Tariff Analysis and Cost-Benefit Tool for Solarizing Irrigation: Methodology

Overview of the Tool

The Tariff Analysis and Cost-Benefit Tool for Solarizing Irrigation (TACTS) has three sections, each serving a unique objective and relevant to distinct groups of stakeholders. These are summarized in Table 1.

Table 1. Sections of TACTS and their functions

		Purpose	Intended for
1	**Tariff calculation**	Analyze tariffs for projects under different components of the Pradhan Mantri Kisan Urja Suraksha Evam Utthaan Mahabhiyan (PM-KUSUM) scheme.	Developers, state nodal agencies designing their tenders or Electricity Regulatory Commissions hearing a tariff petition under PM-KUSUM.
2	**Financing**	Provides details on risk reduction instruments and alternative financing mechanisms that can be used for solar projects.	State policy-makers and financing institutions who wish to catalyze investment under PM-KUSUM in a state through alternative financial mechanisms.
3	**Costs and benefits**	Outlines the costs and benefits of solarizing agricultural power demand.	Officials of the state nodal agency and the distribution companies (DISCOMs) to analyze the benefits of solarizing agricultural power demand.

Source: Authors.

Methodology and Data Sources

Tariff Calculation

The tariff calculation for a solar plant under the PM-KUSUM scheme is based on the levelized cost of energy (LCOE) method of tariff determination. It is defined as the ratio of the net present value of total capital and operating costs of a plant to the net present value of the electricity generated by that plant over its operating life. The present value of all costs is calculated by discounting all costs, including depreciation and interest payments, to the base year and then calculating their sum. The guidelines for calculating the LCOE for renewable energy sources have been issued by the Central Electricity Regulatory Commission, which can be accessed here. These regulations also provide for default values of the parameters used for the calculation of the levelized tariff, including

- debt to equity ratio
- return on equity
- interest rate for debt repayment
- loan tenure
- depreciation considerations
- operation and maintenance escalation rate
- working capital requirements
- discount rate

The data sources for arriving at the capital cost of a solar power plant are listed in Table 2.

Table 2. Data sources for different cost components of a solar power plant

Cost head	Source of data
Cost of photovoltaic modules	Wholesale solar module prices have been gathered from JMK Research. During consultations, developers suggested that they pay a premium of approximately 20% over the wholesale prices, which have been used for tariff calculation
Cost of inverters	Analysis of tariff orders and stakeholder consultations
Cost of mounting structure	Analysis of tariff orders and stakeholder consultations
Balance of System and other civil work costs	Analysis of tariff orders and stakeholder consultations
Connectivity cost	Analysis of tariff orders and stakeholder consultations

Source: Authors.

The tariff calculation also considers the operational parameters related to a ground-mounted solar plant for calculating the levelized tariff. The sources for the default values of these operational parameters are as follows:

Table 3. Sources for operational parameters of a solar power plant

Parameter	Source	Reference file
Capacity utilization factor	Default value is based on review of tenders released under PM-KUSUM.	(MSKVY 2.0 Tender Maharashtra)
Annual operation and maintenance expenses	Analysis of tariff orders by State Electricity Regulatory Commissions (SERCs) under the PM-KUSUM scheme.	(MP Tariff order)
Land rent	Analysis of tariff orders by SERCs under the PM-KUSUM scheme.	
Land rent annual escalation	Default value is based on review of tenders released under PM-KUSUM.	(MSKVY 2.0 Tender Maharashtra)

Parameter	Source	Reference file
Grid unavailability	Default value is based on review of tenders released under PM-KUSUM.	(MSKVY 2.0 Tender Maharashtra)

Source: Authors.

Financing

The Financing section analyzes the impact on the LCOE tariff if certain risk reduction instruments and alternative financing models are used to finance the projects under PM-KUSUM. The tool explains these instruments and the mechanism required for their operationalization.

Costs and Benefits

The cost-benefit analysis uses the utility cost test method, which reflects DISCOMs' perspective on solarizing their agricultural power demand. The cost-benefit analysis parallels a CEEW study that analyzes the costs and benefits of grid-connected rooftop solar.

The major costs and benefits of solarization under PM-KUSUM are as follows:

A. Avoided generation capacity cost (AGCC)
DISCOMs procure power mainly from generation companies through power purchase agreements, and they have to make fixed payments toward capacity procurement. Generation from KUSUM can decrease the contracted capacity for a new power purchase agreement, reducing fixed expenses significantly.

Working formula:

$$AGCC = \sum \frac{KUSUM\ output}{(1 - TL\%)} * System\ coincidence\ factor * Degradation\ factor * Capacity\ cost$$

where,

KUSUM output: Rated capacity of the KUSUM plant

System coincidence factor: Ratio of KUSUM output (kW) at the DISCOM's peak supply hour to its rated output (kW)

Degradation factor: Factor to account for the decrease in the plant's performance over time

Capacity cost: Fixed cost (INR/kW) of additional contracted capacity as decided by the regulatory commission

TL%: Transmission loss percentage

B. Avoided power purchase cost (APCC)
This is the power purchase cost incurred by the DISCOM for the actual quantum of electricity procured from a generation company. Solar generation will be procured at a lower tariff, reducing power purchase cost.

