Status of Distributed Solar Energy in Tamil Nadu

Challenges & Roadmap 2025

AurovilleConsulting

Sustainable Energy Transformation Series

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EXECUTIVE SUMMARY

In January 2019, the Tamil Nadu Government released its Tamil Nadu Solar Energy Policy 2019. The policy set an overall solar energy target of 9,000 MW to be achieved by 2023 (TEDA 2019), and envisions a future where solar energy will play an important role in meeting the State's energy needs in an equitable and sustainable manner. As of September 2020, Tamil Nadu has an aggregate installed capacity of 4,221 MW of solar energy (MNRE 2020). Distributed solar energy makes a disproportionately small contribution in this total capacity. For example, as of September 2020, there is an installed capacity of consumer category solar of only 247 MW (MNRE 2020). To operationalise the solar energy policy's vision and objectives, and meet the State's solar energy targets, an accelerated deployment of solar energy is required. This is even more so for distributed solar energy generation.

This report presents the status of distributed solar energy generation in Tamil Nadu – as it relates to policy and regulations, operational challenges, solar PV financing, skill development and grid integration of solar energy. *It identifies and elaborates on the challenges in each of these areas, and recommends a set of measures to the relevant stakeholders (the policy makers or the distribution utility).* Two categories of measures are outlined, with a 2025 timeline: foundational measures and advanced measures. Foundational measures aim at addressing the basic barriers in increased adoption of distributed solar energy, such as:

- Make solar net feed-in metering mechanism available to all consumer categories;
- Determine a realistic net feed-in tariff for consumer category solar to reflect the actual cost of solar energy generation;
- Raise the minimum solar PV capacity for inspection requirement by the Electrical Inspectorate from 10 kW to 100 kW for consumer category solar;
- Introduce time-of-day (ToD) tariffs for all consumers to incentivise behind-the-meter solar and storage solutions.

Advanced measures, which are expected to require significant institutional and government support to be implemented, will require a longer time frame. Some of these are:

- Introduce additional solar energy metering mechanisms including group metering and virtual metering;
- Initiate fundamental reforms in the sector by rationalising the consumer electricity tariffs;
- Regularly publish data on installed solar (as well as other RE) capacity by voltage, location, mode of transaction (rooftop solar, open access and sale to utility) and year of commissioning;
- Introduce regulations and market mechanisms to enable provision of ancillary services by smart inverters and energy storage.

These measures, if implemented, may help in accelerating the transition to a distributed solar and renewable energy future in Tamil Nadu.

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1. INTRODUCTION

Worldwide, the electricity grid operation is changing from the conventional model of centralised generation to distributed generation of electricity from renewable energy (RE). This transformation to a flexible electricity grid is being driven by a number of factors, which include: highly cost competitive renewable energy, consumers becoming prosumers, national climate change commitments with renewable energy targets, and the introduction of flexible distributed energy resources or 'DERs' such as rooftop solar energy, energy storage systems and demand response (Auroville Consulting 2019a). Utilities and policy makers face the challenge to respond to this change in paradigm, by putting right policy and regulatory frameworks in place, designing new market mechanisms and evolving the grid planning tools to accommodate distributed generation.

Defining Distributed Solar Energy Generation

Distributed solar energy generation can be defined around three parameters as follows (Auroville Consulting 2019a):

- Interconnection at voltage level below 33 kV (CEA 2013), that is, 22 kV and below,
- Integration into the existing distribution infrastructure, and
- Consumption of the energy generated primarily within the local distribution network (i.e., close to the point of consumption).

The governing Supply Code in Tamil Nadu (TNERC 2018) limits the connected power capacity to be less than 5 MVA for availing electricity supply at 22 kV. However, the procedure laid down by the utility for connectivity of solar power plants to the distribution system allows a capacity up to 10 MW to be connected at 22 kV (TANGEDCO n.d.). Based on these, *distributed generation can be defined as a single generation unit or multiple units with aggregated capacity of up to 10 MW, interconnected at 22kV voltage level and below.*

Benefits of Distributed Solar Energy Generation

The traditional solution to meet growing electricity demand is procuring power from new centralised power plants and building of new transmission capacity. As the electricity grid operation evolves, this traditional 'wires solution' is being overtaken by distributed generation of power, which offers a number of benefits as follows (Auroville Consulting 2019a):

- Lower T&D losses: Having generation closer to the load reduces energy losses that happen in the transmission and distribution system (about 14% losses in the distribution system in Tamil Nadu [Energy Department 2020a]);
- Reduction in average cost of supply, benefiting both the consumers and the utility;
- Deferred investment in grid infrastructure: distributed solar energy generation can reduce the load on the distribution transformer and substation, deferring (or avoiding) upgradation costs;
- Improved grid resilience, if coupled with other flexible distributed energy resources including demand response and energy storage, because of its geographical spread;
- Improved reliability of power supply for consumers.

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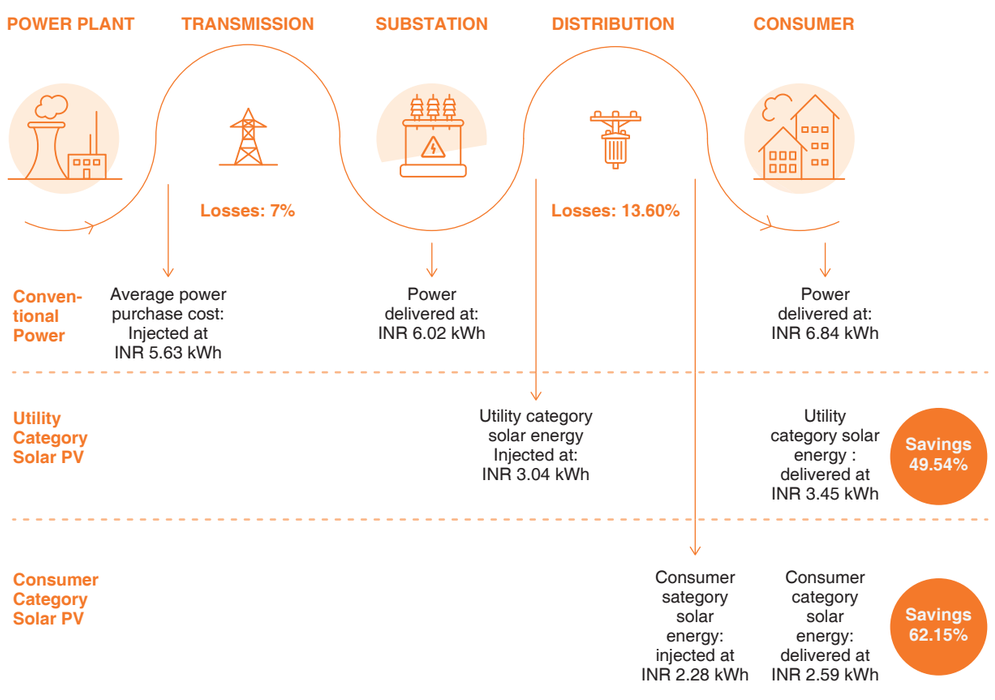
In Tamil Nadu, the State Government-owned distribution utility, TANGEDCO, is burdened with large financial losses (Auroville Consulting 2020a; Financial Express 2020; ET Energyworld 2020b) despite various schemes and measures to improve the health of the sector. In fiscal year 2019, the utility's aggregated debt stood at INR 1,13,438 crore, provisional (CRISIL 2020), and as of April 2020, the utility owed nearly INR 17,000 crore to power generators as per Ministry of Power (MoP n.d.). The transition to distributed solar energy generation provides opportunities to improve the financial health of the utility. The utility will benefit from reduced cost of supply of energy, and lower technical losses of energy (Auroville Consulting 2020b) (Figure 3).

