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DEPLOYING SOLAR PV ROOFTOP ON LOW-PAYING CONSUMERS' PREMISES IN ASSAM

March 2021

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DEPLOYING SOLAR PV ROOFTOP ON LOW-PAYING CONSUMERS' PREMISES IN ASSAM – FINAL REPORT

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ACRONYMS

ABR	Average Billing Rate
ACS	Average Cost of Supply
AEGCL	Assam Electricity Grid Corporation Ltd
AERC	Assam Electricity Regulatory Commissions
APDCL	Assam Power Distribution Company Limited
APEPDCL	Andhra Pradesh Eastern Power Distribution Company Limited
APGCL	Assam Power Generation Company Ltd
ARR	Aggregate Revenue Requirements
AT&C	Aggregate Technical and Commercial (Losses)
DISCOMs	Distribution Companies
DPV	Distributed Photovoltaic
EE	Energy Efficiency
EESL	Energy Efficiency Services Limited
EPC	Engineering, Procurement and Construction
FY	Fiscal Year
GW	Gigawatt
KSEB	Kerala State Electricity Board Limited
HT	High Tension
INR	Indian Rupee
JBVNL	Jharkhand Bijlee Vitran Nigam Ltd.
kWp	Kilowatt Peak
LED	Light Emitting Diode
LPC	Low-Paying Customer
LT	Low Tension
MNRE	Ministry of New and Renewable Energy
MW	Megawatt
PACE-D 2.0 RE	Partnership to Advance Clean Energy – Deployment
PPA	Power Purchase Agreement
PV	Photovoltaic
REC	Renewable Energy Certificate
RESCO	Renewable Energy Service Company
T&D	Transmission and Distribution
UJALA	Unnat Jyoti by Affordable LEDs for All
USAID	United States Agency for International Development

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This report is an output of a comprehensive study carried out by PACE-D 2.0 RE team comprising experts from Tetra Tech and En-genuity.

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EXECUTIVE SUMMARY

India is rapidly transforming its coal-based power sector to a renewable energy-based sector. In the last six years, renewable energy capacity has increased 2.5 times while solar capacity has increased 13 times. However, achieving the Solar PV Rooftop (SPVRT) target of 40 GW by 2022 requires acceleration and fundamental changes in the business model. Several interventions from the Ministry of New and Renewable Energy (MNRE), such as subsidizing the residential sector, empowering and providing incentives for distribution companies (DISCOMs), modifying metering regulations, streamlining the demand aggregation process, and mobilizing financial and technical assistance through international partners and Indian public sector banks have not provided the desired results. Challenges include low awareness on solar rooftop systems, DISCOMs' and consumers' fear that SPVRT will lose residential customers money and a lack of public information about the approval process. COVID-19 has further impacted SPVRT deployment.

DISCOMs' financial analyses and SPVRT business models have not considered SPVRT's inherent advantage in reducing aggregate technical and commercial (AT&C) losses—the most burning problem of the Indian power sector in the past several years—by co-locating generation and consumption. This makes SPVRT more attractive in consumer areas where AT&C losses are higher, contrary to the belief that it will worsen DISCOMs' financial position. Customers with high AT&C losses are generally at the tail end of the network; as a result, their cost of supply is much higher than the revenue DISCOMs collect from them. In this report, we refer to such customers as "low-paying consumers."

The United States Agency for International Development's (USAID) Partnership to Advance Clean Energy-Deployment (PACE-D 2.0 RE) program developed the Super RESCO business model to accelerate SPVRT deployment. The model leverages the co-location advantage and addresses other challenges of SPVRT deployment as well. Under this model:

1. The consumer leases their roof to a renewable energy service company (RESCO), receives compensation, and obtains reliable and better-quality electricity.
2. The RESCO builds, owns and operates the SPVRT on the consumer's premises.
3. A DISCOM purchases all electricity generated by the SPVRT.
4. The RESCO recoups its investment through monthly payments from the DISCOM based on electricity generated by the SPVRT.

Assam is one of PACE-D 2.0 RE's partner states. The model has been conceptualized, developed, analyzed, and tested on the data of Assam Power Distribution Company Limited (APDCL) and cross-examined by Assam stakeholders. National-level stakeholders such as the Central Electricity Regulatory Commission, Solar Energy Corporation of India, and MNRE and stakeholders of other states debated the model in workshops before the advent of COVID-19 and by webinar during the pandemic.

PACE-D 2.0 RE determined that if Assam achieves its MNRE target of 250 MW from SPVRT by using the Super RESCO model, it will save INR106 crore annually. In addition, the model will bring INR1063 crore in investment to the state, create about 1,250 jobs, and produce other economic gains from using green energy. The financial gains can be shared with customers or can be used to reduce the state subsidy or cross-subsidy. The analysis assumed average AT&C losses to be 20 percent. Financial gains will exceed INR106 crore if AT&C losses are higher than 20 percent.

This report suggests that APDCL pilot the deployment of SPVRT using the Super RESCO model before rolling it out across Assam. The pilot and launch should target areas where AT&C losses are 30 percent or more to produce higher financial gains. Of the 46 APDCL divisions studied by the team, nine have AT&C losses of more than 30 percent. This report lists the activities PACE-D 2.0 RE has already completed in Assam and suggests a path to successfully implement the pilot. Important documents such as the request for proposal, power purchase agreement (PPA), and tripartite agreement among the customer, DISCOM and RESCO that PACE-D 2.0 RE has developed for other states are included in the document enclosed with the report.

INTRODUCTION

The Government of India has set a target of 40 GW of SPVRT deployment by 2022. The target achieved as on January 31, 2021 is only 4.2 GW.[1] Industrial and commercial consumers have been the major contributors to SPVRT deployment so far, with limited participation from domestic consumers. Meeting the SPVRT target will require greater participation from domestic consumers, as they own a large share of the roofs in the country. However, SPVRT deployment for domestic consumers has its own challenges, the major one being SPVRT's poor commercial viability due to low consumer tariffs, initial capital cost and DISCOMs' belief that it will cause them a financial loss. Other challenges include high transactional costs due to the fragmented nature of the market and lower contract sanctity due to a lack of credit records.

PACE-D 2.0 RE develops interventions to address the challenges of SPVRT deployment for low-paying consumers with partner states Assam and Jharkhand.[2] The program studied states' interventions to deploy SPVRT or similar technologies in order to understand the deployment challenges specific to the partner states; innovated a new business model (named as super RESCO under Gross Metering Arrangement) and conducted a financial and economic analysis to determine the gains to key stakeholders at various level of SPVRT deployment. These stakeholders include DISCOMs, consumers, state governments, and engineering, procurement and construction (EPC) businesses.

This report presents the study's findings, recommendations and a way forward for deploying SPVRT for domestic low-paying consumers (LPC) in Assam.[3] The recommendations and next steps can also be applied to other categories of low-paying consumers, such as those in agriculture.

[1] Ministry of New and Renewable Energy
[2] For details about the PACE-D 2.0 RE program, please see www.pace-d.com.
[3] Low-paying consumers are consumers who pay less in electricity tariffs than the cost of serving them.

SECTION I: CHALLENGES IN DEPLOYING SOLAR ROOFTOP FOR LOW-PAYING CONSUMERS

As of June 20, 2020, Assam has achieved 30.56 MW of solar PV rooftop out of a total target of 250 MW by FY 2021-2022 under the MNRE's National Solar Mission.[4] Major contributors to Assam's capacity are industrial consumers, commercial consumers and educational institutions. However, participation from domestic consumers has been limited.

Domestic consumers in Assam contribute over 50 percent of total APDCL sales. In FY 2020-2021, APDCL's projected sales to domestic consumers totaled around 5.19 million kWh, with the principal "Domestic A"[5] category accounting for 42 percent of projected sales overall.[6] Due to the limited SPVRT participation from this major consumer category, Assam has been unable to achieve its solar target. Major reasons for the lack of participation are listed below:

1. **Low consumer tariffs**: Tariffs for many of Domestic A consumers are lower than DISCOMs' cost to supply them. The difference in tariff and cost of supply is funded through cross-subsidies by DISCOMs and subsidies from state governments. This is the main reason why these low-paying consumers have stayed away from solar PV rooftop. In FY 2020-21, the tariff for Domestic A consumers is INR 4.09/kWh, including a subsidy of INR 1.01/kWh from the Government of Assam. The estimated cost of energy from SPVRT is about INR 4.75/kWh. With MNRE subsidizing 40 percent of project cost, the cost of energy can fall to INR 3.5/kWh.[7] The INR 0.59/kWh savings from SPVRT are not attractive enough to motivate this consumer category. The payback period on investment is longer and may require about six years for a 1 kW installation. In addition, there is poor awareness of the MNRE subsidy.

