Renewable Purchase Obligation (RPO) for DISCOMs. Under the RPO mandate, a certain percentage of electricity using renewable energy resources has to be procured by DISCOMs. According to the Bill, the RPO should not be below a specific minimum percentage as prescribed by the Central government. Failure to meet the required RPO would be punishable with a penalty of Rs 0.25–0.50 per kW of the shortfall in the RPO.

Several state governments have undertaken initiatives for the deployment of rooftop solar PV such as additional subsidies and demand aggregation for the installation of rooftop solar PV on a large scale. It is imperative to promote new and innovative business models to facilitate and improve the uptake of rooftop solar PV on a large scale for end-users, especially in urban areas with low rooftop space or where there are accessibility issues for rooftop spaces. The DISCOM-driven models identified by the Forum of Regulators (FoR) such as:

1. Consumer-owned (utility-only aggregates);
2. Consumer-owned (utility aggregates and act as an EPC);
3. Third-party owned (utility aggregates and act as a trader between RESCO and the consumer); and
4. Utility-owned (utility aggregates and act as RESCO) have been discussed in detail in the report. In order to understand the implications of residential rooftop solar PV through active interventions of DISCOMs, a cost–benefit analysis has been carried out in the report, assuming various parameters for DISCOMs operating in select states.

Business case studies have been evaluated by analysing the procurement cost and volume of conventional and solar power specifically to meet the residential demand for power and supply by the DISCOMs in 10 states. The analysis reveals a net per-unit cost-saving potential for most of the states and indicates a favourable business case for RESCO-based solar power projects by DISCOMs.

DISCOMs will be able to save Rs 0.34–1.95 per unit through procurement of solar power to meet 10 per cent of the residential electricity demand.

This report highlights the fact that DISCOM-driven demand aggregation can prove to be a successful endeavour to improve and accelerate deployment of rooftop solar PV in India. RTS PV is in a laggard mode. It is imperative that DISCOMs in collaboration and partnership with other stakeholders steer and drive the sector as enabler, facilitator and offtaker.

The way ahead

Rooftop solar PV, with the benefits and challenges associated with its implementation, execution, metering, grid integration and techno-commercial aspects, cannot achieve glory without the proactive involvement of DISCOMs as key stakeholders, enablers, facilitators and offtakers. It is also imperative to safeguard the business interests of these utilities, which revolve mainly around procurement and distribution of electrical power providing last-mile access and consumer connectivity at the household level. We cannot therefore afford the failure of DISCOMs. We would also benefit from the overall growth and improvement in the health of DISCOMs, and RTS PV can prove to be a means for DISCOMs to improve their overall health and business objectives. Nonetheless, it is best left to the decision-makers, DISCOMs and policymakers to decide the greatest interest of RTS PV as well as DISCOMs.

We, however, would like to draw a few conclusions from the discussions in the preceding chapters and suggest a few recommendations to advance the sector in the desired direction.
To summarize:

- India had set an ambitious goal to achieve 175 GW of installed power capacity by 2022 and 500 GW of installed power capacity by 2030 through renewable energy. The growth in solar power has been unprecedented, with installed capacity reaching 71 GW by July 31, 2023 while the rooftop solar PV category lags behind with only 10.3 GW of the installed capacity over the same time frame of about eight years since the setting of the targets.

- Rooftop solar PV has several advantages for utilities, such as low technical and commercial loss, greater demand-side management and economies in power-procurement cost. Demand Aggregation entails low capital investment and transactional charges on rooftop solar PV projects.

- Lack of awareness among end-users about rooftop solar PV and high investment and development cost, especially for low-paying consumers, are some of the roadblocks to the adoption of rooftop solar PV on a large scale in India.

- Policies need not have restrictive overtones. Rooftop solar PV policies are meant to accelerate the growth of the sector. This is, however, not the case as is evident from the total rooftop solar PV installed capacity in the country. Policies need to be revisited and modified, with a balanced approach that benefits consumers as well as operators and minimizes or eliminates restrictions on export, installed capacities and priority/slab structure tariff for export of surplus/excess power to the grid coupled with storage options.

- In order to cater to the needs of various categories of consumers and residential customers (such as those with kaccha roofs, pakka roofs, local shopowners, smaller businesses that cannot be otherwise categorized as C&I consumers or group-housing societies etc.), and localities (rural, semi-urban and urban) it is imperative for states to transition to a mixed bag of policies—they need not be restricted to just one set of policies—such as zero export, net billing, gross metering and net metering, all applying in one state.

- As one of the most important stakeholders, DISCOMs are the nodal point for RTS PV. Currently, C&I consumers provide the maximum revenue to DISCOMs. They need to transition to an active facilitator, generator and investor role to avoid losing out on low-paying end-users.

- The existing business model does not offer a wide range of benefits to all the key stakeholders. The RESCO-based business model would be advantageous for all the stakeholders involved in RTS PV projects.

- In rural areas, many end-users have more rooftop space than what is required to install an RTS PV system based on the contracted load. Lowering the limit in capacity sizing will result in increased penetration of RTS PV, which in turn would result in incremental financial benefits of stakeholders.

- Taking into account limited awareness of end-users on techno-commercial and legal contracting aspects, they should be more participatory, transparent and inclusive.

- With increased solar PV market maturity and technological advancements, adoption rates of rooftop solar PV are expected to grow as it eliminates the requirement of large spaces of land for deployment of infrastructure and lowers the load on the distribution sector due to generation and utilization of electricity locally through clean resources.

- Generation of energy through clean resources of energy would help in achieving the United Nations Sustainable Energy Goal 7 (SDG7)[35] of clean and affordable energy for all.

- Consumers of RTS PV have faced a host of issues and problems, including the need to understand various policy implications, benefits, net-metered billing from DISCOMs, technicalities, and performance-related parameters of projects for which the consumer has to depend on the developer. In such a scenario, it becomes difficult for the consumer to navigate through these aspects, especially in the case of any dispute that may arise between parties. Therefore, a coherent structure for monitoring the institutional setup is recommended for RTS PV in India. Currently, there is no provision for an RTS PV ombudsman or a grievance-redressal mechanism for consumer-specific issues that would also play a watchdog role in monitoring performance.

5

ANNEXURES

Annexure I

Production Linked Incentive scheme under Tranche II for high efficiency solar PV modules by MNRE https://mnre.gov.in/img/documents/uploads/file_f-1664601098820.pdf

F. No. 283/62/2020-GRID SOLAR
भारत सरकार / Government of India
नवीन और नवीकरणीय ऊर्जा मंत्रालय/ Ministry of New & Renewable Energy (MNRE)
ग्रिड सौर ऊर्जा प्रभाग / Grid Solar Power Division

Atal Akshay Urja Bhawan
Lodhi Road, New Delhi – 110003
Dated: 30th September, 2022

To

The Pay & Accounts Officer,
Ministry of New & Renewable Energy
New Delhi – 110003.

Sub: Production Linked Incentive Scheme (Tranche II) under 'National Programme on High Efficiency Solar PV Modules'

Sir/ Madam,

I am directed to convey the sanction of the President for implementation of the Production Linked Incentive Scheme (Tranche II) under 'National Programme on High Efficiency Solar PV Modules' for achieving manufacturing capacity of Giga Watt (GW) scale in High Efficiency Solar PV Modules.

2.0 Aims and Objectives:

2.1 Aim: To promote manufacturing of high efficiency solar PV modules in India and thus reduce import dependence in the area of Renewable Energy.