Figure 1: Comparison of costs of distributed generation versus conventional generation of power.



Notes:
- *The average power purchase cost of utility of INR 5.63/kWh is based on our analysis of TAGNEDCO P&L sheet for 2017-18. TANGEDCO's fixed costs, including overhead costs and transmission costs, are excluded in this analysis.*
- *Transmission and distribution losses are as per Energy Department (2020a).*
- *Solar gross and net feed-in tariffs are as per respective tariff orders by Tamil Nadu Regulatory Commission (TNERC 2019b and 2019a).*

Distributed Solar Energy and Tamil Nadu Solar Energy Policy 2019

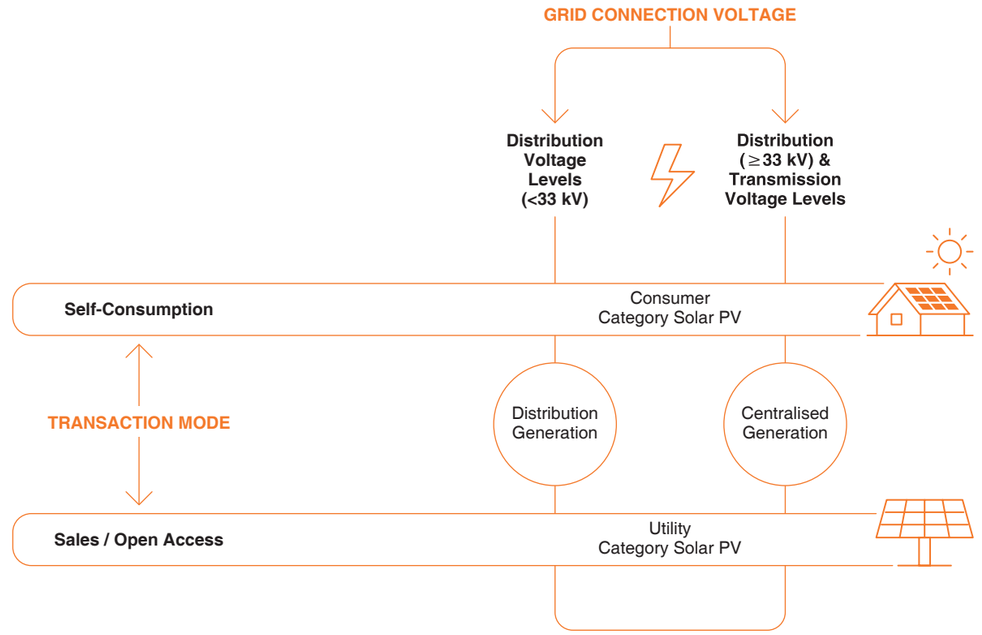
The Tamil Nadu Solar Energy Policy 2019 distinguishes between two types of solar power plants based on the grid feed-in mechanism: consumer category solar PV and utility category solar PV. For consumer category solar PV plants, the primary purpose is self-consumption of the generated solar power, with any excess being exported into the grid at a net feed-in tariff. For utility category solar PV plants, all the generated electricity is fed into the grid (gross feed-in) for sale to the distribution utility or for wheeling of power (captive consumption or sale to third party). The policy allows gross v-in at all voltage levels (TEDA 2019).

As per the definition adapted in this paper, distributed solar energy generation (including, on-site or rooftop solar generation) can fall into either of the two categories of solar PV plants (consumer category and utility category) as defined in the Tamil Nadu Solar Energy Policy 2019. While distributed solar PV is defined in relation to the interconnection voltage, the classification of solar energy into consumer category and utility category is based on the mode of transaction. Figure 3 illustrates how these two classifications of solar energy intersect.[1]

Figure 2: Consumer category solar and utility category solar PV as per Tamil Nadu Solar Energy Policy 2019.

[1] *Though technically possible, it is unlikely that any consumer category solar PV plants will be connected at distribution voltage levels at or above 33 kV.*

Figure 3: Classification of solar PV systems in the solar policy framework of Tamil Nadu and relation to distributed/centralised generation.



Purpose of this Paper

This paper provides an overview of the current state of distributed solar energy in Tamil Nadu, while looking at various aspects such as financing of distributed solar energy and use of solar PV in agriculture. It attempts to summarize current policy, regulatory and operational challenges and outlines a roadmap for policy makers and the utility to accelerate the transition to distributed solar energy in Tamil Nadu.

2. STATE OF DISTRIBUTED SOLAR ENERGY IN TAMIL NADU

Key Points:

- As of September 2020, only 6.87% of the consumer category solar energy target has been achieved.
- Under Phase II of the Grid-Connected Rooftop Solar Program, the utility has put in place an online application portal for consumers who want to install rooftop solar.
- The market for financing of rooftop solar by banks in the State is at an early stage. The national banks SBI and PNB have so far only approved loans for 75 MW and 25 kW.
- In August 2020, the State Government accorded approval and financial sanction for implementation of Component C of KUSUM. 20,000 pumps will be targeted for solarisation with a total capacity of 220 MW.
- A need has been identified to level up skills of the workforce in the sector and provide more hands on training to support the growth in distributed solar energy deployment.