2. **Limited capacity to invest**: SPVRT is capital-intensive technology, requiring an upfront investment of about INR 42,000 to 50,000 per kW, which discourages many domestic consumers. Securing credit from a bank is a cumbersome process and customers feel the savings from SPVRT are not worth the time and cost.

3. **Hurdles for third-party developers**: Though the costs of solar rooftop have decreased, many LT consumers cannot afford the capital expenditure by themselves. LT consumers are predominantly residential, small commercial and agricultural consumers. This has resulted in the development of third party-based business models like RESCO models. Third-party developers run the SPVRT plants under a build-own-operate model. However, RESCOs have seen limited success due to issues such as high transaction costs, the fragmented nature of the distributed photovoltaic (DPV) sector, difficulties in consumer acquisition, the aggregation of demand to

[4] https://mnre.gov.in/img/documents/uploads/file_s-1594347424972.xlsx
[5] Refer to the following chapter for definition of Domestic A consumers
[6] FY 2020-21Tariff Order for APDCL passed by AERC on March 7, 2020.
[7] MNRE provides a capital subsidy to domestic consumers deploying SPVRT. For SPVRT with capacity up to 3 kilowatts peak (kWp), the capital subsidy is 40 percent of project cost. For capacity of more than 3 kWp, 40 percent subsidy is available for the first 3 kWp and 20 percent is available for the rest of the capacity up to 10 kWp. Capacities larger than 10 kWp are only eligible for subsidies for the first 10 kWp.

achieve economies of scale and lack of contract sanctity. RESCO market development has also lagged in less developed states.

4. **Lack of suitable roofs**: Many houses in Assam have roofs with asbestos sheets supported by wooden beams. Such roofs are not suitable for the SPVRT deployment and may need major renovations, adding to costs.

5. **Lack of support from DISCOMs:** SPVRT poses some challenges to APDCL, which explains its lack of enthusiastic support. These include:

    a. Under export-import metering, SPVRT will reduce consumption of DISCOM-distributed energy, lowering electricity purchases from the higher slabs under telescopic tariffs that increase with consumption. This will lead to lower revenue for APDCL.
    b. Due to domestic consumers' high share of consumption and their low daytime demand, APDCL has a power surplus during the daytime. The generation from SPVRT would add to the current daytime surplus and also create local pockets of generation with surplus.
    c. APDCL field staff have limited awareness of SPVRT.

Solar PV systems located on low-paying consumers' roofs can be a win-win proposition for the DISCOM, the consumers, the SPVRT industry and the government. Assam can achieve its solar PV rooftop target while maximizing the benefits of SPVRT to all these stakeholders by deploying of SPVRT on the premises of low-paying consumers. The report details down the benefits Assam can cherish by accelerated deployment of Solar PV Rooftop systems in the state

SECTION II: LOW-PAYING CONSUMERS HAVE A HIGHER COST OF SUPPLY

WHO IS A LOW-PAYING CONSUMER (LPC)?

LPCs are small-scale consumers who receive electricity to meet their basic needs at low rates (because of their limited ability to pay) even though the cost of supplying electricity to them is higher than the tariff. In the case of Assam, the following low tension (LT) consumer categories are designated as low-paying.

- **Jeevan Dhara consumer category**: any premises exclusively for the purpose of own requirements with a connected load of not more than 0.5 kW and consumption up to 1 kWh/day or 30 kWh/month.
- **Domestic A consumer category**: residential premises (for domestic purposes only) with a connected load below 5 kW. Includes occupants of flats in multi-story buildings if the premises have not been classified under Domestic B or HT Domestic and receive bulk power at a single point without any individual metering arrangements.

TARIFF FOR LOW-PAYING CONSUMERS

The Assam Electricity Regulatory Commission (AERC) released the following tariff schedule for LPVs on March 7, 2020. Both Jeevan Dhara and Domestic A consumers pay a two-part tariff: a fixed charge and a telescopic variable charge depending on consumption.

Table 1: Tariff schedule as of April 1, 2020

CONSUMER CATEGORY	FIXED CHARGES			ENERGY CHARGES		
LT Consumer Category	**Base Rate**	**Govt Subsidy**	**Effective Rate**	**Base Rate**	**Govt Subsidy**	**Effective Rate**
	(Rs/kW/month)			(Rs/kWh)		
Jeevan Dhara 0.5 kW and 1 kWh/day	20	20	0	4.25	4.25	0
Domestic A – below 5 kW						
0 to 120 kWh/month	50	-	50	5.10	1.01	4.09
121 to 240 units per month	50	-	50	6.35	-	6.35
Balance Units	50	-	50	7.35	-	7.35

Jeevan Dhara consumers pay a fixed charge of INR 20/kW/month and a variable charge starting at INR 4.25/kWh. The charges are fully subsidized by the government. However, any Jeevan Dhara consumer who uses more than 30 kWh per month for two consecutive months is transferred to the Domestic A category and billed accordingly thereafter, irrespective of the amount consumed.

Domestic A consumers pay a fixed charge of INR 50/kW/month and a variable charge starting at INR 5.10/kWh. Starting at 120 kWh/month, the tariff increases to INR 6.35/kWh, then rises again to INR 7.35/kWh for any monthly consumption beyond 240 kWh.

While Domestic A is the largest consumer category, Jeevan Dhara consumers contribute only 0.1 percent of total APDCL sales. The tariff for Domestic A consumers is generally among the lowest after Jeevan Dhara/consumers below the poverty line and agricultural consumers. In fact, in its multiyear tariff petition, APDCL submitted that there was a decline in Jeevan Dhara consumption in the last fiscal year. Because the impact of Jeevan Dhara consumers is negligible, this study will focus on Domestic A consumers.

COST OF SUPPLY FOR LOW-PAYING CONSUMERS

An important indicator of a DISCOM's financial viability is the gap between the **average billing rate (ABR)** and the **average cost of supply (ACS)** per unit of energy supplied. The formulae used to determine ABR and ACS are provided in Annex V. Utility operations will be profitable if the ABR exceeds the ACS each year of operation, that is, revenue from selling power to different consumer categories should cover the cost of service plus a profit margin for the DISCOM. In the case of Assam, APDCL provided ABR and ACS for all consumer categories to AERC in its petition for revised tariff and aggregate revenue requirements (ARR) for FY 2020-2021.

Table 2: Cost of supply for Domestic A consumers in Assam

INDICATORS FOR ASSAM (APDCL)	UNIT	VALUE
Average Billing Rate for Domestic A Consumers (P)	Rs/kWh	5.92
Average Cost of Supply (Q)	Rs/kWh	7.87
Difference (P-Q)	Rs/kWh	(1.95)

As indicated in Table 2. APDCL's projected ABR, which includes all fixed and variable charges for Domestic A consumers, is about INR 5.92/kWh. However, projected ACS is about INR 7.87/kWh. This is an undercharge of INR 1.95/kWh, meaning the DISCOM cannot recover its costs of operation by selling power to Domestic A consumers. Instead, it fills the gap with a cross-subsidy from other consumer groups and a subsidy from the Government of Assam.

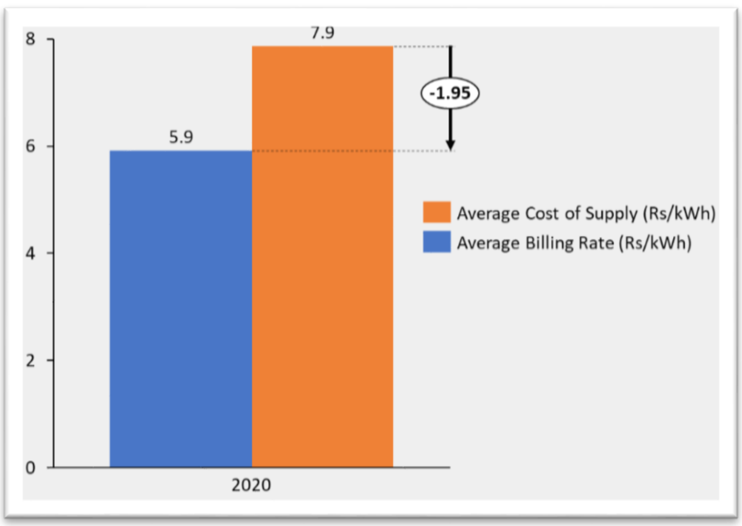


Figure 1: Difference between ACS and ABR for Domestic A consumers

IMPACT OF TRANSMISSION AND DISTRIBUTION (T&D) LOSSES ON COST OF SUPPLY FOR LOW-PAYING CONSUMERS

One important element of the cost of supply is T&D losses that occur during the process of supplying electricity to consumers. Although APDCL has made significant efforts to reduce distribution losses from 17.64 percent in FY 2018, losses in 2019 and 2020 exceeded the target of 16 percent (Figure 2).