2.2 Objectives:

i. To build up solar PV manufacturing capacity of high efficiency modules.
ii. To bring cutting-edge technology to India for manufacturing high efficiency modules. The scheme will be technology agnostic in that it will allow all technologies. However, technologies which yield better module performance will be incentivized.
iii. To promote setting up of integrated plants for better quality control and competitiveness.
iv. To develop an ecosystem for sourcing of local material in solar manufacturing.
v. Employment generation and technological self-sufficiency.
vi. To encourage sustainable manufacturing practices and adoption of circular economy approaches.

3.0 Implementation Methodology: The Scheme will be implemented as per the detailed Scheme Guidelines enclosed at Annexure-I.

4.0 Necessary funds for implementation of this Scheme during 2022-23 (if any required) and subsequent years will be drawn from the budgetary allocations to Ministry of New & Renewable Energy.

Page **1** of **13**

5.0 This issues with the concurrence of IFD vide their Dy. No. 154 dated 30.09.2022.

Yours faithfully,

(Sanjay G. Karndhar)
Scientist-D
Email: karndhar.sg@nic.in

Copy for information and necessary action to:

1. All Central Government Ministries and Departments.
2. NITI Aayog, Sansad Marg, Sansad Marg Area, New Delhi.
3. Renewable Energy /Power/Energy Departments of all States & UTs.
4. State Nodal Agencies for Renewable Energy (SNAs) of all States / UTs.
5. Major Public Sector Enterprises operating in Renewable Energy /Power /Energy sector.
6. Principal Director of Audit, Scientific Audit-II, DGACR Building, I.P. Estate, Delhi – 110002.
7. Director General (Local Bodies), Office of the Comptroller & Auditor General, 9-Deendayal Upadhyay Marg, New Delhi.
8. Solar Energy Corporation of India Limited (SECI), 6th Floor, Plate-B, NBCC Office Block Tower-2, East Kidwai Nagar, New Delhi-110023.
9. National Institute of Solar Energy (NISE), Gwal Pahari, Faridabad-Gurugram Road, Gurugram, Haryana- 122003.
10. Indian Renewable Energy Development Agency Limited (IREDA), 3rd Floor, August Kranti Bhawan, Bhikaiji Cama Place, New Delhi – 110 066

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Yours faithfully,

(Sanjay G. Karndhar)
Scientist-D
Email: karndhar.sg@nic.in

Annexure-I

Sub: Scheme Guidelines for Implementation of the Production Linked Incentive Scheme (Tranche II) under 'National Programme on High Efficiency Solar PV Modules' for achieving manufacturing capacity of Giga Watt (GW) scale in High Efficiency Solar PV Modules.

1. Introduction & Background

1.1. The Union Cabinet approved the Production Linked Incentive (PLI) Scheme for National Programme on High Efficiency Solar PV Modules, for achieving manufacturing capacity of Giga Watt (GW) scale in High Efficiency Solar PV Modules) on 7th April, 2021. The outlay for this PLI Scheme was initially ₹ 4,500 crore (Tranche I) and the Ministry of New & Renewable Energy (MNRE) issued the Scheme Guidelines for Production Linked Incentive Scheme on 'National Programme on High Efficiency Solar PV Modules' on 28th April, 2021.

1.2. Under this tranche, Indian Renewable Energy Development Agency Limited (IREDA), the implementing agency on behalf of MNRE for the PLI Scheme (Tranche-I), issued the Bid Documents for selection of manufacturers for setting up manufacturing capacities for High Efficiency Solar PV Modules. In response, 18 bids corresponding to a Solar PV manufacturing capacity of 54,809 MW were received and Letters of Award were issued by IREDA on 11.11.2021/02.12.2021 to three successful bidders for setting up of 8,737 MW capacity of fully integrated Solar PV Module manufacturing units within PLI scheme outlay of ₹ 4,500 crore.

1.3. To establish a larger manufacturing base for solar PV modules, an additional allocation of ₹ 19,500 crore (Tranche II) for PLI for manufacture of high efficiency modules, with priority to fully integrated manufacturing units from polysilicon to solar PV modules, was announced in the Budget 2022-23, on 1st February 2022.

2. Aims and Objectives

The scheme aims to promote manufacturing of high efficiency solar PV modules in India and thus reduce import dependence in the area of Renewable Energy. The objectives of the scheme include the following:

i. To build up solar PV manufacturing capacity of high efficiency modules.
ii. To bring cutting-edge technology to India for manufacturing high efficiency modules. The scheme will be technology agnostic in that it will allow all technologies. However, technologies which yield better module performance will be incentivized.
iii. To promote setting up of integrated plants for better quality control and competitiveness.
iv. To develop an ecosystem for sourcing of local material in solar manufacturing.
v. Employment generation and technological self-sufficiency.
vi. To encourage sustainable manufacturing practices and adoption of circular economy approaches.

3. Implementation Methodology

National Programme on Solar PV Manufacturing involving Production Linked Incentive (PLI) to enhance domestic manufacturing capacity of High Efficiency Solar PV Modules will be implemented through a transparent selection process, details of which are furnished in the succeeding paragraphs.

3.1. Implementing Agency

i. The PLI Scheme (Tranche-II) will be implemented by MNRE with Solar Energy Corporation of India Limited (SECI) as the Implementing Agency. SECI will be responsible for providing secretarial, managerial and implementation support and carrying out other responsibilities as assigned by MNRE from time to time. The responsibilities of SECI inter alia, include receipt of applications, examination and appraisal of applications as per the provisions of the scheme, issuing acknowledgements and letters of award to applicants, examination of claims of beneficiaries for disbursement of PLI, verification and reconciliation of disbursement claims with prescribed documents, compilation of data regarding progress and performance of the scheme through Quarterly Review Reports and other information / documents. SECI will also submit progress to MNRE on a quarterly basis along with details of disbursement claims received for PLI, amount disbursed, reasons for delay in disbursement of the incentives etc. SECI will be eligible to get **0.50%** of the PLI amount disbursed as administrative charges on annual basis.

ii. SECI will have the right to carry out physical inspection of an applicant's manufacturing units and offices. It may take help of National Institute of Solar Energy (NISE) for verification of efficiency and temperature co-efficient of modules. If required, MNRE may also designate National Accreditation Board for Testing and Calibration Laboratories (NABL) accredited labs, etc. for such verification. A Project Management Unit (PMU) shall be established in MNRE to assist MNRE & SECI in the implementation of the scheme. Expenditure for PMU will be met out of the administration charges cited at para 3.1 (i) above.

3.2. Criteria for Selection of Beneficiaries

i. Selection

The beneficiaries of the PLI Scheme will be selected through a transparent selection process. Applications will be shortlisted after consideration of the following parameters. It is proposed to call bids for the award of manufacturing capacities commensurate with the additional fund allocation of ₹ 19,500 crore announced in the Union Budget 2022-23.

ii. Bidders eligible for PLI

The bidder manufacturer can be a single company or a Joint Venture/ Consortium of more than one company. However, in case of Joint Venture/Consortium, a partner/company will be allowed to tie up their manufacturing capacity (of any stage) with another partner/company for one bid only. Manufacturing units which have availed any benefit under the MNRE's tender(s) for solar Power Purchase Agreements linked to PV manufacturing or SIPS/ M-SIPS / SPECS schemes of Ministry of Electronics & Information Technology (MEITY), will not be eligible for benefits under this programme. However, any benefit under SIPS/ M-SIPS/ SPECS/ Manufacturing Linked Tender can be availed by manufacturers for the difference of offered bid capacity and double the PLI awarded capacity. For example, for a bid capacity of Y, if a manufacturer has been awarded PLI capacity of X, then it may avail any benefit under SIPS/ M-SIPS/ SPECS /Manufacturing Linked Tender, for capacity in excess of double the PLI awarded capacity i.e. Y-2X. SECI shall obtain an undertaking from bidders in this regard. Goods, equipment and services for which contracts have been concluded by technically qualified bidders in earlier PLI bid, after 11.11.2021 (the date of issue of Letters of Award under Tranche-I), will be eligible for counting towards calculating benefits under the PLI Scheme Tranche-II. For any other case to be eligible for PLI disbursement, the contract for capital equipment / services, etc. should be concluded after the issuance of letter of award.

iii. Greenfield & Brownfield projects

Greenfield solar PV module manufacturing will involve installation of new plant, machinery and equipment. Such Greenfield units must be established in physically segregated premises from any existing manufacturing units.

