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Assessment of IP set Consumption in Agricultural Feeders

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ABSTRACT: Farmers in India receive electricity either free of charge or at extremely low rates for operating irrigation pump (IP) sets. The distribution utilities are compensated for the free (or nearly free) supply through subsidies by state governments. To claim higher subsidy amounts, utilities often show inflated figures of agricultural consumption. The higher consumption (by IP sets) estimates also help utilities portray lower loss in their network. Therefore, accurate assessment of agricultural consumption is crucial to calculate actual losses occurring in the system and reduce the inflating subsidy burden on state governments. This paper provides an illustrative methodology for accurately assessing the consumption and technical losses in an agricultural feeder. The study is based on a dedicated agriculture feeder in the Indian state of Karnataka, where the agricultural sector is supplied free power. The results demonstrate much higher loss in the feeder, compared with the normative losses assumed by utilities. The accurate calculation of losses would provide a clear picture of the energy consumption in the agriculture sector, leading to accurate (reduced) subsidy claims.

KEYWORDS: Agriculture Feeder, Electricity Consumption, Irrigation Pump set, Agriculture Subsidy, Distribution loss.

I.INTRODUCTION

The Indian agriculture sector consumed 17.69% of the country's total energy consumption in 2018-19, which is the highest proportion recorded worldwide for the agriculture sector. The energy consumed by the agriculture sector (for irrigation pump sets) is supplied either free of charge or at nominal rates in India. States such as Karnataka and Telangana provide free power supply to farmers, whereas Maharashtra and Haryana charge subsidized rates. The state governments pay subsidy amounts to distribution companies (DISCOMs) to compensate for the cost incurred on free power supply to the agriculture sector. In some Indian states, where state governments do not provide subsidy, the DISCOMs are allowed to charge higher tariffs from the category of consumers that can afford to pay higher charges (such as industrial and commercial consumers). Thus, high-paying consumers cross-subsidize farmers and other economically weaker sections of consumers.

The power supply to the agriculture sector is mostly unmetered, so DISCOMs estimate the energy consumed by the sector and claim subsidy from the government. Because of the largely unmetered supply, there has always been a debate on the quantum of estimated electricity consumption in nearly all Indian states. It has been alleged that DISCOMs overestimate the electricity consumption by the agriculture sector to claim higher subsidy amounts.

Further, a few DISCOMs portray lower loss levels in their network by overestimating the unmetered agricultural electricity consumption. While supplying electricity to the end user, some electricity is lost in transit via the distribution network, which is called the distribution loss. The distribution loss is the difference between the total electricity input received by a DISCOM and the total electricity sold by the DISCOM. It has two components: technical loss (power loss in the electricity supply lines and distribution transformers) and commercial loss (loss due to unaccounted consumption or theft). In the case of unmetered electricity consumption, it is difficult to ascertain the precise amount of electricity consumed by the end consumer and the amount lost as the distribution loss. Because of the widespread unmetered supply in the agriculture sector, computation of distribution loss is highly dependent on the estimated consumption. Thus, any overestimation of the agricultural electricity consumption would lead to an underestimation of the distribution loss.

To provide a better estimate of state-level agricultural consumption of power, the Government of India introduced a feeder-segregation scheme. All feeders supplying power to only agricultural loads were segregated from those supplying non-agricultural loads. As non-agricultural loads are metered and their consumption is known, the remaining consumption is considered to be agricultural. However, such segregation has not taken place in all states. A few states, such as Gujarat, Karnataka, and Punjab, claim to have successfully implemented the scheme. Despite these claims, the subsidy requirement of the agricultural sector is increasing year-on-year. The total power subsidy to the agriculture sector in India increased by 36% in four years: from INR 66,349 crore (USD 8.817 billion) in FY14 to INR 90,000 crore (USD 11.961 billion) in FY18.

In this paper, one agricultural feeder in Karnataka is selected to demonstrate the methodology for accurate calculation of electricity consumption by the agriculture sector. Karnataka is chosen because the agriculture sector in this state receives free electricity supply for operating irrigation pump (IP) sets. The state government compensates DISCOMs for the cost incurred on supplying free power through subsidy payments. The subsidy to the agricultural sector in Karnataka increased from INR 4,993 crore (USD 663 million) in FY13 to INR 9,295 crore (USD 1.235 billion) in FY18, an increase of 86% in five years. The inflating subsidy burden is not fiscally sustainable in the long run. On the other hand, the overestimated agricultural consumption helps DISCOMs in Karnataka cover up the transmission and distribution losses in their network. As described earlier, losses can be calculated correctly only if there is accurate information on energy input and energy consumed. In the absence of reliable consumption data, the reported loss data is questionable. The combined losses (based on losses reported by DISCOMs) of all the DISCOMs in Karnataka are 14.9% in FY15, increasing to 16.4% in FY16 and then dropping again to 14.2% in FY17 (Table 1). One of the factors resulting in this discrepancy could be the variation in the assessment of agricultural consumption.