APDCL claims that the increase in losses has been due to a massive increase in LT consumers without an adequate HT consumer base as a backbone. The increase in LT:HT consumer ratio and rural electrification (under the SAUBHAGYA scheme) further focused the utility on identifying ways to lower supply-side losses. Transmission losses remain at 3.34 percent.

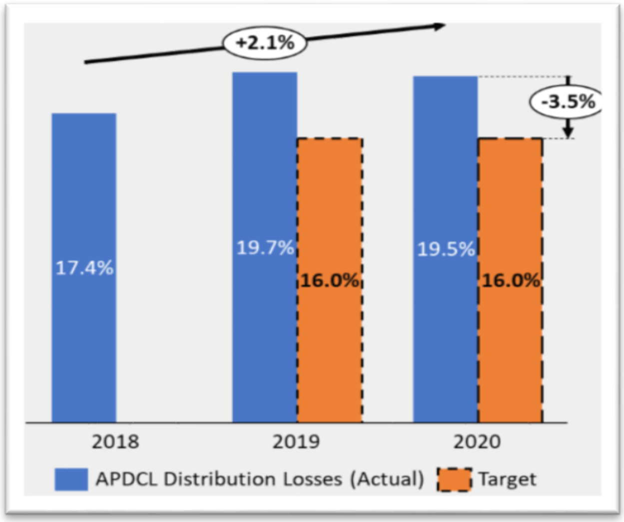


Figure 2: APDCL distribution losses

If distribution losses are significantly reduced or eliminated, this can reduce the cost of supplying electricity and create significant savings for DISCOMs and the state government, which often pays for subsidies to cover LPCs' electricity. SPVRT co-located on consumer premises is one intervention that has potential to not only reduce the impact of technical distribution losses, but also improve commercial inefficiencies (aggregate technical and commercial, or AT&C losses). The table below indicates the overall cost of supplying electricity to LPCs after including the impact of T&D losses, which contribute INR 1.21/kWh to the cost of supply.

Table 3: Contribution of losses to cost of supplying electricity to LPCs

OVERALL COST OF SUPPLYING ELECTRICITY TO LOW-PAYING CONSUMERS	VALUE
Average purchase cost of electricity at state periphery	INR 4.12/kWh
Transmission loss	3.34%
Distribution loss for LT	20%[8]
Total loss, %[9]	22.67%
Cost of electricity supplied to the consumer's doorstep[10]	INR 5.33/kWh
Total loss, INR/kWh	INR 1.21/kWh

[8] The tariff order for FY 2019-2020 allows APDCL an aggregated distribution loss of 16 percent but does not mention voltage-wise losses. A distribution loss of 20 percent is assumed for LT consumers.
[9] Total loss = 1 - (1 - transmission loss) x (1 - distribution loss)
[10] Cost of energy at consumer doorstep = Average purchase cost at state periphery/(1 – Total loss)

The cost of electricity supplied should not be confused with ACS, which includes infrastructure maintenance cost, employee cost, depreciation, finance cost and other overhead costs not factored into in the above calculation. The goal is to understand the contribution of losses to the overall cost of electricity.

AREA OF FOCUS FOR APDCL

During an APDCL presentation on ARR for the FY 2019-20 and Revised ARR & Determination of Tariff for FY 2020-2021, the DISCOM informed the regulatory commission that high AT&C losses are a matter of concern for the company.[11] One of the reasons for these high losses is the high HT: LT ratio which is about 1:3 in Assam.

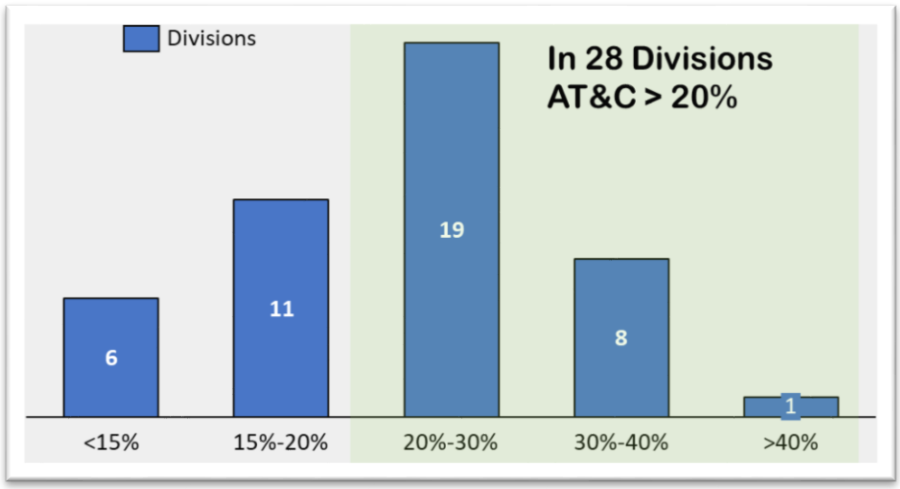


Figure 3: AT&C losses across APDCL

An analysis of AT&C losses across all APDCL divisions found that the losses are uneven.[12] Among the 45 divisions, 28 have losses of more than 20 percent (Figure 3). Within the divisions, AT&C losses for sub-divisions and feeders vary. Annex III illustrates feeder-specific AT&C losses for Boko and Hajo subdivisions between August 2019 and October 2019. Out of 14 feeders, seven have losses of 50 percent and above.

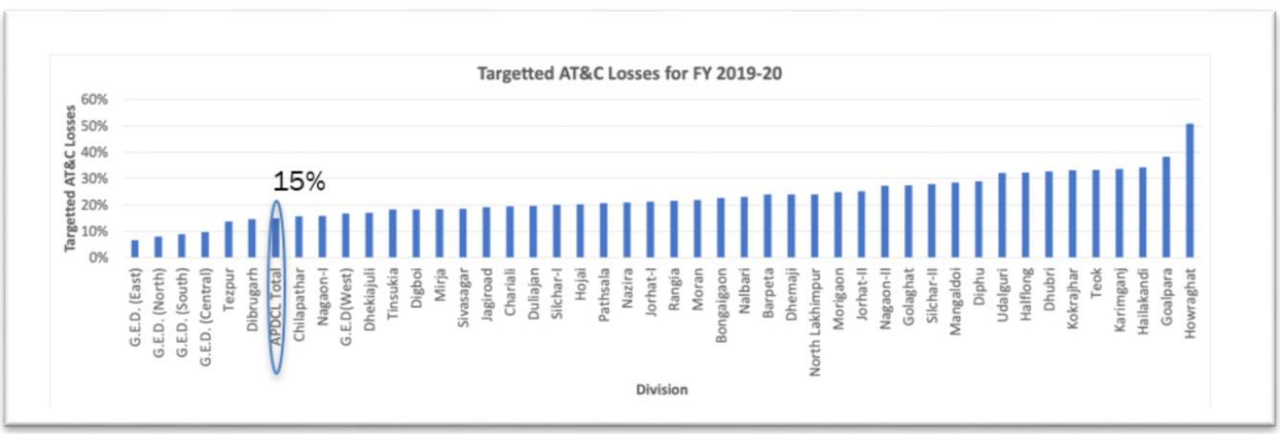


Figure 4: AT&C loss targets by division for FY 2019-2020

[11] APDCL Tariff Order for FY 2020-21 passed by AERC on March 7, 2020.
[12] Memorandum of Understanding between Ministry of Power, Government of India, Government of Assam and APDCL signed in January 2017 to implement the UDAY Scheme.

APDCL aims to reduce loss levels to 15 percent overall and has set targets for each division based on division profiles. Reducing distribution losses in high-loss areas and feeders will have a greater impact and help APDCL achieve its target. Using the SUPER RESCO model to deploy SPVRT can help APDCL reduce the cost of supply if implemented in divisions with AT&C losses greater than 20 percent.

SECTION III: RELEVANCE AND APPLICABILITY OF THE INNOVATIVE BUSINESS MODEL DEVELOPED BY PACE-D 2.0 RE

Increasing SPVRT among LPCs hinges on the design and adoption of an appropriate business model that addresses all the challenges of deploying with consumers who pay very little for grid-based electricity, have little to no credit history and very often have not seen a solar rooftop system. A RESCO model would have to ensure that no upfront investments are required from either the DISCOMs or the LPCs, while also ensuring that the RESCO's returns were protected through appropriate long-term contract arrangements.