If a bidder who was issued Letter of Award under earlier bid, is awarded additional capacity under new bid, the new capacity established, will be considered Greenfield, even if it shares common facilities / infrastructure built for the capacity under PLI Tranche-I.

Brownfield manufacturing units will involve expansion of existing manufacturing facilities with addition of new production lines within the existing physical infrastructure and will also be allowed to participate. PLI receivable for such Brownfield projects will be 50% of the PLI receivable for Greenfield projects.

iv. Extent of Integration

In order to qualify for the bid, the applicant manufacturer will have to promise minimum integration across solar cells and modules. Based upon the extent of integration proposed, the bidder can opt for bidding for any one of the following three baskets:

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Basket No.	Code	Description
1	P+W+C+M	**Stage-1:** Manufacturing of Polysilicon + **Stage-2:** Manufacturing of Ingots-Wafers + **Stage-3:** Manufacturing of Solar Cells + **Stage-4:** Manufacturing of Modules or Fully integrated manufacturing of Thin Film plant or Fully integrated plant of any other technology
2	W+C+M	**Stage-2:** Manufacturing of Ingots-Wafers + **Stage-3:** Manufacturing of Solar Cells + **Stage-4:** Manufacturing of Modules **or** similar level of integration of any other technology
3	C+M	**Stage-3:** Manufacturing of Solar Cells + **Stage-4:** Manufacturing of Modules **or** similar level of integration of any other technology

v. Manufacturing Capacity

In order to qualify for the bid, the applicant manufacturer will have to undertake to set up a manufacturing plant of minimum 1,000 MW capacity (1,000 MW each for all individual stages included in the manufacturer's proposal). The maximum capacity that can be bid for, i.e. the manufacturing capacity that a bidder will set up will be 10 GW for P+W+C+M and 6 GW each for W+C+M and C+M categories. However, the maximum capacity that will be awarded to one bidder under the PLI scheme will be 50% of the capacity to be set up by the applicant. This awarded maximum bid capacity will include any capacity awarded as per LoA issued by IREDA in Tranche-I.

To illustrate, if a bidder was earlier issued LoA(s) in P+W+C+M category, with 'manufacturing capacity to be installed' as 4 GW and 'eligible capacity (for claiming PLI)' as 2 GW, it can bid for maximum [10-4] = 6 GW in the new bid and if it bids for his maximum possible (6 GW) in the new bid and is successful in the new bid, it will have to set up new 6 GW manufacturing capacity, in addition to the 4 GW capacity that it has to set up as per the LoA issued in respect of the earlier bid. However, it would be eligible for a PLI against a manufacturing capacity of 50%, i.e. 2GW from earlier LoA and 3GW from LoA awarded under these guidelines.

vi. Trajectories of Module Performance and Local Value Addition (LVA)

Manufacturers will have to fulfill certain minimum values of module performance (combination of module efficiency and module's temperature co-efficient of P_{max}) and Local Value Addition (LVA) for being eligible for PLI, as follows:

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Parameter & integration category		Minimum values required for 1st year after commissio-ning	Minimum values required for 2nd year after commissio-ning	Minimum values required for 3rd year after commissio-ning	Minimum values required for 4th year after commissio-ning	Minimum values required for 5th year after commissio-ning
Module Efficiency* & Module's temperature co-efficient of Pmax	P+W+C+M	*Minimum module efficiency of 21.00% with temperature coefficient of Pmax equal to or better than -0.40% per degree Celsius* *OR* *Minimum module efficiency of 20.50% with temperature coefficient of Pmax better than -0.30% per degree Celsius*				
	W+C+M					
	C+M					
Local Value Addition (LVA)	P+W+C+M	75%	78%	82%	86%	90%
	W+C+M	60%	65%	70%	75%	85%
	C+M	50%	55%	60%	65%	75%

** Under Standard Test Conditions (STC), i.e. Irradiance 1000 W/m², cell temperature 25°C, air mass (AM)= 1.5;*

vii. Category-wise Baskets

The capacities will be allocated in separate categories based on the fund allocated for each category. This will enable competition among bidders within a particular level of integration, while also promoting a diversified supply chain.

Basket No.	Code	Fund Allocation (crore Rs.)
1	P+W+C+M	12,000
2	W+C+M	4,500
3	C+M	3,000

In case a particular category is undersubscribed, i.e. funds are left over even after award of capacities in the category, there will be inter-category fungibility of funds, with preference to higher integration baskets for allocation of leftover funds. To illustrate, if capacity equivalent to only Rs. 2500 crore of W+C+M have been awarded among all bidders, the remaining Rs. 2000 crore would be allocated for any unmet bid capacity in P+W+C+M category first and then in C+M category.

4. Bid Submission

Bidders will submit the following details which will be used for determining the award of capacities for PLI and calculation of PLI:

Sl. No.	Parameter
a	Extent of Integration
b	Manufacturing Capacity proposed to be set up (in GW)
c	Year-wise percentage of Local Value Addition (LVA)
d	Year-wise performance parameters of manufactured modules (module efficiency and module's temperature co-efficient of P_{max})

The applicant shall, in its application, also declare the type of technology proposed to be set up, plan for local value addition, and the estimated employment generation and exports during the tenure of the Scheme.

5. Calculation of Production Linked Incentive (PLI) and Allocation of Capacities

5.1. The PLI for allocated bid capacity will be calculated year-wise as a product of following four components:

a. Base PLI Rate (in ₹/Wp) as identified from the applicable Performance Matrix, based on the module efficiency and module's temperature coefficient of Pmax, quoted by the bidder for the particular year;
b. LVA Factor, which is a function of percentage of Local Value Addition (LVA), as quoted by the bidder for the particular year;
c. Tapering Factor (TF) for the particular year;
d. Yearly sales [in Watt peak (Wp)] corresponding to the manufacturing capacity eligible for claiming PLI.

5.2. Formula for calculation of PLI amount shall be as follows:

$$\boldsymbol{PLI\ (in\ Rs.)} = \sum_{i=year1}^{year5} (\mathbf{Base\ PLI\ Rate_i} \times \mathbf{LVA\ Factor_i} \times \mathbf{TF_i} \times \mathbf{Sales_i})$$

where,

a) 'i' is the year counted from date of scheduled or actual commissioning (whichever is earlier) ranging from 1 to 5;

b) Base PLI Rate: On the basis of module efficiency and module's temperature co-efficient of P_{max} (hereinafter also referred to as module's temperature co-efficient), 'Base PLI Rate' will be determined in ₹/Watt peak (₹/W*p*) as per the Performance Matrix Tables given below. The Base PLI Rate (₹/W*p*) increases with module efficiency to motivate and incentivize manufacturers for producing higher efficiency modules which also requires higher investment into R&D.