Table 1: Combined losses of all DISCOMS in Karnataka

	FY15 (%)	FY16 (%)	FY17 (%)	FY18 (%)
BESCOM	13.5	13.5	13.2	13.2
CESC	13.9	17.3	13.1	13.2
GESCOM	18.9	18.7	17.3	16.4
HESCOM	16.7	20.9	16.0	14.8
MESCOM	11.6	11.5	11.4	11.3
KARNATAKA	14.9	16.4	14.2	13.8

To overcome these challenges, we recommend computing the technical losses in the network through modelling and simulation of the agricultural feeders on a load-flow software tool. Establishing losses accurately would help determine the exact electricity consumption by the agriculture sector.

II. CONSTRAINTS IN THE EXISTING PROCESS OF AGRICULTURAL CONSUMPTION ASSESSMENT

The distribution network includes primary distribution lines (33 kV/11 kV) called high-tension (HT) lines, which emerge from substations to carry power to load centres'. The HT consumers are supplied at an 11 kV/33 kV voltage level. The high voltages can be stepped down through distribution transformers (DTs) to secondary distribution lines (415 V/230 V) called low-tension (LT) lines, supplying power to LT consumers. An 11 kV feeder caters to the load of all categories of consumers—including domestic, commercial, industrial, and agricultural. A feeder catering to the load of domestic, commercial and industrial consumers is categorised as non-agricultural feeders, whereas a feeder supplying to only irrigation pump set load is agriculture feeder. To accurately estimate the agricultural electricity consumption, feeders were segregated, wherein agricultural loads were segregated from non-agricultural loads.

The agricultural feeder selected for analysis was a segregated agricultural feeder catering to only agricultural consumers. The DISCOM assumed a normative loss of 9% to determine the agricultural consumption in the feeder. The considered loss levels were deducted from the total energy input received at the segregated 11 kV agricultural feeder. Because the agricultural feeder supplied power only to irrigation pump (IP) sets, the derived consumption figure was assumed to be the electricity consumption in the agricultural feeder. The constraint in this assessment was the assumption of normative losses. The load-flow methodology proposed in this paper to calculate losses in an agricultural feeder estimated much higher losses than the normative loss considered by the DISCOM (Table 2).

Another feeder—where loads were not segregated—was analysed to understand the methodology used for assessing agricultural consumption. In this case, the 11 kV feeder supplied electricity to both agricultural and non-agricultural loads. The non-agricultural loads included rural domestic and commercial consumers, who are usually metered. The agricultural consumption (being unmetered) in such a case was measured by deducting the metered sales and estimated losses from the total energy received at the 11 kV feeder. The constraint in this case was that the DISCOM inflated the consumption by the agricultural sector as a means to show reduced loss. The loss level is a good indicator to measure the operational efficiency of utilities. Lower loss levels would mean that the utility is able to bill all the energy that has been sold and collect revenue for all the energy that has been billed. In such scenarios, the agricultural consumption helps shroud the operational inefficiencies of utilities. In the case of this feeder (Table 3), the loss levels with only

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metered sales was 43%. To show optimum loss levels, the IP consumption was added to the metered sales to derive the total consumption or sales. This total sales was used to compute the losses in the feeder network. However, the loss levels calculated do not reflect the reality as they are based on the assumed agricultural consumption. This provided a perverse incentive to overestimate the agricultural consumption to demonstrate lower loss levels in the network.

Table 2: DISCOMs' methodology for assessing agricultural consumption with Feeder Segregation

Particulars	Symbol	Values
Energy input (units)	X	234,600
Assumed T&D loss (%)	L	9
Total sales (units)	P=X(L%*X)	213,486
Total IP sets	A	289
Total HP	B	1,721
Consumption/HP	R=P/B	122.8

Table 3: DISCOMs' methodology for assessing agricultural consumption without feeder Segregation

Particulars	Symbol	Values
Energy input (units)	X	83,000
Metered sales (units)	Y	47,113
T&D loss (%)	Q=(X-Y)/X	43
Assessed IP consumption (units)	Z	24,000
Total sales (units)	P=Y+Z	71,113
Revised T&D loss (%)	Q1=(X-P)/X	14

III. PROPOSED PROCESS OF ASSESSMENT OF AGRICULTURAL CONSUMPTION

The primary consideration for the accurate assessment of agricultural consumption was to identify the number of IP sets connected to a feeder. To understand the actual loss and consumption, one agricultural feeder in Karnataka was surveyed to geo-locate all the distribution transformers and IP sets connected to the feeder (Fig 1).