In general, solar PV rooftop installations can be deployed using a variety of models. These can range from the simple net or gross metering models to RESCO-based models using both gross and net metering. Other DISCOM-anchored models such as on-bill financing or an aggregator could also achieve this objective. However, all these models face several challenges in reaching LPCs, which were identified during PACE-D 2.0 RE stakeholder interviews in Assam. Some are highlighted below:

1. Consumers, especially LPCs, have no capital to make any investments in these systems. This effectively rules out the **gross and net metering models**.

2. RESCOs rate LPCs very low in terms of long-term contract security. This, along with the relatively high cost of solar PV rooftop power (compared to the subsidized power that LPCs receive) excludes **standard RESCO models**.

3. A third option is a **DISCOM-anchored model**. Assam's DISCOM does not want to invest in the systems, and bill financing and aggregation would not work due to the lack of adequate arbitrage for consumers (in terms of savings).

Addressing these critical issues requires a new business model. The DISCOM is already in the business of supplying power and sees solar developers starting to take a share of the market, thus making a case for DISCOMs to play a key role in various aspects of SPVRT deployment that can lead to large-scale usage. The DISCOM can take the role of a facilitator, a mediator or an investor (Table 5).

Table 4: Possible DISCOM roles under DISCOM-based business models

	FACILITATOR	MEDIATOR	INVESTOR
Activities/ Responsibilities	• Increase consumer awareness • Standardize components and services • Empanel vendors and rate list • Run procurement for the consumers	• Procure systems and to consumers under consumer-owned model • Procure power to supply to consumers under RESCO-owned model • Arrange consumers' roofs for RESCOs to supply electricity to DISCOM • Collect interest and repayments on loans from consumers	• Invest and own systems to provide services to consumers (under net metering) or to DISCOM (under gross metering)
Advantages to consumers and developers	• Aggregation of demand leading to economies of scale • Better quality systems/services	• Payment security • Contract sanctity • Better project management	• Better project management • Better quality systems/services • No risk to consumers

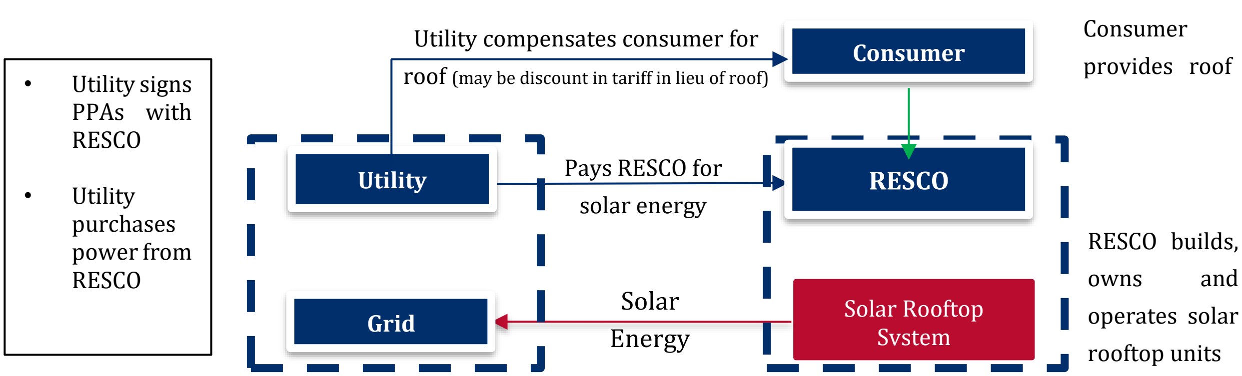
	FACILITATOR	MEDIATOR	INVESTOR
		• Better quality systems/services • Lower risk to consumers and developers	
Return to DISCOM	Low/none – facilitation fee	Medium – project management fee/loan collection fee/low cost of supply	High – return on projects
Risk to DISCOM	Low	Medium	High
Risk to consumers and vendors	High	Medium	Low
Overall risk profile of project	High	Medium	Low

Based on an analysis of the requirements and process of elimination, APDCL and PACE-D 2.0 RE determined that the Super RESCO-based gross metering model (also referred to in the report as "the proposed model") is the best.

This model would leverage the market for financing, ensure investor returns through a gross metering tariff and incentivize consumer participation through a rebate on their electricity bills. Due to its ability to reach every consumer in the state and its existing relationship with them, APDCL can aggregate many roofs for SPVRT deployment. At the same time, developers will be comfortable signing PPAs with APDCL due to its creditworthiness.

Under this model (Figure 5), APDCL will aggregate RESCOs for the deployment of SPVRT installations on the roofs of low-paying consumers. This aggregation of capacity enables larger procurements, leading to economies of scale that will reduce both prices and the DISCOM's cost of power purchase. The DISCOM will facilitate RESCOs to deploy these systems on LPCs' premises and then buy all solar power generated from those systems. DISCOMs have the technical know-how and ability to monitor the quality and timely execution of projects, which will improve deployment. Consumers will receive compensation for their roof in terms of lease or a discount on their electricity bills.

Figure 5: Super RESCO Model



Key stakeholders in this model are the DISCOM (APDCL), consumers and RESCOs. Their roles and responsibilities are outlined in Table 5 below:

Table 5: Responsibilities of key stakeholders in the pilot

APDCL (DISCOM)	RESCO	CONSUMER
• Get regulatory and legal approvals for the pilot • Sign PPA with RESCO and tripartite agreement with RESCO and consumer • Facilitate interconnection for RESCO • Maintain high reliability of the substation and downstream lines • Timely payment against monthly bills to RESCO • Testing, sealing, installation, reading and maintenance of meters	• Identify substations • Engage with consumers for roofs • Make any necessary improvements to roofs • Obtain all necessary clearances for developing solar PV rooftop systems • Sign agreements with consumers • Build, own and operate the solar PV rooftop systems for 25 years • Send monthly invoices to APDCL	• Provide RESCO with round-the-clock access to roof • Make necessary (minor) changes in the roof and internal circuit • Sign tripartite agreement with APDCL and RESCO

As highlighted earlier, the role of APDCL is critical in implementing the proposed model. APDCL will:

- Acquire consumers
  - Develop a compensation scheme for LPCs to participate in the model
  - Identify areas/feeders with high AT&C losses
  - Identify LPC households with suitable roofs
  - Tie up with LPC for SPVRT development
- Identify RESCOs
  - Develop a procurement process through tariff-based bidding
  - Develop procurement documents including a request for proposal, PPA and tripartite agreement (See document enclosed for procurement documents developed for Jharkhand Bijlee Vitran Nigam Ltd, or JBVNL, to implement a pilot)
  - Aggregate identified roofs and carry out procurement to identify RESCOs
- Execute the project
  - Facilitate RESCOs to access roofs and support from LPCs
  - Monitor RESCOs' execution
  - Carry out commissioning tests for SPVRT
  - Connect SPVRT to the grid
- Operate the project
  - Provide stable reference voltage to SPVRT invertors for smooth operation
  - Regularly manage billing and payment for solar generation
  - Monitor RESCOs' performance
- Ensure regulatory support
  - Obtain regulatory approvals for the proposed model, including for the compensation scheme

- Obtain regulatory approvals for the tariffs determined through tariff-based competitive bidding

HOW DOES THE PROPOSED MODEL ADDRESS THE CHALLENGES?

Consumers and developers cannot overcome the challenges highlighted in Section I by themselves; they will need the intervention of a large, state government organization.

The Super RESCO model would bring together the participants needed to address the challenges, as in the table below. Most importantly, the it would enable LPCs to participate in SPVRT deployment without requiring any investment or consumption of solar power.

Table 6: How the Super RESCO model addresses the challenges of SPVRT deployment

CHALLENGE	SUPER RESCO SOLUTION
Low consumer tariffs	Low consumer tariffs discourage domestic consumers from investing in SPVRT due to the longer payback period. Under the proposed model, RESCOs install SPVRT on the LPCs' premises and sell all solar generation to APDCL. LPCs are not compelled to buy solar power and would receive compensation for leasing their premises.
Limited consumer capacity to invest	No investment from LPCs is required; the RESCOs are responsible for the full investment.
Hurdles for RESCOs	• The fragmented nature of the LPC base increases transaction costs. Under this model, APDCL acts as an aggregator, bringing capacities from LPCs to scale. • Another major hurdle is LPCs' poor creditworthiness. Under the Super RESCO model, RESCOs sign PPAs with APDCL, leveraging APDCL's strong credit rating to help RESCOs secure their investment and source cheaper capital. The tripartite agreement with APDCL and the LPC further reduces project risk.
Lack of ssuitable rroofs	Due to its ability to reach every electricity consumer in the state, APDCL has an advantage over developers in identifying LPCs with suitable roofs and approaching them about deploying SPVRT.
Lack of support from APDCL	Since APDCL will purchase all solar power generated from SPVRT, they would not lose any revenue. Any llocal surplus can be consumed in the immediate vicinity, *i.e.*, the same distribution transformer or feeder. Moreover, sites can be selected for SPVRT consumption within immediate vicinity.