PERFORMANCE MATRIX TABLE for P+W+C+M Basket							
	Module Efficiency* (%) →	During five Year period after commissioning Base PLI Rate (₹/W_p)					
		≥20.50% & <21.00%	≥21.00% & <21.50%	≥21.50% & <22.00%	≥22.00% & <22.50%	≥22.50% & <23.00%	≥23.00%
Module's Temperature Coefficient of P_{max}** (in % per degree Celsius)↓	Position	U	V	W	X	Y	Z
-0.40 to -0.30	A	0.00	1.45	1.65	1.85	2.00	2.20
Better than -0.30	B	1.45	1.65	1.85	2.00	2.20	2.20

PERFORMANCE MATRIX TABLE for W+C+M Basket							
	Module Efficiency* (%) →	During five Year period after commissioning Base PLI Rate (₹/W_p)					
		≥20.50% & <21.00%	≥21.00% & <21.50%	≥21.50% & <22.00%	≥22.00% & <22.50%	≥22.50% & <23.00%	≥23.00%
Module's Temperature Coefficient of P_{max}** (in % per degree Celsius)↓	Position	U	V	W	X	Y	Z
-0.40 to -0.30	A	0.00	0.90	1.05	1.25	1.40	1.55
Better than -0.30	B	0.90	1.05	1.25	1.40	1.55	1.55

PERFORMANCE MATRIX TABLE for C+M Basket							
	Module Efficiency* (%) →	During five Year period after commissioning Base PLI Rate (₹/W_p)					
		≥20.50% & <21.00%	≥21.00% & <21.50%	≥21.50% & <22.00%	≥22.00% & <22.50%	≥22.50% & <23.00%	≥23.00%
Module's Temperature Coefficient of P_{max} (in % per degree Celsius)↓**	**Position**	**U**	**V**	**W**	**X**	**Y**	**Z**
-0.40 to -0.30	**A**	**0.00**	**0.50**	**0.65**	**0.85**	**1.00**	**1.15**
Better than -0.30	**B**	**0.50**	**0.65**	**0.85**	**1.00**	**1.15**	**1.15**

** Under Standard Test Conditions (STC), i.e. Irradiance 1000 W/m², cell temperature 25°C, air mass (AM)= 1.5;*

***P_{max} = Maximum Power at Standard Test Conditions (STC); Module's temperature coefficient refers to percentage change in P_{max} per degree Celsius rise in temperature*

c) Local Value Addition (LVA) Factor$_i$ is a function of the percentage of LVA, submitted for the i^{th} year. LVA Factor is derived as per the following table:

LVA%	LVA% less than 50%	LVA% ≥50% but less than 60%	LVA% ≥60% but less than 70%	LVA% ≥70% but less than 80%	LVA% ≥80% but less than 90%	LVA% ≥90%
LVA Factor	0	0.73	0.79	0.85	0.92	1

The PLI amount increases with increased LVA, in order to encourage manufacturers to source their material from the domestic market. The percentage of LVA will be calculated as follows: [(Sale value of Module as per the GST invoice excluding net domestic indirect taxes) – (Value of direct and indirect imported materials and services (including all Customs Duty) as per Bill of Entry filed in Customs, used in manufacture of module)] / [(Sale value of Module as per GST invoice excluding net domestic indirect taxes] x 100%.

d) TF or Tapering Factor: In order to give a signal to Solar PV Manufacturing industry that they will need to be competitive after five years, the PLI rate (₹/W*p*) will be higher in the beginning and lower towards the end of the five-years period over which the PLI will be paid. To achieve the objective of tapering down the PLI rate (in ₹/Wp), the PLI rate (₹/Wp) will be multiplied by a tapering factor of 1.4 for the 1st year of the five years PLI disbursement period followed by a tapering factor of 1.2, 1.0, 0.8 and 0.6 for the 2nd, 3rd, 4th and 5th year of the PLI disbursement period respectively.

Year	1	2	3	4	5
Tapering Factor	**1.4**	**1.2**	**1**	**0.8**	**0.6**

e) **Sales (in W_p)** is the net sales of solar PV modules of performance parameters (efficiency and temperature coefficient) and LVA equal to or better than those given at para 3.2(vi). The PLI disbursed to a manufacturer will be calculated as per the formula at para 5.2 and will depend on sales or the maximum eligible capacity awarded under the PLI scheme, whichever is less; actual Performance and actual Local Value Addition achieved, provided that only those modules will be counted in sales whose performance and LVA satisfy the levels given at para 3.2(vi).

5.3. Sequence of Allotment and Tie Breaking

i. The bid with the highest efficiency in the first year of production shall be first allocated the admissible bid capacity. In case of a tie in efficiency in the first year, the bid with the highest efficiency in the second year of production shall be allocated the admissible bid capacity first and so on. In case two bids have the exact same efficiency trajectory over all five years, the LVA trajectory shall similarly be compared year wise. In case, both efficiency and LVA trajectory over all the five years are the same, such tied bids will be prioritized on the basis of bid capacity and if bid capacities are also the same, then such tied bidders will be given the same ranking and allotted manufacturing capacity accordingly. However, in case of insufficient funds, the remaining possible allocation shall be divided equally between such tied bidders.

ii. In case the funds available at any point are sufficient to allocate only a part capacity of a bid that is next in priority, such a bidder would be free to exercise refusal on accounts of economies of scale and this allocation shall be offered to the next bidder in sequence.

6. Disbursement of PLI

The manufacturing units sanctioned under the programme will be eligible for getting PLI on annual basis on sales of high efficiency solar PV modules for 5 years from commissioning or 5 years from scheduled commissioning date, whichever is earlier. Consequently, in case of delayed commissioning, the PLI period will reduce from 5 years by the period of the delay in commissioning. A team constituted by MNRE or SECI will visit the manufacturing unit immediately after its commissioning to verify promised extent of integration, manufacturing capacity, efficiency and temperature co-efficient of modules. The manufacturers will be asked to give a self-declaration and a Statutory Auditor's or Chartered or Cost Accountant's certificate in support of claims of

PLI. The manufacturers will be required to provide documents in support of the PLI claimed for a particular year based on (i) sales (watt) of modules, (ii) percentage of local value addition and (iii) PLI rate (as per the position in Performance Matrix). Documents required to be submitted by manufacturer for availing PLI will be detailed in the tender documents. MNRE will also make provisions for adequate safeguards, including for periodical special audits and appointing technical organizations to conduct sample checks to verify claims of manufacturers in respect of module efficiency and temperature coefficient.

7. Timelines for commissioning of solar PV manufacturing facilities

The time-period allowed for commissioning of solar PV manufacturing units under the Scheme is as follows:

Level of Integration	Time allowed for commissioning
P+W+C+M	Within 3 years from the date of the Letter of Award
W+C+M	Within 2 years from the date of the Letter of Award
C+M	Within 1.5 years from the date of the Letter of Award

8. Sustainable manufacturing

8.1. Manufacturers will be required to set up facilities for recovery and recycling of solar waste. Manufacturers will be encouraged to adopt circular economy principles in their manufacturing and supply chains.

8.2. Considering India's International commitments, particularly to achieve about 50% cumulative electric power installed capacity from non-fossil fuel-based energy resources by 2030, the scheme would encourage use of renewable energy in the manufacturing facilities set up under the scheme. The successful bidders will ensure that at least 20% of the electricity consumption for the solar PV manufacturing plant will be sourced from renewable energy sources. Different modalities for compliance of this requirement will be permitted. Detailed provisions in this regard will be specified in the tender documents.