Tamil Nadu has been a pioneer in solar energy policy in India. It was the first state to introduce a comprehensive solar energy policy in 2012, setting state-level solar energy targets and introducing net metering for rooftop solar PV. The 2012 solar energy policy set a target of 3,000 MW by 2015. By the end of 2015, the State achieved less than 200 MW of installed solar energy (Energy Department 2015b). The overall solar energy target of 3,000 MW also included a sub-target of 350 MW for rooftop solar PV, out of which only 76 MW was installed by the end of 2015 (Bridge to India 2016), and even the currently installed capacity (MNRE 2020) falls short of the target five years down the line. The 2012 solar energy policy, in contradiction to its ambitious targets, had also left out high tension (HT)[2] industrial consumers from availing net metering.

The 2012 solar energy policy was succeeded by the Tamil Nadu Solar Energy Policy 2019. Key features of the 2019 solar energy policy are:

- The policy targets 9,000 MW of installed solar energy capacity by 2023;
- The policy has set a sub-target of 3,600 MW of consumer category solar PV;
- Net metering mechanism has been replaced by the net feed-in mechanism (consumer category solar energy);
- Gross metering is permitted at all voltage levels;
- All HT consumers are excluded from the net feed-in mechanism;
- The only option available to an HT consumer for on-site generation of solar power is through 'paralleling' operation.

[2] Low tension (LT) consumers are those who are connected to the distribution system at voltage levels below 250 V. For high tension (HT) consumers, the voltage exceeds 250 V and goes up to 33 kV.

2.1. Growth of Distributed Solar in Tamil Nadu

The growth of rooftop solar PV in Tamil Nadu has failed to pick up and is far behind what is needed to meet the State's clean energy goals. Further, the 2019 regulations on the net feed-in metering mechanism for rooftop solar generation (TNERC 2019a) have set a very low feed-in tariff, which has contributed to a sharp drop in capacity addition, particularly for the residential rooftop solar segment (see Chapter 3 for more details). As of September 2020, only 247 MW (6.87%) of the consumer category solar energy sub-target of 3,600 MW by March 2023 has been achieved (MNRE 2020) (see Figure 4).

Further, plant-wise data on installed RE capacity in Tamil Nadu furnished by CEA (CEA n.d.) shows that as of March 2019, distributed solar PV made up only 15% of the total solar PV capacity installed in the State. This is summarised along with other available data on the installed solar PV capacity in the state in Figure 5 (Energy Department 2019, MNRE 2020).

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Figure 4: Target vs achievement for consumer category solar PV (MNRE 2020).

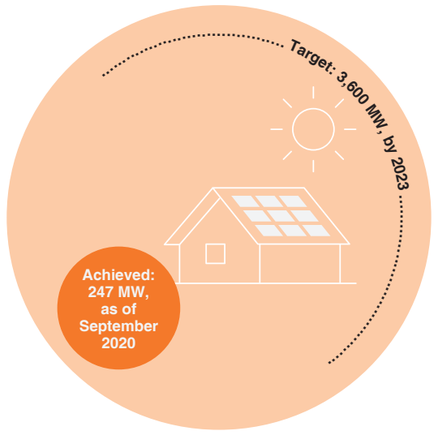
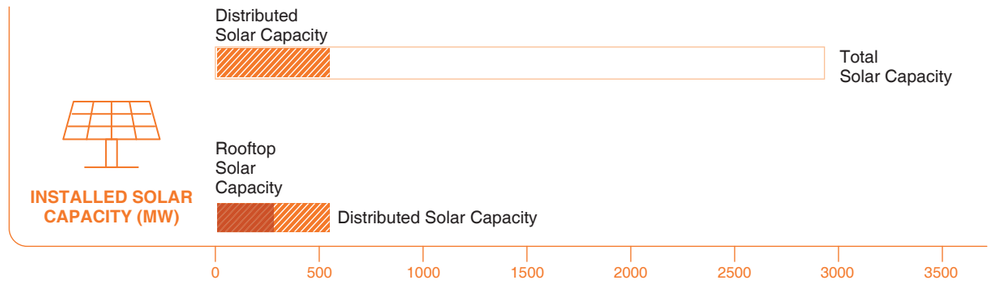


Figure 5: Distributed solar PV capacity in the total installed solar PV capacity in Tamil Nadu, as of March 2019.

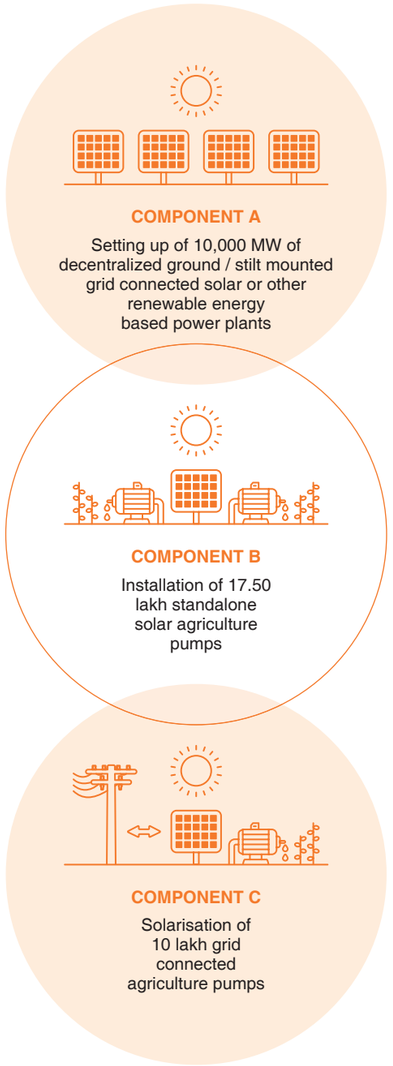


2.2. Ongoing Schemes and Programs

Solarisation of Government Buildings
For solarisation of government buildings in the State, the Tamil Nadu Energy Development Agency (TEDA) has entered into an agreement with Energy Efficiency Services Limited (EESL) in September 2019 for developing at least 50 MW of rooftop solar PV under the Renewable Energy Service Company (RESCO) model (EESL 2019). TEDA will act as the nodal agency for the program, and EESL will make the entire investment to develop the projects. EESL will be carrying out tendering to select a third party for installation and commissioning. The government departments that are the rooftop owners will make fixed monthly/ quarterly payments, through TEDA, to EESL. As of October 2020 agreements with government departments are in place, and around 300 kW of capacity is under installation. So far, no capacity is operational.

Implementation of KUSUM in Tamil Nadu
The flagship scheme developed by Ministry of New & Renewable Energy (MNRE) for solarisation of agriculture, KUSUM, was approved in February 2019 by the Central Government. It has three components aiming to install an aggregate capacity of 25,750 MW in the country, as shown in Figure 6.

Figure 6: Components of KUSUM scheme.