The Super RESCO model is more attractive than others, because it generates specific benefits for each stakeholder:

1. For the **consumer:** LPCs can participate in environmentally friendly infrastructure development at no cost and earn compensation for their roof.
2. For **APDCL**:
    a. No investment required
    b. Avoids the burden of managing solar PV rooftop systems
    c. With its technical and legal capabilities, APDCL can ensure the high quality of generating assets supporting its grid
    d. Enables APDCL to focus SPVRT deployment on areas with infrastructure congestion and high losses to maximize benefits

e. Uses a tariff-based bidding process to identify RESCOs, which can drive down tariffs due to capacity aggregation and competition

3. For **RESCO**s:
    a. Partnering with DISCOMs reduces payment risk and increases reliability of contracts
    b. PPA with DISCOMs allows competitive terms for financing from mainstream investors
    c. Aggregation and standardization allow bulk procurement of components
    d. High project volume due to aggregation allows RESCOs to plan and implement better

Later sections discuss the financial (cost and benefit) and economic effectiveness of the model.

SECTION IV: FINANCIAL ANALYSIS

Deploying SPVRT will help APDCL reduce its T&D losses, which will reduce the cost of supplying electricity to LPCs. This can lessen the need for cross-subsidies and state government subsidies, benefiting both APDCL and the government. This section estimates the monetary value of these benefits based on field visits, APDCL's strategy and operations, PACE-D 2.0 RE's recommendations to APDCL, and globally recognized assumptions for solar PV rooftop systems.

The report includes national- and state-level assessments using secondary data from tariff and ARR orders, petitions, and published reports. Tariff orders and other regulatory documents provided key parameters such as energy sales, quantity of power purchase and cost, T&D losses, fixed and variable charges, ARR, revenue gaps and subsidies, cross-subsidies, tariff details, *etc*. Based on these parameters, PACE-D 2.0 RE developed a financial model to estimate DISCOMs' savings and the total benefits to the system from implementing SPVRT.

Solar rooftop business models have evolved based on the ownership of systems and external stakeholder participation. In DISCOM-based business models, the role of the DISCOM can vary from facilitator to mediator to investor. As one of the objectives of this study was to design a business model that will help DISCOMs reduce their AT&C losses, specifically for LPCs, the team also reviewed the following business models (described in detail in Annex I):

5 MW Gandhinagar Rooftop Solar Program deployed in Gujarat by Torrent Power under gross metering for government and residential buildings. Here the DISCOM acted as a facilitator.

SOURA model of grid-connected rooftop/ground-mounted solar PV plants by Kerala State Electricity Board Ltd (KSEB), which acts as an investor. SPVRT is deployed on all types of buildings.

Andhra Pradesh pilot for low-income, low-consumption consumers by Andhra Pradesh East Power Distribution Company. In this case, the DISCOM mediates consumer loans financed by Andhra Bank.

UJALA Program for Energy Efficient and Affordable Lighting to All implemented by several DISCOMs across many states. In this case, the DISCOM acts as an investor.

After quantifying the benefits for each stakeholder, the team estimated that by deploying 250 MW of SPVRT, APDCL can save about INR 68.5 crore from reduced cost of supply. APDCL can increase its savings if it achieves 8 percent of total FY 2021-2022sales from solar power and avoids purchasing renewable energy certificates (RECs) to meet its solar renewable energy purchase obligations. Overall, deploying 250 MW of SPVRT, APDCL can save about INR 106.0 crore, as in the table below.

Table 7: Assumptions and savings from 250 MW of SPVRT

NO.	FACTOR	ASSUMPTION
	SPVRT Generation	
1	Generation from 1 MWp SPVRT	1.5 MUs
2	Generation from 250 MWp SPVRT (1)	375 MUs

NO.	FACTOR	ASSUMPTION
Savings from reduced T&D		
3	Average purchase cost of electricity at state periphery	INR 4.12/kWh
4	Transmission loss	3.34%
5	Distribution loss for LT	20%[13]
6	Total loss[14]	22.67%
7	Cost of energy supplied at consumer doorstep[15]	INR 5.33/kWh
8	Cost of electricity from SPVRT	INR 4.75/kWh
9	Cost of electricity from SPVRT after 40% capital subsidy	INR 3.50/kWh
10	Savings from SPVRT (Difference between lines 7 and 9)	INR 1.83/kWh
11	Savings from reduced T&D (Product of lines 8 and 10)	INR 68.5 crore
Savings from avoiding RECs		
12	Avoided cost of RECs	INR 1,000/REC i.e., INR 1/kWh[16]
13	Savings from avoiding RECs (Product of lines 2 and 12)	INR 37.5 crore
14	Total reduction in cost of supply (Sum of lines 11 and 13)	INR 106.0 crore

The INR 106.0 crore savings can be used to reduce the cross-subsidy and state government subsidy, benefiting APDCL and the state government. Furthermore, cost of supply is highly sensitive to T&D losses. The decrease in APDCL's cost of supply when SPVRT is deployed in areas with higher distribution losses is estimated in Table 8.

Table 8: Impact of 250 MW SPVRT on T&D losses

DISTRIBUTION LOSS	20%	30%	40%	50%	60%
Reduction in T&D loss (MUs)	85	121	157	194	230
Impact of T&D loss on cost of supply (INR/kWh)[17]	1.21	1.97	2.98	4.40	6.54
Reduction in cost of supply (INR Crore)	106.0	134.6	172.6	225.9	305.8

Savings from T&D loss reduction are sensitive to SPVRT capacity and T&D losses as well:

Table 9: Sensitivity analysis of savings to SPVRT capacity and T&D losses

GAINS TO APDCL FROM SPVRT (INR CRORE)					
SPVRT Capacity (MW)	**T&D Losses**				
	20%	**30%**	**40%**	**50%**	**60%**

[13] The tariff order for FY 2019-2020 allows APDCL an aggregated distribution loss of 16 percent but does not mention losses by voltage. A distribution loss of 20 percent is assumed for LT consumers.
[14] Total loss = 1 - (1 - transmission loss) x (1 - distribution loss)
[15] Cost of energy at consumer doorstep = Average purchase cost at state periphery/(1 – Total loss)
[16] 1 REC is issued for 1 MWh. The floor price for RECs is set at INR 1,000.
[17] Assumes a transmission loss of 3.34 percent.

GAINS TO APDCL FROM SPVRT (INR CRORE)					
100	42.4	53.8	69.1	90.4	122.3
150	63.6	80.8	103.6	135.6	183.5
200	84.8	107.7	138.1	180.7	244.7
250	106.0	134.6	172.6	225.9	305.8
300	127.3	161.5	207.2	271.1	367.0
350	148.5	188.4	241.7	316.3	428.2

APDCL may not realize the gains estimated above in the short term due to its power surplus position. However, it can realize these gains in the long term. For now, SPVRT can add to APDCL's current surplus energy. PACE-D 2.0 RE has developed and submitted a "Report to Optimize Supply-Side Resources and Green Tariff in Assam" to APDCL, recommending interventions to reduce surplus.

In addition, MNRE provides DISCOMs performance-based incentives, paying at least 5 percent of their capital cost for adding 10 percent or more additional capacity above that in the previous financial year. If the new capacity exceeds 15 percent of the previous year, an additional incentive of 10 percent is available. This translates into INR 21.25 lakh/MW of SPVRT deployed.

SECTION V: ECONOMIC ANALYSIS

SPVRT can also support Assam to meet its sustainable development goals through three key growth factors: creating jobs, mobilizing investment and reducing carbon emissions.

1. **Creating jobs**: Each MW of SPVRT can create an estimated five jobs in operations and maintenance. Deploying 250 MW of SPVRT can create 1,250 new jobs in Assam.
2. **Mobilizing investment**: The estimated capital cost of solar rooftop systems is about INR 42,500/kWp, which amounts to INR 4.25 crore per MW. Deploying 250 MW of SPVRT capacity can mobilize investment of INR 1,063 crore to Assam.
3. **Reducing carbon emissions**: SPVRT can help Assam reduce its purchases from thermal power plants, which emit high amounts of carbon. Each kWh generated by SPVRT can lead to a 0.932 kg reduction in carbon emissions, which means 250 MW of SPVRT can reduce carbon emissions in Assam by 350 million tons annually.