9. Penalties

9.1. In case a selected manufacturer fails to meet the extent of integration or manufacturing capacity promised at the time of selection, it will not get any PLI till it overcomes these deficiencies. If the manufacturer achieves the promised levels subsequently, it will be eligible for PLI from the next month following the month in which it achieved the promised levels of integration and capacity. However, in such cases, the manufacturer will not be able to get PLI for full 5 years since 5 years PLI is counted from the scheduled date of commissioning of the plant or the actual date of commissioning, whichever is earlier. In case, the modules manufactured by a selected manufacturer do not meet the minimum parameters as per the table for trajectories of minimum module performance and minimum LVA at para 3.2 (vi), then it will not get any PLI in respect of such modules.

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9.2. Bidders will have to submit, at the time of bid submission, Earnest Money Deposit (EMD) as prescribed in the tender document. The tender document will inter-alia, contain provisions regarding forfeiture of EMD in case of selected bidder refusing to submit the requisite documents/ Performance Bank Guarantees (PBG) as per tender document / extant guidelines or the selected bidder not meeting eligibility criteria upon submission of documents.

9.3. Bidders who have been awarded capacities will have to submit Performance Bank Guarantees (PBG), at the time of accepting the award as per extant Ministry of Finance guidelines. In case they fail to implement the promised 'Extent of integration' or the 'Manufacturing capacity' submitted by them in their bids, within the scheduled commissioning date, Bank Guarantees commensurate to the manufacturing commitments not fulfilled by the bidder will be forfeited by SECI and balance Bank Guarantees will be released by them. Detailed modalities in this regard will be given in tender documents. Encashment of bank guarantees, accrued interest or other charges collected by SECI will be remitted to the Consolidated Fund of India by SECI as per rule-230(8) of GFRs 2017.

9.4. To ensure that the bidder-manufacturers quote realistic levels of year-wise module performance and LVA, in case, for any given year, the bidder-manufacturer falls short on quoted level of module efficiency/ quoted level of temperature co-efficient of P_{max} / quoted level of LVA, but meets the minimum requirements as prescribed in the trajectories of module performance and LVA at para 3.2(vi), the amount of PLI to be disbursed to it for that given year, will be limited to 75% of the PLI amount as per the actual achieved levels of module efficiency, temperature co-efficient of P_{max} and LVA.

10. Monitoring of the PLI scheme and power to remove difficulties:

10.1. As approved by the Cabinet on 11th November 2020, the Empowered Group of Secretaries (EGoS) chaired by Cabinet Secretary will monitor implementation of the PLI scheme, undertake periodic review of the outgo under the Scheme, ensure uniformity of all PLI Schemes and take appropriate action to ensure that the expenditure is within the prescribed outlay. Any changes required in the modalities of the scheme, subject to the condition that the overall financial outlay remains within ₹ 19,500 crore, will be placed for consideration of the EGoS.

10.2. A Scheme Monitoring Committee (SMC) under the chairmanship of Secretary, MNRE, and comprising representatives from MNRE, SECI, NISE, other organizations, and experts as may be required for the purpose, shall take periodical review of the status of implementation/ performance of solar PV manufacturing capacities awarded/ set up under the scheme. The committee will also facilitate / recommend measures to resolve difficulties, if any including delay in commissioning.

10.3. Any changes required in the scheme guidelines, without changing the modalities which require placing before EGoS as mentioned in Para 10.1 above, will be done with the approval of Hon'ble Minister (Power and New & Renewable Energy), subject to the condition that the overall financial outlay remains within ₹ 19,500 crore.

Annexure II

Clarification on applicability of central financial assistance (CFA) available under Rooftop Solar (RTS) Programme Phase-II for solar systems installed under Virtual Net Metering (VNM) Arrangement by MNRE https://mnre.gov.in/img/documents/uploads/file_f-1664883789129.pdf

Government of India
Ministry of New and Renewable Energy
***

Atal Akshay Urja Bhawan,
Lodhi Road, New Delhi -110003.
Dated: 03rd of October, 2022

OFFICE MEMORANDUM

Subject: Clarification on applicability of central financial assistance (CFA) available under Rooftop Solar (RTS) Programme Phase-II for solar systems installed under Virtual Net Metering (VNM) arrangement.

Ministry is implementing Rooftop Solar (RTS) Programme Phase-II and providing CFA for installation of RTS plant in residential sector by individual household or by GHS/RWA. Some of the States and UTs are having provision of Virtual Net Metering, wherein a group of consumers of a Distribution company can install a solar plant within the area of the same company and avail benefits of net metering against the solar power fed into the grid from that solar plant.

2. A clarification has been sought by different stakeholders on the applicability of CFA available under RTS Programme Phase-II for residential consumers installing solar plants under VNM arrangement.

3. In this regard, it is to clarify that the CFA applicable under RTS Programme Phase-II of MNRE will also be applicable for solar plants setup under VNM arrangement, subject to following conditions: -

i. CFA would be available only for residential consumers of rural areas,

ii. Considering that connected load of a residential consumer in rural areas would generally be not more than 3 kW, each participating consumer under VNM would be allowed to install capacity upto 3 kW and avail subsidy available under RTS Programme Ph-II.

iii. Solar plant installed under VNM shall supply power to the same distribution sub-station (HT or LT side) through which the participating consumers are connected. This will ensure reliable power supply to the participating consumers and other benefits of co-locating power generation and consumption.

4. Further, to facilitate the installation of solar plants under VNM arrangement this Ministry has prepared a Concept Note (attached herewith) covering some of the possible business models including CAPEX, RESCO and Utility operated model. Please note that these models are indicative and only for guidance. The actual implementation will depend on the applicable regulations and other conditions.

Encl: As above.

Veepin Kumar
03-10-2022

(Dr. Veepin Kumar)
Deputy Director (RTS)

To,

All concerned State Implementation Agencies.

Concept Note on Virtual Net Metering

1. Need

Residential consumers, especially the households with inadequate roof area/roof strength/ roof right/ shadow free roof/inaccessible roof etc. have remained deprived of rooftop solar despite numerous efforts from the Ministry of New and Renewable Energy (MNRE) and States. It is critical to promote and facilitate new and innovative models for proliferation of rooftop solar (RTS) systems under different metering mechanisms for the eligible segment of the consumers.

2. Concept of Virtual Net Metering

"Virtual Net Metering" means an arrangement whereby entire electricity generated from a Solar Project installed at Consumer premise or any other location is injected through Solar Electricity Meter and the electricity exported is adjusted in either one or more than one electricity service connection(s) of participating Consumer(s) located within the same Distribution Licensee's area of supply.