Working formula:

$$APCC = \sum \frac{KUSUM\ energy}{(1 - TL\%)(1 - DL\%)} * Variable\ power\ purchase\ cost$$

where,

KUSUM energy: Actual electricity produced by KUSUM plant

Variable power purchase cost: Variable component (INR/kWh) of the power purchase cost of the DISCOM as set by the SERC

DL%: Distribution loss percentage

C. Avoided transmission capacity cost (ATCC)

This represents fixed payments made by DISCOMs for using the transmission network. KUSUM plants, being located close to the source of consumption, will reduce the need for transmission capacity.

Working formula:

$$ATCC = \sum \frac{KUSUM\ output}{(1 - TL\%)(1 - DL\%)} * Transmission\ coincidence\ factor * Degradation\ factor * Transmission\ capacity\ cost$$

where,

KUSUM output: Rated capacity of the KUSUM plant

Transmission coincidence factor: Ratio of KUSUM plant output (kW) at transmission load's peak hours to its rated output (kW)

Degradation factor: Factor to account for the decrease in the plant's performance over the years

Transmission capacity cost: Fixed capacity charge (INR/kW) payable to transmission licensee as per the commission

TL%: Transmission loss percentage

DL%: Distribution loss percentage

D. Performance-based incentive (PBI)

The Ministry of New and Renewable Energy provides DISCOMs with a PBI for progress under Component A of PM-KUSUM for 5 years from the date of commissioning, which the DISCOM can keep for themselves or transfer to the plant owner.

Working formula:

PBI = 0.40 x No of units of electricity produced per year x 5

E. Feed-in tariff (FIT) cost

This is a loss to the DISCOM as there is a financial outlay in terms of the power purchase cost from solar developers at the FIT. This tariff is discovered after competitive bidding.

To calculate the coincidence factors, the total power demand and variable renewable energy (VRE) generation in 15-minute time periods for each state over a 1-year period have been taken into account. Further, the net demand in these time intervals has been calculated by subtracting VRE generation from the total power demand. The top 5% of net power demand is identified as peak demand. The respective coincidence factors have then been calculated as follows:

- **System coincidence factor** is the average of the VRE generation during time intervals corresponding to the top 5% of net power demand in the respective state.
- **Transmission coincidence factor** is the average of the VRE generation during time intervals corresponding to the top 5% of total power demand in the respective state.

The data for total power has been acquired from respective state departments and MERIT portal. The data for VRE generation has been acquired from the respective state departments.

The cost-benefit analysis also requires the collation of DISCOM-level data for the entities for which the analysis is being conducted. The data for DISCOMs across six states have been collected and fed into the TACTS tool. The dropdowns for state and DISCOM selection in the "Costs and Benefits" section of the tool can be used to select any DISCOM from any of these six states. The sources of data collection for DISCOM-level data are listed in Table 4.

Table 4. Sources for DISCOM-level data used in the cost-benefit analysis

Variable	Source
Total electricity consumption (MU)	Aggregate revenue requirement true-up orders for DISCOMs
Total agricultural consumption (MU)	
Transmission losses (%)	
Distribution losses up to 11 kV substation	
Fixed cost of generating stations (INR crores)	
Capacity allotted to generating stations (MW)	
Total variable cost of power purchase (INR crores)	
Total energy units purchased (MU)	
Fixed transmission charges (INR crores)	Transmission multi-year tariff orders
Transmission capacity (MW)	

Source: Authors.

In addition to variables for which data has been collected directly from published documents, such as aggregate revenue requirement true-up orders, there are other variables used for the cost-benefit analysis that have been calculated. They are listed below:

- **Discount rate (DR):** The discount rate is used to convert future cash flows or benefits into their present value. It reflects the time value of money. The DR is calculated as

$$\text{DR} = [(\text{Debt component X Interest on debt}) \text{ X } (1 - \text{Corporate Tax})] + (\text{Equity component X return on equity})$$

- **Average fixed capacity charges (AFCC):** This refers to the per-unit cost that a DISCOM pays to generators or suppliers for ensuring the availability of generation capacity. It is calculated as

$$\text{AFCC} = \frac{\text{Fixed charges for each generating station (INR crores)}}{\text{Capacity allocated to each generating station (MW)}}$$

- **Average variable cost of power (AVCP):** This refers to the weighted average per-unit cost DISCOMs pay to procure electricity from various sources. It is calculated as

$$\text{AVCP} = \frac{\text{Total variable cost of power purchase (INR crores)}}{\text{Total energy units purchased (MU)}}$$

- **Average fixed transmission charges (AFTC):** This refers to the average per-unit cost paid by the DISCOM for accessing the interstate and intra-state transmission network. It is calculated as

$$\text{AFTC} = \frac{\text{Fixed transmission charges (INR crores)}}{\text{Transmission capacity (MW)}}$$

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