SECTION VI: IMPLEMENTING THE SUPER RESCO MODEL

The new Super RESCO model has yet to be implemented in India, but piloting this innovative approach specifically targeting LPCs will produce results and learning that can be used to fine-tune the model before statewide scale-up. In Assam, PACE-D 2.0 RE team recommends the following:

1. Designing a pilot to understand the implementation challenges and benefits; and
2. Adjusting certain regulatory provisions.

PILOT DESIGN

Through a pilot, APDCL can assess the model's large-scale deployment potential and identify challenges, such as:

- Changes in the power supply situation;
- Reduction in T&D losses, thereby reducing power purchase costs; and
- Understanding the challenges of a wider roll-out and developing solutions.

Key design features of the pilot project include:

- **Capacity**: The proposed capacity of the pilot is 10 MW, which may be split into two or more projects at one substation each. The minimum capacity of each project should be 1 MW and no RESCO will be awarded projects of more than 4 MW of cumulative capacity.

- **Selection of RESCOs**: RESCOs will be selected through a competitive bidding process based on the lowest quoted tariff and strict qualifying criteria to ensure their ability to execute the project. The pilot will ensure the quality of the SPVRT systems by specifying standards in the tender and monitoring project execution regularly.

- **Location**: The pilot should be rolled out among APDCL substations with the highest losses. APDCL will provide a list of such substations during the tendering process and the RESCOs will identify the substations they want to bid for.

- **Power purchase agreement**: After project allotment, each RESCO will sign a PPA with APDCL specifying obligations for the sale and purchase of the power generated by the systems. The PPA will also set out the design, output and operations and maintenance requirements for the project. APDCL will procure all power generated from the systems through a competitive bidding process under a gross metering arrangement and on the terms and conditions defined in the PPA.

- **Tripartite agreement**: Each RESCO will sign a tripartite agreement with individual consumers and APDCL for use of and access to the consumers' roofs to install the systems. The agreement will set out each party's obligations during the project period. Important clauses will include: (a) scope of work, (b) responsibilities, (c) security of the solar PV rooftop systems, (d) conditions of entry and access, (e) conditions of default, (f) penalties, (g) compensations against defaults, etc.

PACE-D 2.0 RE has prepared a request for proposal, PPA and tripartite agreement for JBVNL to implement the Super RESCO model in Jharkhand, which APDCL may use for reference.

A robust implementation approach includes details of the project boundary and roles and responsibilities of various stakeholders, as outlined in Section III. The pilot should be carried out within controlled boundaries to support data analysis. For the pilot, PACE-D 2.0 RE recommends a substation-based approach that will allow a thorough study of the power supply reduction upstream of the substation, the reduction in T&D losses and any changes in power quality. The pilot will also be useful in understanding localized impacts, such as changes in consumer behavior and local job creation.

CHALLENGES AND RISKS

Being the first of its kind, the pilot may face some challenges and risks, to which this report recommends the following mitigation strategies:

- **Contract sanctity**: The pilot will involve many LPCs with no available credit history, which increases the risk to the RESCO and APDCL. A tripartite agreement among the consumer, RESCO and APDCL will allow APDCL to enforce the consumer's obligations and take appropriate action if consumers default on their responsibilities. Consumers are more likely to honor the agreement with APDCL as a party due to their ongoing relationship.

- **Lack of or limited power availability at consumer's premises**: APDCL consumers face power outages due to the lack of upstream supply or technical faults in the grid. During these outages, solar rooftop systems stop generating due to their anti-islanding features, which will lead to losses for RESCOs. To compensate the RESCOs for power outages, the PPA should include "deemed generation." APDCL will commit to a maximum number of daytime hours in the year during which power will be not available from the grid. If the power outage exceeds this number of hours, the deemed generation clause will provide the RESCO with the benefit of the same.

- **Consumer acquisition**: Signing up a large number LPCs will be a challenge for the RESCO. APDCL can help recruit consumers and provide incentives to participants. The incentive may be an electricity tariff rebate, free units on the monthly bill, monthly lease rent (from the RESCO, as part of the tripartite agreement) or any other provision.

- **Payment security**: Any investor faces the risk that the purchaser will not pay as promised. However, APDCL has a good track record of paying their generators for electricity procurement. Moreover, APDCL may provide the RESCOs with a letter of credit.

- **Capacity-building for APDCL field staff**: APDCL's staff and management have experience with the conventional model of selling electricity over a power network, but minimal awareness of solar rooftop. They will need training and capacity-building as their roles expand to include additional services made possible by greater penetration of solar rooftop energy. APDCL will need to provide the technical training to its staff for smooth pilot implementation.

REGULATORY PROVISIONS

To implement the Super RESCO model more widely in Assam, PACE-D 2.0 RE recommends a set of regulatory interventions, including the following changes to AERC's draft "Assam Electricity Regulatory Commission (Grid Interactive Solar PV Systems) Regulations, 2019":

1. **Allow gross metering**: The Super RESCO model is based on a gross metering mechanism. The draft regulations only allow export import and net metering, which are not attractive to domestic consumers for to the reasons highlighted in Section II. To make SPVRT more appealing and enable the Super RESCO model, gross metering should also be allowed.
2. **Relax the upper limit on SPVRT capacity for individual consumers**: Draft regulations limit individual consumers' SPVRT capacity to 80 percent of the connected load/contract demand. Because Assam has limited availability of suitable roofs, the constraint does not allow Assam to maximize SPVRT deployment with the space it has. The upper limit should be relaxed to the roof's technical feasible capacity.
3. **Relax the upper limit on cumulative SPVRT capacity for LT distribution transformers**: Draft regulations limit the cumulative SPVRT capacity for each LT distribution transformer to 20 percent of its peak load. Due to the limited availability of roofs, this limit should be relaxed to the technical feasible capacity of the LT distribution transformer.
4. **Allow compensation to consumers for leasing their roofs**: To incentivize consumers to participate in the scheme, consumers should be compensated with half of the profit from the SPVRT systems installed on their premises. APDCL will pay this compensation through a rebate in each consumer's monthly electricity bill. If the owner of the system is other than APDCL, then APDCL will make an arrangement with the user.

PACE-D 2.0 RE ACTIVITIES IN ASSAM

With the support of MNRE and the Government of Assam, PACE-D 2.0 RE organized a kick-off workshop on August 19, 2019 in Guwahati. This workshop, hosted by APDCL, featured participants including Mr. Niraj Verma, Principal Secretary, Power, Government of Assam; Mr. Rakesh Agarwala, APDCL; Ms. Kalyani Baruah, Assam Power Generation Company Ltd. (APGCL); Mr. Satyendra Nath Kalita, Managing Director, Assam Electricity Grid Corporation Ltd. (AEGCL); and other senior officials from these organizations. PACE-D 2.0 RE introduced the concept of using DPV for LPCs.

After further discussions, PACE-D 2.0 RE developed a pilot analysis matrix to identify DPV pilots for LPCs in Assam, visited substation areas and worked with DISCOMs to identify and collect rural division- and feeder-level data in order to identify one or two feeders for pilots. Based on data from 160 rural feeders, the team worked on framing business cases for LPCs.

The team developed the concept of the Super RESCO model with gross metering and presented it to senior APDCL officials Mr. Agarwala; Mr. Manoranjan Kalita, Chief General Manager (Com & EE Department); Mrs. Bandana Goswami, Chief General Manager (Non-Conventional and Renewable Energy Department); and other officials on January 27, 2020. The team explained the need for a pilot and requested that APDCL identify one or two substations to carry out a brief survey to assess the pilot's feasibility. PACE-D 2.0 RE also presented the concept to AERC and received feedback.

On January 28, the team surveyed substations at Hajo and Ramdia; later, they consulted SPVRT developers on the model, highlighting developers' roles and responsibilities and the vendor selection process. Developers saw the model's merits and expressed willingness to participate in the pilot.

Based on feedback, PACE-D 2.0 RE developed and submitted a concept note for the Super RESCO model to APDCL with the design, benefits, regulatory requirements and need for a pilot. The team met with APDCL officials, with Mr. Kalita as chair, to discuss the model on July 30. APDCL noted that with its power surplus, APDCL would not be able to achieve the estimated savings as the power surplus would increase due to SPVRT. Because APDCL sells surplus power on the Indian Energy Exchange below cost, APDCL would lose revenue from greater SPVRT deployment.