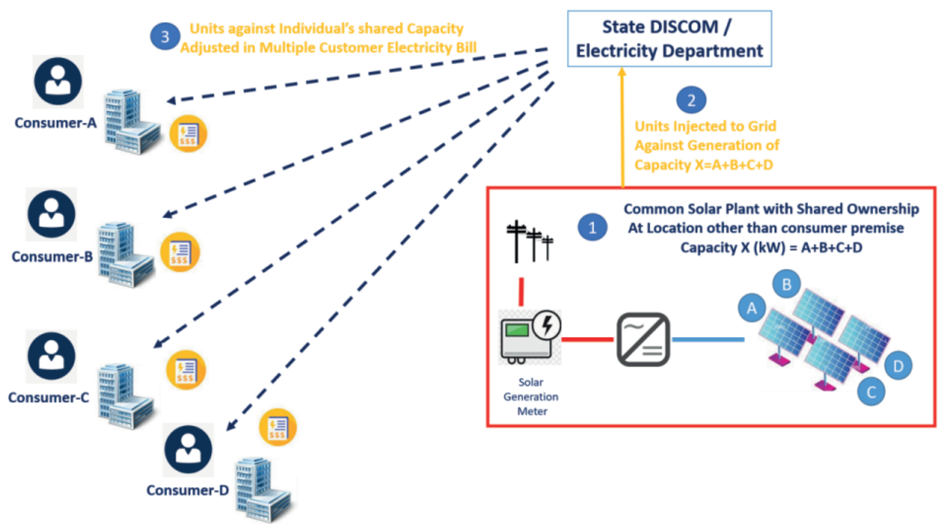

Fig.1 Virtual Net Metering Concept

Since the power flow is virtual, parties need not set up the system on consumer premises rather it can be anywhere within the Distribution Licensee area. This gives the opportunity for the system to serve more than one consumer. For example, suppose a group of 4 consumers, within the same distribution license area, decide to install a single large solar plant on a single roof or multiple roofs or a mix of roof(s) and ground(s) or ground(s) only, within the same distribution license area. They decide to share the solar plant capacity in the proportion of A:B:C:D and notify the same to the DISCOM. The units generated from the solar plant will be injected into the grid and their units will be measured by a solar meter. The units, so generated, will be allocated to the 4 consumers in the same ratio of A:B:C:D which is adjusted against the consumption of units from grid by individual consumers (See Fig. 1). The solar plant capacity proportions for each consumer is completely at the discretion of group of consumers. However, the allocation shall still be as per the state regulations for solar energy.

Instead of small solar plants on individual roofs a common solar plant of higher capacity will have advantage of economies of scale, higher efficiencies and lower maintenance cost, thus solar power can be generated at lower per unit cost.

3. Current Status

Virtual net-metering is increasingly gaining traction among different States of the country. In such cases, the solar plants can be set up on any adjoining land or rooftops as per Virtual Net Metering regulations by a group of households (either in CAPEX or RESCO mode). Following States and Union Territories (UTs) already have provisions for Virtual Net Metering:

1. Goa
2. Delhi
3. Jammu and Kashmir
4. Ladakh
5. Odisha
6. Puducherry
7. Andaman & Nicobar
8. Lakshadweep
9. Chandigarh
10. Dadra & Nagar Haveli and Daman & Diu

The Ministry is pursuing with Regulators of other States and UTs also to allow virtual net metering.

Process flow of Virtual Net Metering is given below:

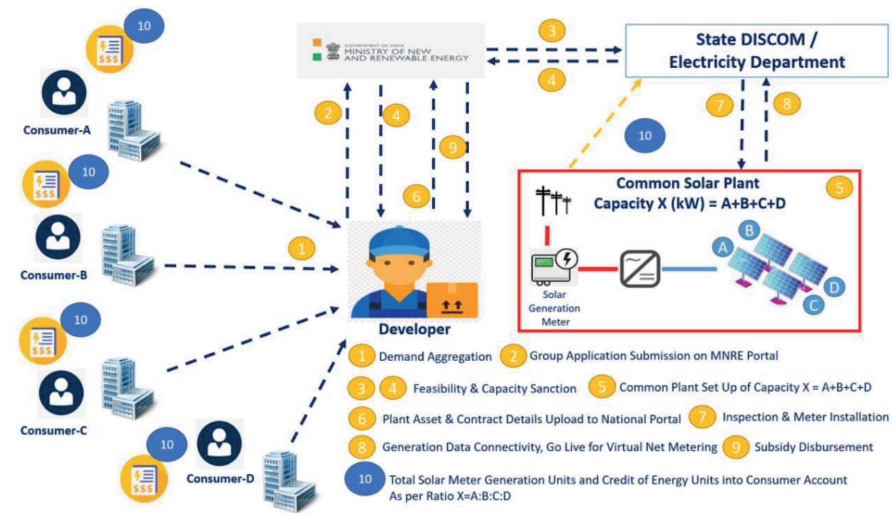

Fig.2 VNM Implementation Process

4. VNM Financial Models:

4.1. Model-1: Capital Investment (CAPEX) Model

In this model, a group of residential consumers will identify a piece of land/roof/mix of land & roof to set up a solar plant under VNM arrangement. The cost of plant (excluding MNRE subsidy) and land is borne by the consumers. The EPC developer/vendor will install the plant and maintain as per agreed terms. The electricity generated from the solar power plant is distributed to all the 4 participating consumers in the same ratios as the share of cost of plant (including land) among them. The DISCOM or Electricity department will adjust generated units in consumer's electricity bill.

Capital Investment:

MNRE	Consumer
Rs. 14,558/- per kW	Balance cost

Plant Ownership: Shared Consumer ownership

Illustration:

Suppose a group of four residential consumers set up a 10kW Solar plant, under VNM arrangements, as given in figure below:

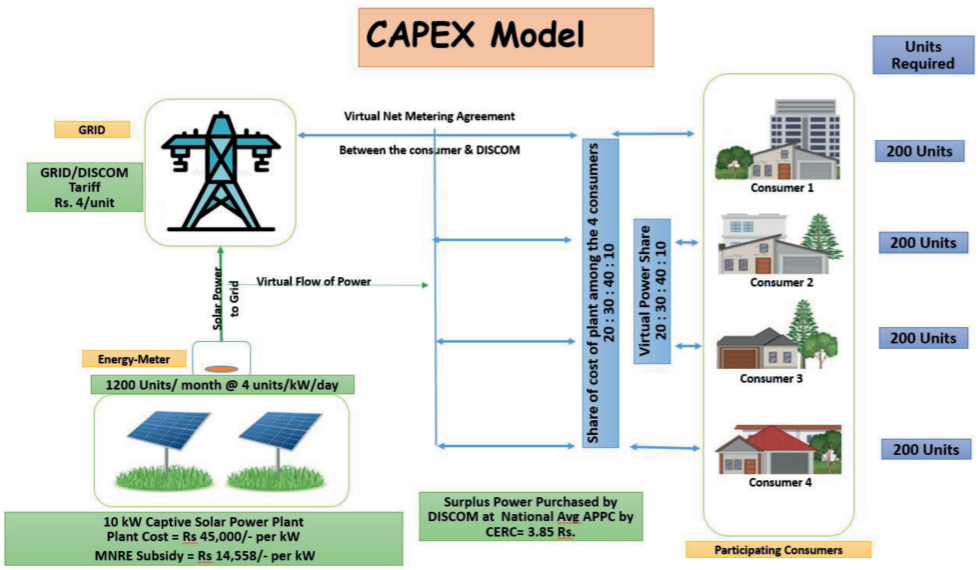

Fig. 3: VNM in CAPEX Model

Following assumption are made:

1. Cost of plant = Rs. 45,000/- per kW
2. Ratio of share of cost and virtual power among the 4 consumers = 20:30:40:10
3. MNRE subsidy = Rs. 14,558/- per kW
4. Rate at which surplus power is purchased by the DISCOM = APPC, in the illustration National Average APPC of Rs. 3.85/unit has been considered.
5. DISCOM Grid tariff = Rs 4/unit.

The electricity generated from the solar power plant is distributed to all the 4 participating consumers in the same ratios as the share of cost of plant among them. The DISCOM or Electricity department will adjust generated units in consumer's electricity bill. This will lead to either reduction in the electricity bill in case (import of electricity is more than export of electricity to the grid) or payment to the consumer by the DISCOM (in case) export of electricity is more than the import of electricity to the grid. Therefore, there will be monthly savings for the 4 consumers. It has been calculated that payback price will be 6 years and thereafter they will be earning for next 20 years. The calculated financial details are given in the table below.