For implementation of KUSUM–C in Tamil Nadu, TEDA has been designated as the implementing agency. As part of the scheme, 20,000 pumps with 7.5 HP capacity each will be solarised with a 11 kW grid-connected solar PV system each (Energy Department 2020b). Hence, KUSUM–C 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 model. Capital subsidy of 30% will be provided by the Central and the State Government each. The utility will pay the RESCO a fixed tariff for the gross solar energy generated. The RESCO can either be a special purpose vehicle, SPV, formed by TEDA with its financial partners, or an independent developer. No capital investment by the participating farmers is required.

An innovative feature of the KUSUM–C implementation in Tamil Nadu is that while the participating farmers will not make any capital investment, they will receive an incentive that will be determined based on the net solar energy export. The incentive will be disbursed to the farmer annually through bank transfer, with a minimum payment of INR 3,000 guaranteed, subject to the condition that the solar PV plant is operational (TNERC 2020). This additional income will incentivise the farmer for daytime operation of pump using solar energy, avoiding grid energy usage and exporting excess solar energy. Further, time-of-day (ToD) export and import factors, to be multiplied with the energy export and import respectively, have been introduced for the purpose of incentive calculation. This will help the utility in managing the demand on rural feeders and shifting the load from on-peak to off-peak hours.

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With the implementation of KUSUM–C, the State Government and TANGEDCO are expected to save substantially on their tariff subsidy and cost of supply to agricultural connections, respectively – much higher than the capital cost of installing the solar PV systems. The farmer will benefit through i) reliable day-time power supply, and ii) additional income from the farmer incentive. Apart from KUSUM–C, there is some interest growing in implementing KUSUM–A in the State. Tamil Nadu has an allocation of 75 MW under this KUSUM component.

Phase II of National Rooftop Solar Program
In March 2019, MNRE launched its Phase II of the Grid-Connected Rooftop Solar Programme (MNRE 2019). Phase II makes the utility an implementing agency for the programme and a key facilitator for growth in rooftop solar to meet the national targets. The program provides Central Financial Assistance (CFA) for up to 4 GW of rooftop solar PV in the domestic sector in the country by 2022. The CFA will be disbursed through the utility to the installers. The program also includes a performance-based incentive to the utilities that will be determined on the kW of annual incremental rooftop solar capacity addition. Further, as per the MNRE guidelines for Phase II, the utility shall put in place a dedicated online portal to streamline the entire application process for rooftop solar.

In Tamil Nadu, in accordance with the mandates of the Phase II of the Grid-Connected Rooftop Solar Programme, the utility has put in place an online portal for application for rooftop solar, available on its website[3]. In order to avail the CFA, domestic consumers have to apply through the online portal and select from the available list of empaneled installers. For installing the system, the consumer only needs to make the net payment, after the CFA. The utility then intimates TEDA about the application, which coordinates the work with the installer.

In Tamil Nadu, in accordance with the mandates of the Phase II of the Grid-Connected Rooftop Solar Programme, the utility has put in place an online portal for application for rooftop solar, available on its website.

As part of Phase II of the national program on rooftop solar, TANGEDCO plans to add 5 MW of rooftop solar capacity for domestic consumers (i.e., utility-facilitates rooftop solar). As September 2020, TEDA was close to releasing bids for selection of installers.

Solar Village/Amma Green Gramam

In 2015, the Tamil Nadu Government had approved the setting up of a 170 kW grid-connected solar power plant in Irumbai village as a model 'Solar Village' (Energy Department 2015a). In 2017, an announcement was made in the State Assembly to make the Irumbai Solar Village part of a broader scheme 'Amma Green Gramam,' with TEDA as the implementing agency (Energy Policy Note 2018-19).

In March 2020, TEDA invited bids to design, install and commission the solar PV plant in Irumbai, which is expected to be completed in 2020. The pilot, once implemented, is expected to inform future replication and scale up of the concept of using solar energy as a lever to create sustainable rural communities.

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2.3. Financing of Consumer Category Solar Energy in Tamil Nadu

With the objective of helping developing countries meet their climate commitments, various multilateral and development banks, including World Bank and Asian Development Bank (ADB), have extended credit lines to Indian financial institutions to develop the rooftop solar sector in the country. World Bank has a program for financing of rooftop solar with the State Bank of India (SBI), while ADB has a program with the Punjab National Bank (PNB). These programs aim to i) increase the availability of debt financing to installers, developers and rooftop owners, ii) develop different business models (CAPEX, RESCO, rooftop rental) and expand the market to include riskier categories like non-banking financial institutions and medium and small enterprises (SMEs), and iii) provide technical assistance to building the institutional capacity for handing out of these loans.

A recent evaluation on the availability of financing products in Tamil Nadu, including those by SBI and PNB, found that as of July 2019, five banks and the Indian Renewable Energy Development Agency (IREDA) have financing products dedicated to rooftop solar in the State (Auroville Consulting 2020e). In the case of SBI, financing has been made available in one in every 60 branches, of the total 1,556 branches in the State. Further, to date SBI and PNB have approved loans of 75 MW and 25 kW respectively for rooftop solar. The loans have covered the CAPEX and RESCO models of development. *The slow progress on the approval of loans can be attributed to banks continuing to build their capacity to be able to assess loans to this sector, and the lack of awareness about the availability of these loans amongst consumers.* Chapter 3 discusses the challenges facing the financial institutions in the State with regards to rooftop solar in more detail.

As of July 2019, five banks and the Indian Renewable Energy Development Agency (IREDA) have financing products dedicated to rooftop solar in Tamil Nadu.

2.4 Skill Development for Consumer Category Solar Energy

Distributed solar PV, and rooftop solar PV in particular, are more job intensive compared to large-scale solar PV. It creates more than four times as many jobs, measured in full-time equivalent or FTE, including both indirect and direct jobs. If Tamil Nadu achieves its target for consumer category solar PV by 2023, it will create an additional 92,014 FTE jobs, assuming a job creation potential of 27.32 FTE/MW for small-scale solar PV (Auroville Consulting 2019a).

Comprehensive skill development programs for the workforce will be essential to support the growth of distributed solar energy in the State. A recent review of the skill development programs in the State has identified the need to level up skills of the workforce in the sector and provide more hands-on training to support a rapid growth in distributed solar energy generation (Auroville Consulting 2020d). The following are five out of the 20 Government of India supported solar skill development programs that are operational in Tamil Nadu: Suryamitra, Varunmitra, Rooftop Solar Grid Engineer, Solar PV Installer – Electrical, and Rooftop Solar Photovoltaic Entrepreneur.