With this consideration, PACE-D 2.0 RE re-estimated the impact on APDCL and found that the negative impact only appears in the short term. As the demand increases and power surplus decreases, SPVRT's impact on APDCL will become positive. The team shared this assessment with APDCL and met on October 9 to discuss the findings. Because the initial impact will be negative, APDCL informed PACE-D 2.0 RE that they would need approval from the Government of Assam. PACE-D 2.0 RE offered to support APDCL in the approval process and pilot implementation. For a full list of meetings and communications, please see Annex IV.

SECTION VII: KEY RECOMMENDATIONS AND WAY FORWARD

Installing 40 GW of SPVRT is an important step to achieving the Government to India's goal of 100 GW of solar by 2022. Challenges have arisen for both national and state governments due to low consumer tariffs and limited investment capacity among the residential consumers who own most roofs.[18] Previous sections of this report highlighted how the Super RESCO model can address these challenges and accelerate SPVRT deployment even in the LPC category.

Section IV analyzes the financial impact of deploying SPVRT. APDCL requires 250 MWp to meet its renewable energy purchase obligations target. Deploying 250 MWp of SPVRT will save APDCL INR 68.5 crore annually by reducing the cost of supply and INR 37.5 crore annually by avoiding REC purchases if the capacity is deployed in areas where AT&C losses are 20 percent or higher. APDCL's financial gains are sensitive to the AT&C losses and will reach as high as INR305.8 crore if SPVRT is deployed in areas where AT&C losses are 60 percent.

Economic gains (Section V) are more sensitive to capacity. The deployment of 250 MWp of SPVRT will lead to investment of INR 1030 crore, generation of 1,250 new jobs and an annual reduction of 350 million tons of carbon emissions.

Therefore, SPVRT brings financial gains to the DISCOM and economic gains to the state. Consumers will receive higher-quality, more reliable electricity and compensation for the use of their roofs.

APDCL has surplus power during the day. This should not deter APDCL from promoting SPVRT due to the high financial and economic gains overall and the reduction of AT&C losses in areas where APDCL has struggled. Furthermore, Assam's per capita consumption is the second lowest in India. APDCL should use these low-cost, high generation opportunities to improve demand, its business and the economy of Assam.[19]

PACE-D 2.0 RE has shared the concept of the Super RESCO model and other details with the Government of Assam, APDCL, AERC and developers, who have not registered any concerns. Nevertheless, the team recommends that APDCL pilot the model in high-loss areas before rolling it out across Assam to understand challenges and mitigate any doubts APDCL might have about the financial benefits. APDCL should take the following steps:

1. Identify substations with high AT&C losses (greater than 20 percent).
2. Conduct a preliminary survey or use Google Earth to estimate the capacity of SPVRT that can be deployed in the area under those substations.
3. The pilot should deploy 10 to 25 MW of SPVRT. Smaller pilot results might not scale consistently and developers might quote higher prices for lower capacity. If necessary, the pilot can select more than one substation to ensure 10 to 25 MW of capacity.

[18] According to the 2001 census, of 187 million households in India, 38 million have concrete roofs.
[19] PACE-D 2.0 RE, "Note on Optimal and Market-Based Utilization of Electricity Supply Resources of Assam," www.pace-d.com.

4. Build the capacity of APDCL field officers to educate them about the program and how they should they encourage consumers to participate.
5. Hold meetings in identified areas/substations to educate consumers about the benefits of participating and the procedure to take part.
6. The procedure for consumer participation should be simple and with few paper requirements.
7. The developer should be allowed to use the substation roof and space for SPVRT installation.
8. Select developers based on open competition.
9. The tender should include a PPA to be signed by APDCL, the developer and the consumer. All documents PACE-D 2.0 RE developed for a similar pilot in Jharkhand are attached for APDCL's use as Annex III.
10. Hold a pre-bid meeting and publicize the tender widely to attract more developers and ensure strong competition under the tender.

APDCL should approach either AERC or the Government of Assam on two issues:

1. For residential customers, the capacity of SPVRT should not be restricted.

   Normally, residential customers' allowable load is much smaller than the space they have for SPVRT. Relaxing this limit will help deploy SPVRT at a larger scale, as the Government of Gujrat has already determined.[20]

2. What rent should customers receive for their roofs?

   Legally fixing the roof rent will avoid developer discrimination among consumers. Tender conditions can be modified accordingly.

[20] Gujarat Solar Power Policy 2021.

ANNEX I: SPVRT BUSINESS MODELS IMPLEMENTED IN INDIA

5 MW GANDHINAGAR ROOFTOP SOLAR PROGRAM

About the Program – The Government of Gujarat launched the Gandhinagar solar PV rooftop program in 2010. It was the first pilot demonstration of the public-private partnership model, wherein the government engaged with RESCOs to implement SPVRT projects over government and residential buildings in Gandhinagar. Being the first of its kind, the project faced many challenges, such as owners' acceptance of solar PV installations on rooftops in residential and commercial sectors, owners' ability to execute the installations, lack of readiness to invest and own the installations, funding arrangements, sale of power and the revenue model, permissions and approvals, operations and maintenance, and appropriate system architecture.

Business model – The Gandhinagar program had a total size of 5 MW and was implemented through a RESCO model. Azure Power and Sun Edison were selected through tariff-based competitive bidding and were allotted 2.5 MW each. The program used a gross metering mechanism with Gandhinagar DISCOM Torrent Power Limited as the buyer for the solar power. Roof owners receive a "green incentive" of INR 3/kWh instead of a flat roof rent from RESCOs in order to motivate the rooftop owner to actively engage in the program.

SOURA SCHEME: GRID-CONNECTED ROOFTOP/GROUND-MOUNTED SOLAR PV PLANTS

About the Program – Under the Urja Kerala Mission, the Government of Kerala launched a project called SOURA to add 1,000 MW of solar power capacity to the KSEB grid. Out of that 1,000 MW, the state aims to set up 500 MW in SPVRT projects. As the program facilitator, KSEB released a 200 MW tender under the SOURA program in 2019 and has identified 70,000 roofs that are feasible for SPVRT. KSEB will engage with consumers to acquire roofs and will provide them to developers (selected in a bidding process) for SPVRT installation. A total capacity of 200 MWp will be installed under SOURA.

Business model – KSEB has suggested both engineering, procurement and construction (EPC) and RESCO-based implementation models. Model 1 is RESCO-based: KSEB uses interested consumers' roofs, engages with RESCOs to develop SPVRT projects, and procures all solar generation. Roof owners receive energy credits for 10 percent of the solar power generated on their roofs. Models 2 and 3 are EPC-based. In Model 2, the energy generated is sold to the owners of the respective roofs at a fixed tariff that includes the cost of generation plus a margin. In Model 3, KSEB installs the rooftop system through an EPC developer and transfers it to the consumer.

ANDHRA PRADESH'S PILOT FOR LOW-INCOME, LOW-CONSUMPTION CONSUMERS

About the Program – Realizing the potential savings from low-electricity-consumption consumers (also cross-subsidized consumers), Andhra Pradesh Eastern Power Distribution Company Ltd (APEPDCL) has facilitated a DISCOM-driven solar rooftop pilot for residential consumers requiring less than 200 units of power per month. It was implemented at two locations (Muralinagar and Madhurawada) in the city of Visakhapatnam to demonstrate the concept.

Business Model – The pilot includes both EPC and RESCO models. Model 1 is a customer-owned SPVRT program using a net metering arrangement. The capacity of systems will be 1 kW to 1.5 kW. Financing for system installation is available through a combination of (a) a capital subsidy extended by the Government of India and the Government of Andhra Pradesh, (b) loans to consumers at preferential terms, and (c) an upfront equity contribution from consumer. As part of the pilot, Andhra Bank extends loans to consumers at preferential terms. Participating customers pay monthly installments on their loans via electricity bills from APEPDCL, which passes the payments on to the bank. Installments are designed not to exceed the power bill in any given month.

Model 2 is RESCO-oriented and uses gross metering. Under this model, a RESCO is selected through competitive bidding to supply power to APEPDCL for 25 years using the roofs of participating consumers. APEPDCL compensates the consumers at a rate of INR 0.5/kWh for electricity generated.

UNNAT JYOTI BY AFFORDABLE LED FOR ALL (UJALA) PROGRAM

The UJALA Program does not deploy SPVRT, but its business model can apply to SPVRT deployment.

About the Program – In India, lighting accounts for about 20 percent of total electricity consumption. Conventional incandescent bulbs consume more power and thus increase overall energy demand. In 2015, the Government of India established the nationwide UJALA Program to reduce energy demand in the lighting sector, promoting efficient lighting products such as light emitting diode (LED) bulbs and tube lights.