Consumer	**Consumption** (kWh)	**Cost sharing of RTS plant (%)**	**Monthly Units Share from RTS plant** (kWh)	**Monthly Import from Grid** [(-) for export (kWh)]	**Monthly Electricity bill before VNM** (RS.)	**Monthly Electricity bill after VNM** (Rs.)	**Annual saving (Rs.)**	**Share in cost of RTS plant** (Rs.)	**Payback** (in Years)
1	200	20%	240	-40	800	-154	11448	68884	6.02
2	200	30%	360	-160	800	-616	16992	103326	6.08
3	200	40%	480	-280	800	-1078	22536	137768	6.11
4	200	10%	120	80	800	320	5760	34442	5.98

4.2. MODEL- II: The RESCO Model

A RESCO developer will design, build, fund and operate the entire solar power plant (roof or ground-mounted). Consumer shall pay to the developer against assured monthly unit generation per kW. DISCOM will adjust generated units in consumer's electricity bill.

Capital Investment:

Consumer	**MNRE**	**Developer**
0%	Rs. 14,558/- per kW	Balance cost (30% - Equity, 70% - Bank Loan @ 9% IR and 10 Yrs tenure)

Plant Ownership: RESCO

Illustration:
Suppose a RESCO sets up a VNM plant of 10 kWp on a piece of land under VNM arrangement on behalf of four consumers, as shown in Fig below:

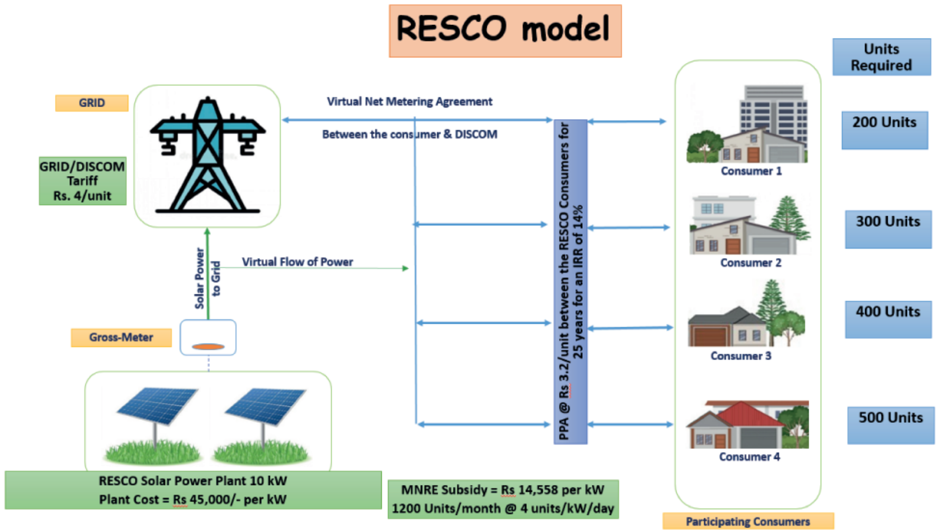

Fig. 4: VNM in RESCO Model

Following assumptions are made:

1. Cost of plant = Rs. 45,000/- per kW
2. MNRE subsidy = Rs. 14,558/- per kW
3. Rate at which surplus power is purchased by the DISCOM = APPC, in the illustration National Average APPC of Rs. 3.85/unit has been considered.
4. DISCOM Grid tariff = Rs 4/unit.
5. Electricity demand (in units) for four consumers per month is 200, 300,400 and 500 respectively.
6. The 1200 units generated per month will be supplied to the consumers as 200, 300,350 and 350 respectively.
7. The responsibility or providing vacant land to the RESCO and bearing cost, thereof, lies with the group of consumers.

The RESCO sells the electricity generated to the participating consumers to offset their consumption. It has been calculated that to get an IRR of 14% the RESCO needs a PPA of Rs 3.2 per unit for 25 years with the consumers. DISCOM will adjust generated units in consumer's electricity bill. This will lead to reduction of electricity bill and thereby, resulting in monthly savings for the four consumers. The financial details are given in table below: -

Consumer	Consumption (kWh)	RESCO solar supply to consumers (kWh)	Import from Grid (kWh)	Electricity bill before VNM (RS.)	Payment to RESCO (Rs.)	Electricity bill after VNM (Rs.)	Annual savings to consumers (Rs.)
1	200	200	0	800	640	640	1920
2	300	300	0	1200	960	960	2880
3	400	350	50	1600	1120	1320	3360
4	500	350	150	2000	1120	1720	3360

4.3. Model III: Utility Model – Special case of RESCO Model:

In rural areas, the electricity is generally subsidized, and realization of electricity bills is very less. Both the factors lead to loss of revenue to the utilities. The utilities can reduce this loss by setting up solar plants in rural areas. With VNM arrangement and subsidy available from central government, the cost of solar power generated from such solar plants would be around Rs 3.2 per unit as shown in Model-II above.

Generally, the APPC for the State/UTs is more than Rs 3.2 per unit. Moreover, there are around 20% technical losses till the LT side of the end beneficiary, thereby increasing the actual cost of power for the utility. The solar plant setup at tail end under VNM arrangement will not have such technical losses.

Let us take an example of a rural area in the state of Andhra Pradesh. The APPC (2020-21) for the state is Rs. 4.71/- per kWh. Considering around 20% technical losses till the LT side of the end beneficiary, the actual cost of power would be around Rs. 5.88 per kWh. With VNM and subsidy from Central Government, a solar plant can be installed in rural areas by the Utility. The cost of solar power generated from such plant would be around Rs. 3.2 per kWh. Thus, utility would save approx. around Rs. 2.68 per kWh.

Therefore, it is very advantageous for the DISCOMs to promote solar plants through virtual net metering arrangement in the rural areas.

Such local generation of power would ensure that the villagers receive reliable daytime power, improving their income through economic activities. This will lead to increase in the number of commercial/industrial consumers for the utility. Further the expenditure on network augmentation and its operation and maintenance will also reduce. It will also help the DISCOM to achieve their RPO target.

Annexure III

Benchmark cost for rooftop solar PV by MNRE https://mnre.gov.in/img/documents/uploads/file_f-1629353920466.pdf

No. 318/38/2018-GCRT
Government of India
Ministry of New & Renewable Energy
***

Block No. 14, CGO Complex,
Lodi Road, New Delhi
Date: 18th August 2021

ORDER

Subject: Benchmark costs for Grid-connected Rooftop Solar Photo-voltaic systems for the financial year 2021-22 -reg.

I am directed to convey the approval of competent authority for issuing of the benchmark costs for Grid-connected Rooftop Solar Photo-voltaic Systems for the financial year 2021-22 as under:

For General Category States/UTs:

System Capacity range	Upto 1 kW	>1kW upto 2 kW	>2kW upto 3 kW	> 3kW upto 10 kW	>10 kW upto 100 kW	> 100kW upto 500 kW
Benchmark cost (Rs./kW)	51100	46980	45760	44640	41640	39080

For Special Category States/UTs (i.e. North-Eastern States including Sikkim, Himachal Pradesh, Uttarakhand, Jammu and Kashmir, Ladakh, Andaman and Nicobar and Lakshadweep islands):

System Capacity range	Upto 1 kW	>1kW upto 2 kW	>2kW upto 3 kW	> 3kW upto 10 kW	>10 kW upto 100 kW	> 100kW upto 500 kW
Benchmark cost (Rs./kW)	56210	51670	50330	49100	45800	42980

2. The above benchmark cost includes cost of Solar PV panels (with domestic cell and modules), inverter (single/3 phase wherever applicable), balance of system e.g. cable, switches/ circuit breaker/ connectors/ junction box, mounting structure, earthing, lightening arrester, and civil works, installation & commissioning, CMC for 5 years, transportation, insurance, applicable taxes, etc. The above benchmark costs are excluding of net metering cost and battery back-up costs.