The Suryamitra program has been the most instrumental skill development program with 3,152 participants who have graduated from it over the past 5 years. It was developed by National Institute of Solar Energy (NISE) to develop a semi-skilled workforce that can be employed in installation, commissioning, & operation and maintenance of solar PV plants. NISE has partnered with training institutes throughout the country to deliver the program. The program is fully sponsored by NISE, whereby the funding is released in tranches to the training institutes that successfully deliver the program.

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[3] *The portal is available at: https://www.tnebltd.gov.in/nsconlinesolar/.*

3. CURRENT CHALLENGES FOR DISTRIBUTED SOLAR ENERGY IN TAMIL NADU

Policy & Regulations

- Exclusion of HT consumers from net feed-in metering mechanism
- Low net feed-in tariff
- Gross feed-in mechanism only for >1 MW
- Delay in inspection for commissioning of consumer category solar PV
- Electricity tax exemption on consumer category solar only till 2021
- Slow progress on tariff rationalization

Operational Challenges

- Lack of granular data on installed solar capacity
- Non availability of bidirectional meters
- TANGEDCO billing software not updated to show energy import/export
- Lack of uptake of novel implementation models for rooftop solar

Financing of Rooftop Solar

- Lack of awareness of financing products
- Limited experience of banks with solar PV loans
- Lack of clarity on policies
- Lack of capacity to assess technical risks
- Low accessibility
- Lack of understanding of risks for different business models

Skill Development

- Delays in disbursement of funding for skill development programs
- Lack of support from Central Government in program implementation
- Non-active online support portals
- Need for more hands-on training
- Current low market for rooftop solar
- No option of instruction in Tamil

Grid Integration Challenges

- No time-of-day (ToD) tariffs, except for HT industry
- No market for ancillary services provided by smart solar inverters
- Lack of focus on energy storage in policy
- Need to evaluate locational value of distributed generation

The Tamil Nadu Solar Energy Policy 2019 lays down a vision for Tamil Nadu where 'Solar energy will be a major contributor to sustainable energy future' (TEDA 2019). Further, the policy aims to create a framework that promotes the role of distributed solar energy in meeting the State's energy needs in an equitable and sustainable manner. However, there remain number of challenges in operationalising the policy vision and objective, and meeting the State's solar energy targets. These challenges relate to policy and regulations, operational issues, solar PV financing, skill development and grid integration of solar energy. This chapter aims to identify and understand these challenges.

3.1 Policy & Regulations

Challenges in the current regulatory and policy framework set by the Tamil Nadu Solar Energy Policy 2019 and the subsequent orders on solar power are summarised below.

Exclusion of HT Consumers from Net Feed-in Mechanism

The Tamil Nadu Solar Energy Policy 2019 excludes HT consumers from availing the net feed-in metering mechanism. As per the Supply Code in the State, this limits the maximum capacity of rooftop solar plant availing net feed-in mechanism to 112 kW at three-phase 415 V interconnection (TNERC 2019a). This discourages a large segment of industrial, commercial and institutional consumers from installing consumer category solar PV plants. The only option available for these HT consumers for generating solar energy on their premises is to operate the plant under paralleling, in which any excess generation has to be curtailed. Further, parallel operation of a rooftop solar plant attracts a monthly parallel operation charge (TNERC 2019b).

Under the electricity tariff structure, as of 2020, wherein most HT consumer categories have tariffs lower than the average cost of supply of TANGEDCO, the utility stands to make a greater loss by preventing HT consumers from availing net feed-in mechanism (Auroville Consulting 2020c).

Recommendation: Permit net feed-in metering mechanism for all consumer categories, at all voltage levels.

Low Net Feed-in Tariff

The TNERC regulation on rooftop solar generation (TNERC 2019a) provided a method for the calculation of net feed-in tariff for accounting of solar power. The tariff is fixed as 75% of: i) pooled cost of power purchase for the respective financial year, ii) the last feed-in tariff determined by the Commission, or iii) the tariff discovered in latest bidding, whichever is less (TNERC 2019a). For the financial year 2020-2021, this works out to be INR 2.28 per kWh, based on the feed-in tariff for solar power (TNERC 2019b). This method of fixing the tariff as a percentage of another tariff is in contravention to the provisions of the Electricity Act (MoP 2003) and the National Tariff Policy (MoP 2006). Section 63 National Electricity Act 2003 suggested the following: '(4) *While determining the tariff, the Commission may, to the extent possible consider to permit an allowance / disincentive based on technology, fuel, market risk, environmental benefits and social impact etc., of each type of new and renewable source. (5) While determining the tariff, the Commission shall adopt appropriate financial and operational parameters. (6) While determining the tariff the Commission may adopt appropriate tariff methodology.'*

In order for consumer category solar energy to attract required investments, the feed-in-tariff determination needs to take into consideration the actual cost of energy from small and medium-scale solar PV plants. Our calculations show that the levelised cost of rooftop solar energy, without capital subsidy, is in the range of INR 3.65–5.52/kWh for a capacity in the range of 10 kW to 100 kW (Auroville Consulting 2020h). Further, capacity-specific or voltage-specific tariffs are required to promote distributed solar energy generation.

Recommendation: Set net feed-in tariff(s) as per provisions of the Electricity Act and National Tariff Policy to represent the actual cost of consumer category solar energy.

Limitations on Gross Feed-in Mechanism (Utility Category Solar PV)
Even though the 2019 solar energy policy provides that 'utility category solar energy gross feed-in will be permitted at all voltage levels', the related regulations (TNERC 2019a, 2019b) don't support setting up of small-scale solar PV plants under gross feed-in metering mechanism (see Chapter 1 for categorization of solar power plants in the energy policy based on the feed-in mechanism). The 2019 TNERC Order on Generic Tariff for Solar Power places a limitation of 1 MW capacity for purchase of solar power by the utility. The order sets a single tariff regardless of the capacity of the solar energy generator.

Recommendation: Permit gross feed-in metering mechanism for any solar energy capacity. Determine voltage or capacity-specific feed-in tariffs, taking into account the higher cost of energy from smaller solar PV plants.

Inspection Requirement for Commissioning
For commissioning of rooftop solar plants of capacity higher than 10 kW requires issuance of safety certificate by the Chief Electrical Inspectorate (CEI). Due to the limited availability of staff, this is a key issue contributing to the long delays in commissioning of solar PV plants.

Recommendation: For timely commissioning of solar PV plants, an inspection by CEI can be mandated for HT consumers with a plant capacity more than 100 kW. Raising the inspection limit to 100 kW has also been recommended in the guidelines issued in 2019 by MNRE for the Phase II of the Grid-Connected Rooftop Solar Programme (see Chapter 2). Alternatively, for system sizes from 10 kW to 100 kW, faster IT-based (online) solutions for approval of the rooftop solar plants can be put in place.