Business Model – Energy Efficiency Services Limited (EESL), a public sector enterprise, is the implementer. Energy-efficient appliances, especially LED bulbs, tube lights and fans, lower electricity bills for consumers and reduce the peak load for DISCOMs. EESL's business model is a benefit-sharing approach under which EESL pays the upfront costs of energy-efficient appliances to reduce the burden on customers and DISCOMs, then recovers part of the cost from each party over time. EESL can provide consumers LED bulbs and tube lights at below-market costs: INR 70 and INR 290 respectively. It recovers its upfront investment in two ways:
DISCOM: LEDs and tube lights reduce the DISCOM's load. EESL estimates the savings to the DISCOM based on its peak procurement cost and uses them to calculate an annuity. The DISCOM pays back its portion of the cost through the annuity over a period of three to ten years.

Consumers: Consumers pay back their portion of the cost through eight to 12 monthly installments. DISCOMs collect these installments through electricity bills and pass them on to EESL.

Under the UJALA Program, over 360 million LED bulbs had been distributed by January 2020. This has helped avoid peak demand by 9,000 MW and reduced greenhouse gas emissions by 38 million tons annually.

LESSONS LEARNED FROM THE CASE STUDIES

Each case study is unique in its objective and execution, and each demonstrates the efforts made by state governments, DISCOMs and implementing partners to develop SPVRT projects in their respective states. Key lessons are presented in Table 10:

Table 10: Key lessons from other states

STATE/PROGRAM	KEY LESSONS
Gujarat	• This was the first SPVRT pilot in Gujarat. The projects were implemented under a RESCO model and all power was procured by Torrent Power Limited. About 4.6 MW of solar capacity was implemented under the pilot, based on which the scheme was repeated in other districts of Gujarat. • Different agreements were prepared under the pilot, such as a PPA, a power supply agreement, a lease agreement, *etc*. • Consumers received green incentives. PACE-D 2.0 RE suggests a similar model using gross metering. This model showcases a generation-based mechanism to compensate consumers for their roofs. It also produced documents that will improve contract adherence among consumers, RESCOs and DISCOMs.
Kerala	The SOURA scheme uses both EPC- and RESCO-based models. Under the RESCO projects, KSEB procures all power generated from the projects and consumers receive an energy rebate as an incentive. SOURA displays a compensation model using energy credits for participating consumers. This incentive mechanism allows consumers to gain more, as it allows higher savings on energy bills as the consumer's tariff increases. PACE-D 2.0 RE suggests considering this compensation model for the pilot.
Andhra Pradesh	Though Model 1, APEPDCL has taken the novel step of providing financing to consumers who are interested in implementing SPVRT projects. Andhra Bank supports the scheme, providing consumers with loans to be repaid in monthly installments. The target consumers are LPCs who consume less than 200 kWh of electricity per month. Through Model 2, APEPDCL compensates the consumers for their roofs directly. This pilot demonstrates on selecting low-paying consumers and developing a scheme for them. PACE-D 2.0 RE suggests adopting APEPDCL's consumer selection criteria for the pilot as well as a compensation model (*e.g.*, DISCOMs compensate consumers for their roofs based on amount of power generated).
UJALA Program	The UJALA Program introduced a cost-sharing approach that successfully distributed energy-efficient appliances, showing that the high cost of these appliances can be covered by both consumers and DISCOMs through their respective savings. The UJALA Program also demonstrates how benefits are shared between DISCOMs and consumers, making it attractive for both. PACE-D 2.0 RE recommends that the pilot follow a similar approach.

ANNEX II: AT&C LOSSES BY FEEDER AT BAKO AND HAJO SUBSTATIONS

SUBSTATION	FEEDER	AT&C LOSSES
Bako	Boko Local	37%
	Sontoli	58%
	Tupamari	75%
	Bamunigaon	47%
	Sakhati	65%
	Malibari	48%
	Sekhadari	54%
	Chamaria	51%
	Dakuapara	50%
	Nagarbera	40%
	Total	**53%**
Hajo	Hajo	44%
	Satdala	53%
	Ramdia	46%
	Damdama	31%
	Total	**45%**

ANNEX III: LIST OF MEETINGS AND COMMUNICATIONS

TYPE OF COMMUNICATION	DATE	PARTICIPATION	PROCEEDINGS
Face-to-face meeting	July 31, 2019	• PACE-D 2.0 RE team • APDCL, NRE cell	The objective of the meeting was to provide APDCL with three or four options for DPV for LPCs in the state, create an understanding of the concepts and enable APDCL to identify the best fit option in the interest of the state.
Kick-off meeting and technical workshop	August 19, 2019	• Chaired by Principal Secretary, Department of Power (E), Government of Assam • Senior Officials - Managing Directors of APDCL, APGCL, and AEGCL • PACE-D 2.0 RE team • Other participants included senior and mid-level officers from the Government of Assam, all three utilities, the regulatory commission, the state nodal agency for RE, and the electrical inspector	The kick-off included the implementation road map of the activities to be performed in the state, including DPV pilots for LPCs. The meeting also aimed to ascertain which activities would be in the best interests of the state.
Face-to-face meeting	November 19, 2019	• APDCL officials • PACE-D 2.0 RE	Members of the PACE-D 2.0 RE team from Tetra Tech met with Assam officials to discuss the data requirements for the activity. APDCL officials were briefed on data needs and the support they must provide to facilitate data collection.
Face-to-face meeting	January 27, 2020	• Chaired by Managing Director, APDCL • APDCL Officials - CGM Commercial, GM NRE cell and other officials • PACE-D 2.0 RE team	PACE-D 2.0 RE presented the concept and the need for a DPV pilot.
Face-to-face meeting	January 28, 2020	• Local APDCL officials of Hajo substation • PACE-D 2.0 RE team	PACE-D 2.0 RE carried out a survey of the substation near Hajo and consulted with developers charged by the General Manager of NRE.
Webinar	June 19, 2020	• Chaired by Secretary to the Government of Assam, Power (E) Department; Principal Secretary, Government of Assam, Power (E) Department • CGM, NRE cell, AERC, AEGCL, APDCL • PACE-D 2.0 RE team	PACE-D 2.0 RE appraised the Energy Secretary, AERC and APDCL on the concept in a steering committee meeting.
Virtual meeting	July 30, 2020	• Chaired by CGM (Comm & EE) • APDCL Officials - AGM (Comm), DGM, AM, GM (TRC), AM • PACE-D 2.0 RE team	PACE-D 2.0 RE presented the concept to CGM, Commercial and received feedback from APDCL.
Email	August 10, 2020	PACE-D 2.0 RE, APDCL	APDCL shared detailed feedback through email.
Email	September 16, 2020	PACE-D 2.0 RE, APDCL	PACE-D 2.0 RE re-worked the cost and benefits and shared a revised PowerPoint presentation.

TYPE OF COMMUNICATION	DATE	PARTICIPATION	PROCEEDINGS
Email	October 5, 2020	PACE-D 2.0 RE, APDCL	APDCL raised queries on the re-worked cost benefit analysis.
Email	October 5, 2020	PACE-D 2.0 RE, APDCL	PACE-D 2.0 RE addressed the queries,
Virtual meeting	October 9, 2020	• Chaired by CGM (Comm & EE) • APDLC Officials - AGM (Comm), DGM, AM, GM (TRC), AM • PACE-D 2.0 RE team	PACE-D 2.0 RE presented the findings of the assessment. APDCL highlighted the need for approval from the Government of Assam to adopt the proposed model and carry out a pilot.

ANNEX IV: AVERAGE BILLING RATE AND AVERAGE COST OF SUPPLY

INDICATORS	UNIT	REMARKS
Average Billing Rate (ABR)	Rs/kWh	ABR is the total revenue earned by charging consumers at specified tariffs for the energy supplied plus the subsidy (if any) received by the utility divided by the total sales. $$ABR = \frac{Revene\ from\ sale\ of\ power + subsidy\ recieved}{Total\ Sales\ (MU)}$$
Average Cost of Supply (ACS)	Rs/kWh	ACS is the cost of purchasing power from various generators (conventional, non-conventional, power exchanges, *etc.*) plus the cost of operating and maintaining the distribution network (such as service lines and distribution transformers) plus employee cost, depreciation, and finance cost—all divided by the total sales to consumers. $$ACS = \frac{Power\ purchase\ cost + O\&M + Depreciation + Finance}{Total\ Sales\ (MU)}$$

When the ABR equals or exceeds the ACS, the DISCOM is in a good financial position and can recover its cost of operation by selling power to consumers. It also signifies that the utility can invest in augmenting or upgrading its network in the future.

In the case of Assam, APDCL has estimated the average billing rate for each consumer category and computed average cost of supply for all consumers, which it provided to AERC in its petition for revised ARR and tariffs for 2020-2021.