3. The benchmark cost for year 2021-22 will be applicable for all LoAs to be issued/empanelment of vendors to be done by the state implementing agencies, under Ph-II of rooftop solar programme of MNRE, after 10 days from the date of issuance of this benchmark cost notification.

Borah 18.08.2021

(Hiren Chandra Borah)
Scientist D
E Mail: hiren.borah@nic.in

To
All Concerned

Annexure IV

Quality Certification, Standards and Testing for Grid-connected Rooftop Solar PV Systems/Power Plants https://solarrooftop.gov.in/pdf/Quality_standards_np.pdf

Quality Certification, Standards and Testing for Grid-connected Rooftop Solar PV Systems/Power Plants

Quality certification and standards for grid-connected rooftop solar PV systems are essential for the successful mass-scale implementation of this technology. It is also imperative to put in place an efficient and rigorous monitoring mechanism, adherence to these standards. The vendor will be solely responsible for compliance of all quality certifications in rooftop solar installations under simplified procedure. All components of grid-connected rooftop solar PV system/ plant must conform to the relevant standards and certifications given below:

Solar PV Modules/Panels	
IEC 61215/ IS 14286	Design Qualification and Type Approval for Crystalline Silicon Terrestrial Photovoltaic (PV) Modules
IEC 61701	Salt Mist Corrosion Testing of Photovoltaic (PV) Modules
IEC 61853- Part 1/ IS 16170: Part 1	Photovoltaic (PV) module performance testing and energy rating: Irradiance and temperature performance measurements, and power rating
IEC 62716	Photovoltaic (PV) Modules – Ammonia (NH3) Corrosion Testing (As per the site condition like dairies, toilets)
IEC 61730-1,2	Photovoltaic (PV) Module Safety Qualification – Part 1: Requirements for Construction, Part 2: Requirements for Testing
IEC 62804	Photovoltaic (PV) modules - Test methods for the detection of potential-induced degradation. IEC TS 62804-1: Part 1: Crystalline silicon (mandatory for applications where the system voltage is > 600 VDC and advisory for installations where the system voltage is < 600 VDC)
IEC 62759-1	Photovoltaic (PV) modules – Transportation testing, Part 1: Transportation and shipping of module package units
Solar PV Inverters	
IEC 62109-1, IEC 62109-2	Safety of power converters for use in photovoltaic power systems – Part 1: General requirements, and Safety of power converters for use in photovoltaic power systems Part 2: Particular requirements for inverters. Safety compliance (Protection degree IP 65 for outdoor mounting, IP 54 for indoor mounting)
IEC/IS 61683 (as applicable)	Photovoltaic Systems – Power conditioners: Procedure for Measuring Efficiency (10%, 25%, 50%, 75% & 90-100% Loading Conditions)

BS EN 50530 (as applicable)	Overall efficiency of grid-connected photovoltaic inverters: This European Standard provides a procedure for the measurement of the accuracy of the maximum power point tracking (MPPT) of inverters, which are used in grid- connected photovoltaic systems. In that case the inverter energizes a low voltage grid of stable AC voltage and constant frequency. Both the static and dynamic MPPT efficiency is considered.
IEC 62116/ UL 1741/ IEEE 1547 (as applicable)	Utility-interconnected Photovoltaic Inverters - Test Procedure of Islanding Prevention Measures
IEC 60255-27	Measuring relays and protection equipment – Part 27: Product safety requirements
IEC 60068-2 (1, 2, 14 & 30)	Environmental Testing of PV System – Power Conditioners and Inverters a) IEC 60068-2-1: Environmental testing - Part 2-1: Tests - Test A: Cold b) IEC 60068-2-2: Environmental testing - Part 2-2: Tests - Test B: Dry heat c) IEC 60068-2-14: Environmental testing - Part 2-14: Tests - Test N: Change of temperature e) IEC 60068-2-30: Environmental testing - Part 2-30: Tests - Test Db: Damp heat, cyclic (12 h + 12 h cycle)
IEC 61000 – 2,3,5 (as applicable)	Electromagnetic Interference (EMI) and Electromagnetic Compatibility (EMC) testing of PV Inverters
Fuse	
IS/IEC 60947 (Part 1, 2 & 3), EN 50521	General safety requirements for connectors, switches, circuit breakers (AC/DC): a) Low-voltage Switchgear and Control-gear, Part 1: General rules b) Low-Voltage Switchgear and Control-gear, Part 2: Circuit Breakers c) Low-voltage switchgear and Control-gear, Part 3: Switches, disconnectors, switch-disconnectors and fuse-combination units d) EN 50521: Connectors for photovoltaic systems – Safety requirements and tests
IEC 60269-6	Low-voltage fuses - Part 6: Supplementary requirements for fuse-links for the protection of solar photovoltaic energy systems
Surge Arrestors	
IEC 62305-4	Lightening Protection Standard
IEC 60364-5-53/ IS 15086-5 (SPD)	Electrical installations of buildings - Part 5-53: Selection and erection of electrical equipment - Isolation, switching and control

IEC 61643-11:2011	Low-voltage surge protective devices - Part 11: Surge protective devices connected to low-voltage power systems - Requirements and test methods
Cables	
IEC 60227/IS 694, IEC 60502/IS 1554 (Part 1 & 2)/ IEC69947	General test and measuring method for PVC (Polyvinyl chloride) insulated cables (for working voltages up to and including 1100 V, and UV resistant for outdoor installation)
BS EN 50618	Electric cables for photovoltaic systems (BT(DE/NOT)258), mainly for DC Cables
Earthing /Lightning	
IEC 62561 Series (Chemical earthing)	IEC 62561-1: Lightning protection system components (LPSC) - Part 1: Requirements for connection components IEC 62561-2: Lightning protection system components (LPSC) - Part 2: Requirements for conductors and earth electrodes IEC 62561-7: Lightning protection system components (LPSC) - Part 7: Requirements for earthing enhancing compounds
Junction Boxes	
IEC 60529	Junction boxes and solar panel terminal boxes shall be of the thermo-plastic type with IP 65 protection for outdoor use, and IP 54 protection for indoor use
Energy Meter	
IS 16444 or as specified by the DISCOMs	A.C. Static direct connected watt-hour Smart Meter Class 1 and 2 — Specification (with Import & Export/Net energy measurements)
Solar PV Roof Mounting Structure	
IS 2062/IS 4759	Material for the structure mounting

Note: Equivalent standards may be used for different system components of the plants.

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India's installation of rooftop solar (RTS) photo voltaic (PV) is far behind the Government of India's target of achieving 40 GW of RTS PV installation by 2022. While the year of achieving the RTS PV installation target has been revised by the government to 2026, the capacity remains unchanged. Although there is currently no definitive information on overall residential rooftop capacity in the public domain, residential RTS PV has a very nominal share of the total rooftop solar PV installed capacity of 10.9 GW, with about 2 GW accounting for about 20 per cent of the overall RTS PV capacity.

This report argues, based on a cost–benefit analysis for DISCOM-driven residential RTS PV in ten selected states, that residential rooftops can contribute about 29 GW of residential RTS PV by 2030 even if the most conservative approach is followed. On the basis of potential of residential RTS PV and developments in its commercial and industrial (C&I) segment, it becomes important to consider scaling residential RTS PV to increase the share of the generation of clean power feeding into the grid. This requires experimenting with various models, involving multiple stakeholders.

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