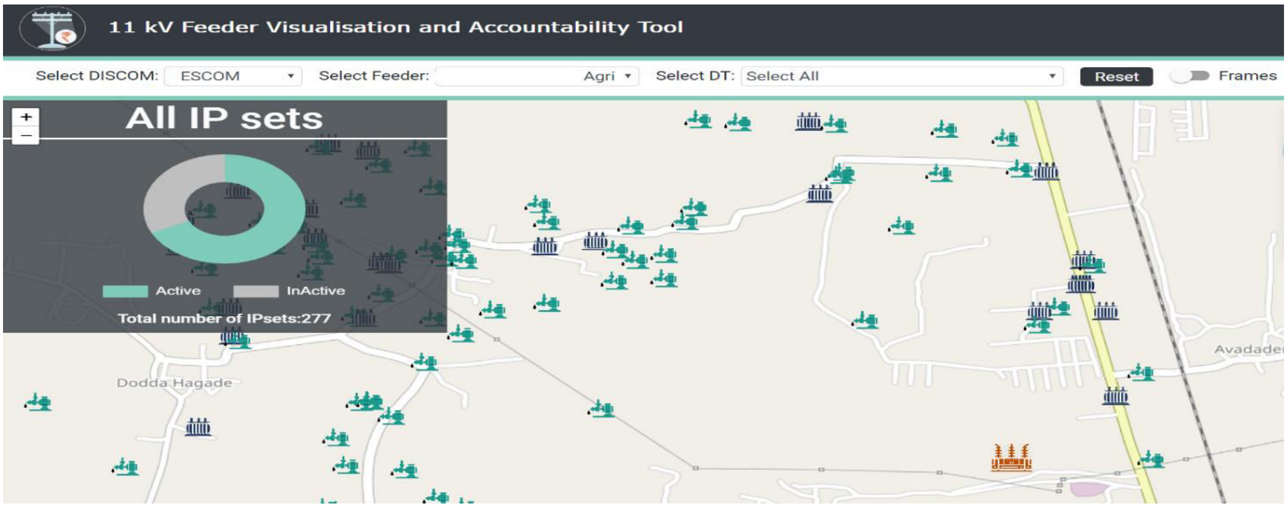

Fig. 1Mapping of DTs and IP sets connected to feeder

The feeder length was 18.75 km. The feeder had 77 distribution transformers (DTs) and 277 IP sets connected to it. Of the 277 IP sets, 188 were active and in working condition. Table 4 shows the brief profile of the feeder. Due to the unavailability of the actual load of each IP set (because they were unmetered), we assumed each IP set of capacity 10 HP, accounting for 0.746 kW. Therefore, the total load on the feeder was 2.03 MW.

Table 4: Feeder Profile

Particulars	Values
Number of distribution transformer	77
Total capacity of distribution transformer (kVA)	3580
Feeder length (km)	18.75
Type of conductor	Rabbit (ACSR)
Consumers (IP sets)	277

To compute the technical power loss in the feeder, the feeder network was modelled in the Electrical Transient Analyser Program (ETAP) power-simulation software tool, and load-flow analysis was performed with the Newton-Raphson method. The network was modelled based on the actual data collected during our field survey. Fig 2 shows the radial 11 kV feeder emanating from the 66/11 kV substation. The 11 kV bus of 66/11 kV substation was considered as the source for the radial feeder which fed 77 DTs. The IP sets connected to the 77 DTs were considered as lumped loads.

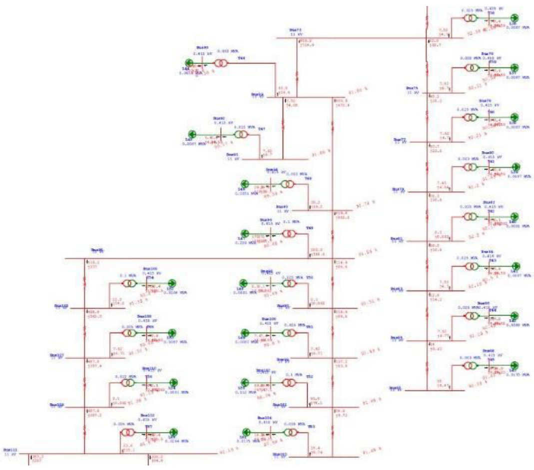

Fig. 2. Modelling of feeder network in ETAP

The load-flow analysis helped identify the total power consumption, power-flow directions through the branches, voltage at DT interconnection points (buses), total power losses in the feeder, and the branch-wise power losses and voltage drop across feeder elements.The load-flow study was conducted for two scenarios, considering *both active and inactive* IP sets in scenario 1 and *only active* IP sets in scenario 2. The two scenarios were analysed to observe variations in the feeder losses with different loading pattern.