Absence of Time-of-Day Solar Feed-in Tariff
The Tamil Nadu Solar Energy Policy 2019 provides for ToD solar energy feed-in tariffs to incentivise consumers to couple energy storage with solar PV and feed excess solar energy into the grid during peak hours. Energy storage is an important flexibility resource that will help unlock the benefits of distributed generation of solar power for the utility. However, no ToD solar feed-in tariffs have been introduced as of September 2020.

Recommendation: Introduce ToD tariffs to incentivise behind-the-meter solar plus energy storage.

Requirement for Gross Energy Meter
In its Order on Rooftop Solar Energy Generation 2019, TNERC provides for a second energy meter to record gross generation, which needs to be installed close to the bidirectional service connection meter. For installations where the service connection point is not near the location of the solar inverter (e.g. campuses and multi-storied buildings), this requirement would involve use of long cables, which may make these systems unviable.

Recommendation: Remove the requirement for gross energy meter to facilitate rooftop solar plant installation. For determination of generation from rooftop solar plant, forecasting of solar energy generation can be done with the help of weather data and a few reference solar systems in different locations in the State.

Levying of Electricity Tax on Rooftop Solar
In the Tamil Nadu Solar Energy Policy 2019, energy generated from rooftop solar plants has been exempted from electricity tax for two years only.

Recommendation: To promote the installation of solar PV systems by consumers, consumer category solar energy generation may be exempted from electricity tax permanently.

Slow Progress on Tariff Rationalisation
Rationalisation of tariffs, to remove electricity tariff subsidy and cross subsidy, will be a fundamental power sector reform for creating a financially sustainable utility. It also changes the incentive structure for the utility and will unlock benefits of distributed solar energy for all the stakeholders. In the cross subsidized tariff structure, the utility sees adoption of solar energy by high tariff paying consumers as a loss of revenue, whereas for the domestic segment, it is not financially attractive to meet their demand from solar energy due to the subsidised tariffs. With rationalized tariffs, the utility will not discourage adoption of solar energy by its consumers.

Currently, amendments to the National Tariff Policy 2016, proposed in May 2018, are before the Central Government for approval (IndiaSpend 2020, The Economic Times 2020). The amendments include reduction in cross subsidy to within 20% of the cost of supply. Further, they propose having consumer categories based on the voltage level, instead of user type, and reducing the number of categories to six.

Recommendation: The current tariff structure in Tamil Nadu with 20 consumer categories, which are further sub-divided into slabs, should be replaced by a single HT tariff and a single LT tariff to cover the utility's cost of supply (Auroville Consulting 2020c). The HT tariff should be lower than the LT tariff as the HT consumers shouldn't bear the downstream LT distribution losses.

3.2 Operational Challenges

Our research and interactions with solar developers revealed the following operational hurdles pertaining to distributed solar energy in Tamil Nadu.

Lack of Public Availability of Data on Distributed Solar Energy
Granular data on installed solar capacity in the State – by interconnection voltage, location, mode of transaction (rooftop solar, open access, sale to utility) and year of commissioning – is not available publicly. The Tamil Nadu Solar Energy Policy 2019 mandates that the utility will *'maintain a section database of solar gross feed-in and net feed-in application requests, approval status, & installation and commissioning data for consumer category solar, which will be submitted to the Government on a periodical basis.'* Making this data publicly available will enable monitoring of the growth of distributed solar energy and grid planning studies (see Section 3.5) by academic, research and civil society groups, and help the State in meeting its solar energy targets.

Recommendation: TEDA to publish the data on a monthly basis on consumer category solar PV and utility category solar PV (along with other RE technologies) under a separate section on its website. It will further make available more detailed dataset on installed capacity by voltage, location, mode of transaction (rooftop solar, open access, sale to utility) and year of commissioning.

Delay in Installation of Bidirectional Meters
Installers highlight the non-availability of bidirectional energy meters with TANGEDCO as a key operational issue for commissioning rooftop solar plants. The Solar Energy Policy 2019 mandates that all meters installed for new service connections or service connections for which meters are replaced in the course of maintenance, will be configured for bidirectional reading of energy (both energy import and export) so that the connections are ready for implementation of net feed-in metering. All digital energy meters are capable of displaying energy flow in both directions and can be configured so at no additional cost.

Recommendation: TANGEDCO to procure and maintain stock of only meters configured for displaying bidirectional flow of energy.

Gaps in TANGEDCO Billing Software
Since the introduction of net metering in the State in 2014, the billing software of TANGEDCO has not been updated to show imported and exported energy for net feed-in/net metering consumers. The Solar Energy Policy 2019 mandates that the utility will *'enhance and update its billing system such that relevant details pertaining to solar gross feed-in and net feed-in are included in the electricity consumers' bill.'*

Recommendation: TANEDCO to update billing software on a priority basis to reflect both energy import and export. The bill can further include key statistics on energy usage patterns of the consumer.

Lack of Novel Implementation Models for Rooftop Solar
In order to make solar energy attractive to all consumers, novel implementation models, including community solar PV plants, utility-driven implementation models and RESCO models need to be undertaken. In community solar systems, consumers invest into a share of a solar plant installed on a common rooftop or land. They are being promoted by governments and utilities in some of the countries and jurisdictions that are leading in distributed solar energy generation, including United States and Europe. This model will be suitable for adoption in Tamil Nadu by domestic consumers with limited rooftop space available for solar installation, or where the rooftop is owned by group housing societies, or where financial viability may only be possible with such an approach (as will be the case of domestic Slab 1 and Slab 2 consumers [Auroville Consulting 2020c]). Community solar will require that virtual net feed-in and group net feed-in mechanisms are introduced.

Recommendations: Introduce virtual and group metering mechanisms to enable novel implementation models for consumer category solar energy. TEDA and TANGEDCO to develop implementation models that are tailored for different consumer categories and will be a win-win for all stakeholders (Auroville Consulting 2020c).

3.3 Financing of Rooftop Solar

The availability, accessibility and awareness about financing products in the State for consumer category solar energy remains low, and they are mostly available to commercial and industrial consumers (Auroville Consulting 2020e). Main challenges are identified below.

Lack of Awareness
A recent study by Auroville Consulting (2020e) found that all the financing stakeholders (development agencies, banks and individual bank branches) agreed that there was a lack of awareness of the financing products available for rooftop solar as well as the financial benefits of rooftop solar.

Recommendations: The financing stakeholders need to put more focus on creating awareness and communicating about financing products available for rooftop solar. TEDA may carry the information on the financing options available on its website and update it regularly through engagement with the banks. It will also promote them through traditional media and social media to help build the market for rooftop solar financing. TANGEDCO may also provide this information on its online rooftop solar portal.

Capacity Gaps for Solar PV Lending
As of 2020, the banks still have limited experience in dealing with the sector. They face gaps in skill and capacity for lending to the solar sector. IREDA, for example, has specifically noted that it faces a lack of manpower. It has also set a minimum of INR 50 lakhs for the loan amount, which will prevent smaller investors and electricity consumers from accessing the financing (Auroville Consulting 2020e).

Recommendation: Banks to regularly carry out training of officers at headquarters for solar lending.

Policy and Technical Risks
Each state in the country has its own policy and regulatory framework for solar energy. Lack of clarity on the policies as well as uncertainty in the policy and regulations makes it difficult for the banks to assess loan applications. Also, banks may lack the knowledge to assess the technical aspects/risks of projects (such as the quality of solar panels used). Further, as the rooftop sector is still in an early growth stage, assessing the execution capability of developers is a challenge for the banks.

Recommendation: TEDA may appoint an official who will act as one-point contact for all banks and other stakeholders to provide clarity on the solar energy policy and regulations. Banks may also appoint technical analysts in regional head offices, who will help with the assessment, approval and monitoring of projects.

Limited Accessibility to Rooftop Solar Financing Products
Though SBI and PNB are well placed through their wide network of branches in the State, dedicated rooftop solar financing products have been set up only at a few branches. In the case of SBI, it has been made available in 1 in every 60 branches in Tamil Nadu. No data is available in the case of PNB.

Recommendation: Banks to expand the accessibility of solar PV financing through the use of their well-established network of branches.

Perceived Business Model Risks
Different business models have unique risks associated with them, which is a hurdle for the banks in trying out new models. E.g., in the rooftop rental model, the ownership of the solar PV system and the rooftop rest with different parties. The loan collateral is not straightforward in this case. ADB has also identified the low market maturity of RESCO model as a reason for the low pipeline of projects developed under its program with PNB.

Recommendation: Banks to develop a rigorous framework for assessment of loans under different business models for rooftop solar.

3.4 Skill Development

Chapter 2 mentions the skills development programs that are active in Tamil Nadu. Amongst them, the Suryamitra Programme has been most instrumental in creating a skilled workforce. A report published in June 2020 by Auroville Consulting (2020d) identified the following challenges in skill development:

Delays in Program Administration
Timely disbursement of funding by the National Institute of Solar Energy (NISE) has been consistently identified by the training institutes as a hurdle in carrying out the training programs optimally and providing quality skills training. Delays of a year or even longer after training completion have been noted by the training institutes. In addition, the online portals to support the training institutes on matters of funding, updating of the study materials, etc. are unresponsive.

Recommendation: NISE and MNRE to ensure timely administration of funding and provide active support though the online portals to the training institutes.

Challenges Faced by Solar Entrepreneurs
Solar entrepreneurs who have graduated from the Suryamitra Programme face challenges relating to the lack of market knowledge, business strategy and hurdles in accessing start-up capital.

Recommendation: Suryamitra training program to be updated to include components relevant for solar entrepreneurs on market knowledge and customer acquisition, business planning and accessing start-up capital.

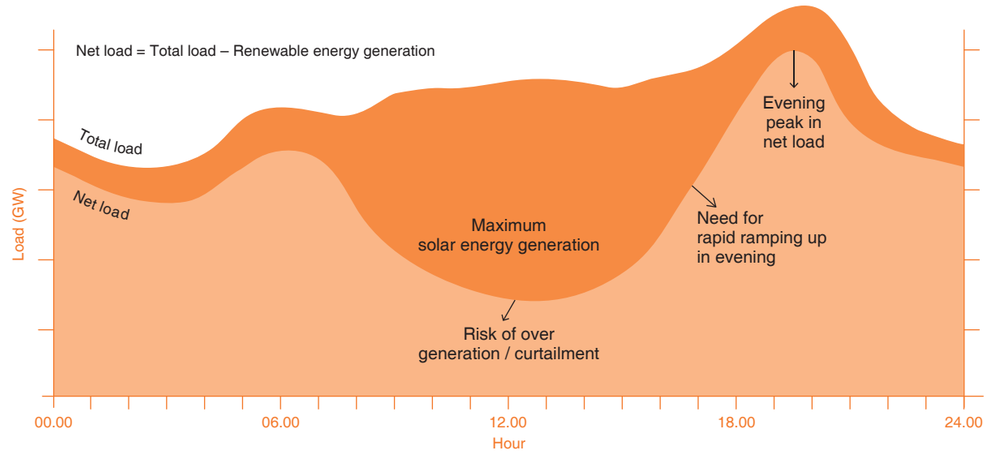
Lack of Employability of Program Graduates
Placement of the graduates in the solar industry is a key issue for the training programs. There is a need for more hands-on training of the participants in solar PV installation and commissioning by providing them practical experience in projects. Along with practical experience, lack of soft skills, particularly communication in English, has been highlighted by the graduates as a major constraint in finding more work opportunities. A very low proportion (less than 20%) of the graduates from whom feedback was collected were employed in the solar industry. (This can also be attributed to the current policy and regulatory headwinds for the solar installation market.) Further, the training programs are currently delivered only in English – they can be made bilingual, to provide the option of taking them in either English or Tamil.

Recommendations: Training programs to be updated to bring about more focus on hands-on training of participants in solar PV installation and commissioning. TEDA to also encourage empanelled solar installers to employ minimum percentage of their employees for field engineering and installation from the solar skill development programs.

3.5 Grid Integration Challenges

Distributed solar energy, compared to the traditional models of centralised generation, provides several benefits as detailed earlier. However, distributed solar energy is also an 'inflexible' and intermittent resource, due to generation occurring as and when the sun is available and not necessarily when there is demand. This challenge results in more ramp up and ramp down in the net load and bigger system peaks. Hence, integration of distributed solar energy requires introduction of other flexible resources, such as demand response and energy storage.

Figure 8: Example net load curve with high solar and renewable energy penetration.



Absence of Demand Response Programs
Demand response refers to reduction and/or shifting of load in response to specific grid condition (such as peak load conditions) or particular market incentives (Grid Lab 2018). A key enabler of demand response is the ToD tariffs, which send a price signal to consumers to shift their demand. ToD tariffs can have different structures: static, dynamic, variable peak pricing and critical peak pricing (IRENA 2019). While ToD is a 'passive' form of demand response, 'active demand response' is the remote control (switching on and off) of loads of consumers, who elect to participate in the demand response program for a financial incentive. Currently, in Tamil Nadu, only the HT Industrial consumers have a ToD tariff. They are billed 20% higher energy charges during peak hours and are provided a rebate of 5% during off-peak hours. Tamil Nadu has not yet ventured into active demand response programs.