A.Scenario 1: Simulating all IP sets (both active and inactive) in the feeder

In this scenario, all IP sets connected to the feeder were considered, irrespective of their active/inactive status. The feeder network was modelled considering the rabbit conductor with a feeder length of 18.75 km and a total load of 2.03 MW connected across 77 distribution transformers. The load-flow analysis indicated the total power drawn from the substation to be 2.38 MW, accounting for a feeder technical loss of 0.346 MW (translating to 14.7%).Table 5 shows the simulation results.

Table5: Assessment of agricultural consumption considering both active and inactive IP sets

Particulars	Values
Load (MW)	2.03
Generation (MW)	2.38
Loss (MW)	0.35
T&D loss in % (Loss/Generation * 100)	14.7

B. Scenario 2: Simulating only active IP sets in the feeder

Our field survey revealed that of the total 277 IP sets in the feeder, only 188 were active and considered to be drawing power. The remaining IP sets were idle and did not consume power (possibly because of dried bore-well or area no longer being cultivated). The assessment of agricultural consumption should be based only on active IP sets. Therefore, in scenario 2, the load for only active IP sets (188) was considered—which are connected across 77 DTs. The total load connected to the feeder was reduced to 1.45 MW and the power drawn from substation to 1.62 MW—accounting for a technical loss of 0.17 MW (translating to 10.5%). Table 6 shows the simulation results for this scenario.

Table6: Assessment of agricultural consumption considering only active IP sets

Particulars	Values
Load-MW	1.45
Generation-MW	1.62
Loss-MW	0.17
T&D loss in % (Loss/Generation * 100)	10.5

IV. RESULTS AND DISCUSSION

The simulation results showed that the feeder losses are much higher than that assumed by the utilities to assess agricultural consumption. The utilities assumed a feeder loss of 9%, considering both active and inactive IP sets, and thus arrived at an energy consumption of 213,486 units. However, our simulation revealed the losses to be 14.7% with both active and inactive IP sets, resulting in electricity consumption of 200,583 units. As explained earlier, higher the electricity consumption from IP sets, higher will be the subsidy claim for the agricultural sector. In scenario 1, the subsidy claim is lower than the utility claim because of higher losses. The subsidy claim would be INR 182 per IP set permonth.
In scenario 2 (with only active IP sets), we determined the losses to be 11%. The electricity consumption in scenario 2 is 209,967 units. The subsidy claim in scenario 2 is lower by INR 13,724 (than the subsidy claim by utilities), resulting in a subsidy claim of INR 49 per IP set per month.The state of Karnataka has almost 2.5 million IP sets. Thus, a subsidy outflow to the tune of INR 546 crores (USD 72 million) could be saved annually in scenario 1 and INR 15 crores (USD 1.9 million) in scenario 2.

Another method of accurately assessing the consumption is by metering the IP sets. But this approach comes with its inherent challenge: political will of the government. The consumers being supplied free power also constitute a significant vote bank. 37% of Karnataka's power consumption is by 12% of the state's electricity consumers (i.e., farmers operating IP sets)—and this electricity is supplied free of charge. So, administrative reforms like introducing IP metering might not be consideredpolitically viable. Utilities make use of such opportunities to claim higher subsidies and show lower losses. The state government could avoid inflating its subsidy burden by using our proposed methodology of feeder-loss calculation.

Table7: Comparison of subsidy savings

Particulars	Symbol	Utility	Scenario 1	Scenario 2
Energy input (units)	X	234,600	234,600	234,600
T&D loss (%)	L	9	14.7	10.5
Total sales (units)	P=X (1-L %)	213,486	200,583	209,967
Subsidy claim (INR)		832,595	782,274	818,871
Subsidy savings per IP set (INR)			182	49
Subsidy savings for all IP sets (INR crore)			546	15

VI. CONCLUSION

Based on the simulation results and discussion, it is evident that an accurate assessment of the electricity consumption by the agricultural sector is urgently required. The research methodology is developed with the aim of reducing ambiguity in the calculation of electricity consumption. The proposed methodology could be extended to all agricultural feeders in Karnataka, as well as in other states where the agricultural sector accounts for a substantial proportion of the electricity consumption. Precisely determining the actual electricity consumption could lead to better uptake of renewable energy for use in agriculture. The recently launched government scheme "KUSUM" (KisanUrja Suraksha evemUtthanMahabhiyan) could be implemented successfully by using the proposed methodology, as it would help evaluate the quantum of renewable energy required to cater to the agriculture sector.
Our simulation-based study for loss calculation could also be applied to other consumer categories such as domestic, commercial, and industrial consumers. This would help utilities make informed decisions about the investment required to upgrade the distribution-network infrastructure. It will also facilitate accurate demand forecasting and power-

purchase planning for the utilities, resulting in their financial viability. The financial viability of distribution utilities would, in turn, help in reviving the overall power sector.

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