Recommendation: ToD needs to be introduced for all consumer categories, including industries, commerce, agriculture, municipal (water pumping) and domestic. In addition, both TEDA and TANGEDCO may create enabling policy, regulatory and market conditions for active demand response programs to emerge.

Absence of Ancillary Services Market
'Smart' solar inverters can provide reactive power or voltage support and frequency regulation in response to grid conditions. In order to accommodate growing penetration of renewable energy in the grid, smart inverters are a cost-effective measure to provide these ancillary services compared to traditional methods of regulators and special transformers (ENEA 2020; GridLab 2018). However, no regulations and market mechanisms exist in Tamil Nadu to enable these ancillary services.

Recommendation: TEDA and TANGEDCO to jointly propose required regulations and market mechanisms to compensate ancillary services by smart inverters.

Absence of Enabling Regulatory Framework for Energy Storage
Behind-the-meter energy storage can provide valuable flexibility and ancillary services to the grid to mitigate the challenges posed by increased distributed solar energy generation. It also provides value to consumers in multiple ways:

- If ToD tariffs are applicable, the stored electricity can be used during peak demand hours, helping consumer to save on electricity bills.
- It will increase self-consumption of the solar energy generated on site. This protects the consumer from any unfavorable metering policy as he is not reliant only on exporting excess energy.
- Demand charges, which are calculated based on the peak consumption during a billing period, are a significant component of the electricity bill for commercial and industrial consumers. Energy storage can be used to cut down the demand charges.

Recommendation: A detailed definition of energy storage and its applications need to be introduced in the policy and regulatory framework.

Need for Hosting Capacity Studies & Assessment of Locational Value of Solar Energy
'Hosting capacity studies' are needed to identify cost-effective measures (such as grid upgrades) to integrate increasing levels of distributed energy. Also, the benefits of distributed generation in avoided capacity procurement and grid upgrade costs varies with the location on the utility's network. Hosting capacity studies help to determine the optimal interconnection points.

A study published in August 2020 by Auroville Consulting (2020b) analyses the hosting capacity for 10 HT feeders of a substation in Erode, Tamil Nadu, at different penetration levels of distributed solar energy: 40%, 70% and 100% (whereby penetration is defined as the percentage of the annual energy demand being sourced from the distributed solar PV). Distributed solar generation results in drastic improvement in the voltage profile (reduction in deviations from the rated voltage) with the increase in penetration levels. Further, no feeder/line current capacity violations were observed for 40% penetration for utility category solar PV and up to 70% for consumer category solar PV. Combining 100% solar energy penetration with ToD tariffs and energy storage to provide round-the-clock solar energy keeps both voltage and current within allowable limits.

Further, no feeder/line current capacity violations were observed for 40% penetration for utility category solar PV and up to 70% for consumer category solar PV.

Recommendations: Utility to carry out hosting capacity studies to identify best locations for interconnecting distributed solar PV, and to assess whether additional grid upgrades (new lines, poles and transformers) are required for grid integration of distributed solar energy. Pilots that demonstrate the benefits of distributed solar energy for the grid maybe carried out. Insights gained from these pilots will further help the utility in understanding the implications of deploying distributed energy resources on the grid.

4. ROADMAP FOR DISTRIBUTED SOLAR ENERGY

Solving the challenges discussed in the previous chapter to enable distribution solar generation will require a host of measures. We can classify these measures as foundational or advanced.

Foundational measures

consist mostly of changes in the policy and regulatory framework to create the basic environment to enable distributed solar energy to thrive. These measures could be easily implemented in a short time span of time, by 2022.

Advanced measures

represent more structural changes in the power sector, such as changes in grid planning paradigm, and new regulations and market mechanisms for compensating ancillary services provided by solar PV and energy storage. These measures are expected to take longer to implement and could be targeted by 2025.

The figure below summarises the different measures by: i) policy, regulatory, operational, ii) institutional, and iii) grid integration for solar energy.

Figure 9a: Measures for enabling distributed solar energy in Tamil Nadu.

Policy, Regulatory & Operational Measures

Foundational

- Make solar net feed-in metering mechanism available to all consumer categories, at all voltage levels.
- Set realistic solar net feed-in tariff that accounts for the actual cost of consumer category solar energy.
- Permit solar energy gross feed-in for any capacity.
- Set gross feed-in tariffs at different capacities or voltage levels, instead of a single tariff.
- Exempt rooftop solar from electricity tax.
- All new meters procured by TANGEDCO to be configured for bidirectional energy reading.
- Update billing software of TANGEDCO to show energy export and energy import values.
- Raise minimum capacity for inspection requirement by Chief Electrical Inspectorate to 100 kW.

Advanced

- **Tariff Rationlisation:** Current tariff structure to be replaced by a single LT tariff and HT tariff.
- Introduce group metering and virtual metering mechanisms to enable development of community solar and other novel implementation models.

Figure 9b: Measures for enabling distributed solar energy in Tamil Nadu.

Institutional Measures

Foundational

- **Solar PV Financing:** TEDA to act as a one-point contact for all stakeholders, including banks, to provide clarity on solar policy and regulations and for gathering suggestions.
- **Solar PV Financing:** TEDA to create and maintain dedicated online portal for rooftop solar to promote the benefits of rooftop solar, provide guidance on installation and compare financing options available.
- **Skill Development:** TEDA to encourage empanelled solar installers to employ minimum percentage of their employees for field engineering and installation from the solar skill development programs.
- **Skill Development:** TEDA to work with the training institutes to address the challenges that have been identified in skill development.

Advanced

- **Data Availability:** TEDA to regularly publish data on its website on installed solar capacity by interconnection voltage, location and mode of transaction (rooftop solar, open access, sale to utility) and year of commissioning.
- **Solar PV Financing:** TEDA can create a rating system to rank installers and developers on experience, quality of executed projects, and financial capability. This information can be hosted on the online portal along with contact information.
- **Skill Development:** TEDA to act as the state nodal agency to facilitate the implementation of further dedicated skill development programs for solar PV design, solar PV project management, solar PV manufacturing technician and solar PV site surveyor, to create a skilled workforce across the entire solar PV value chain.

Figure 9c: Measures for enabling distributed solar energy in Tamil Nadu.

Measures for Grid Integration of Solar Energy

Foundational

- Introduce static ToD tariffs for all consumer categories.

Advanced

- Introduce regulations and market mechanisms to compensate ancillary services by smart inverters and energy storage.
- Utility to carry out hosting capacity studies to identify best technical and commercial measures to integrate higher solar penetrations into LT networks.

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