Continual Support for Implementation of UDAY Initiatives in Karnataka

CSTEP
CENTER FOR STUDY OF SCIENCE, TECHNOLOGY & POLICY

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Center for Study of Science, Technology and Policy (CSTEP)

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Foreword

Power distribution is said to be the weakest link in the value chain of power sector in India. We have seen three major attempts to reform the functioning of the distribution utilities in the last twenty years, the latest being the Ujwal Discom Assurance Yojana (UDAY). There is now a new initiative in the offing called ADITYA, once again to infuse additional funds into the Distribution Companies (DISCOMs) and introduce new technologies in their functioning. The success of these reform initiatives necessarily depends on the underlying assumptions as to the causes of the poor performance of the sector. Also, given the differences in the conditions in which DISCOMs in different states operate, factors affecting their performance differ from case to case and a 'one size fits all' approach does not yield the desired results.

The financial viability of DISCOM operations in the country depends upon three main factors. These include regular tariff revisions to cover reasonable costs, receipt of subsidies from Government to provide free or concessional supply to certain consumers, and reduction of Aggregate Technical and Commercial losses (AT&C losses) to an acceptable level. While reform initiatives like UDAY can more easily impact on external factors like tariff revisions and subsidy payments (or government takeover of accumulated losses), the ultimate sustainability of DISCOM operations cannot be ensured unless their functioning is made more efficient to reduce AT&C losses to a reasonable level of say, about ten per cent.

Reduction of AT&C losses in turn requires tackling DISCOM operations at the lowest level of the system—at the level of each distribution feeder where the actual sale of power takes place. Identifying measures appropriate to the operational situation of each DISCOM to plug leaks in the system at the feeder to consumer level is the key to reduction of AT&C losses.

The present study is an attempt to focus attention on the need for eliminating the flaws in the system at the cutting edge level in two DISCOMs in Karnataka. The study highlights the need for greater thoroughness in measuring and monitoring the sale of electricity to consumers and in conducting regular energy audits. It is hoped that the insights gained through such studies help in bringing about greater commercial discipline in the operations of DISCOMs and enable them to provide more efficient service to consumers.

M R Sreenivasa Murthy
Former Chairman
Karnataka Electricity Regulatory Commission

17 August 2020

Executive Summary

Ujwal DISCOM Assurance Yojana (UDAY)—a flagship scheme of the Government of India that ran from November 2015 to March 2019—was aimed at reducing the aggregate technical and commercial (AT&C) losses of state-owned distribution companies (DISCOMs) by 6%, from 21% in FY15 to 15% in FY19. However, only 50% of the target (18.2%) was achieved by the end of FY19, and there is still a long way to go to achieve the target.

Center for Study of Science, Technology and Policy (CSTEP) undertook a study to analyse the loss calculation methodology, identify the causes for the losses, and estimate the proportion of technical and commercial losses in the recorded AT&C losses. For this purpose, we selected two DISCOMs— Chamundeshwari Electricity Supply Corporation Limited (CESC) and Bangalore Electricity Supply Company Limited (BESCOM)—in Karnataka and focused on 20 feeders from the two DISCOMs.

Our survey of the feeders and analysis of the collected data suggested the following causes for the AT&C losses: lack of feeder-level accountability, ineffective energy auditing process, and inaccurate calculation of consumption by irrigation pump (IP) sets. Our survey revealed huge deviations between the feeder loss calculations by DISCOM and CSTEP. For instance, in an industrial feeder, CSTEP calculations showed a loss of 5.1%, while the DISCOM calculated the losses as 13%. Further analysis revealed that the deviation was due to inaccurate accounting of import/export energy, owing to a lack of boundary meters. Gross overestimation of assessed energy was another issue found in feeders—a practice employed by DISCOMs to depict all losses as normative. During the spot-checking of 173 consumer installations, we observed issues with billing, and feeder-transformer-consumer tagging in 13% of the installations. The survey also showed data entry errors made by DISCOMs. Over a period of one year, CSTEP recorded 36 feeder energy input readings. Forty-two per cent of these did not match with DISCOM's readings.

To tackle the aforementioned issues, we suggest the following implementable measures:

- *Feeder-wise Revenue Accounting and Monitoring of Energy Sales (FRAMES):* In order to avoid incorrect estimation of energy consumption, FRAMES—a framework developed by CSTEP—can be used to monitor revenue and energy sales. This would improve the operational and commercial accountability of DISCOMs at the feeder level. The study analysed a reduction of 2% losses on an average. This could help Karnataka DISCOMs to save a revenue loss of around INR 700 crores.
- *GIS-based energy audit tool:* A centralised energy-auditing portal will help bring all the feeders on one platform. Mapping of feeders, transformers, and consumers would make it convenient to track loss-making feeders and also help in mitigating the issues caused by data entry errors and incorrect tagging. The tool would thus help in robust energy auditing, better asset management, and efficient network planning.
- *Computing accurate IP set consumption through agricultural feeder mapping:* Mapping of IP sets can address the issues caused by the inaccurate assessment of IP set consumption and the increasing number of IP sets over the years.

These recommendations can help DISCOMs reduce their AT&C losses to ~10%. Further, DISCOMs need to introduce some organisational and procedural changes at the field level and train the field-level staff to ensure greater commercial accountability. **Although the study analysed the reasons for losses in the 20 selected feeders of the two DISCOMs in Karnataka, the recommendations can be implemented for any DISCOM across the country.**

Contents

Figures

Tables

1. Introduction

The financial viability of the entire Indian electricity sector is dependent on the financial health of distribution companies (DISCOMs). DISCOMs themselves, however, are facing a severe crisis with their financial condition deteriorating and operations becoming inefficient. The aggregate losses in the DISCOMs in FY19 is INR 49,623 crore[1]. One of the main causes of DISCOMs' distress is high aggregate technical and commercial (AT&C) losses. Therefore, reducing AT&C losses is considered the key to ensuring the sustainability of DISCOMs. As per a Ministry of Power (MoP) report[2], on average, a 1% reduction in AT&C losses can increase the revenue of a DISCOM by up to INR 250–300 crore, in several cases.

Given the importance of AT&C loss reduction in improving the financial health of DISCOMs, Government of India (GoI) launched Ujwal DISCOM Assurance Yojana (UDAY) in November 2015. Under UDAY, one of the measures (among others) for improving DISCOM finances was reduction of AT&C losses from over 20% in many DISCOMs to less than 15% by 2019. Around 32 states and union territories (UTs) are participated in UDAY. Each state and UT had signed a memorandum of understanding (MoU) wherein specific measures were outlined for improving the operational and financial health of the respective DISCOMs. Of the 32 states and UTs, 6 states (including Karnataka) signed the MoU for only operational improvement (i.e., loss reduction). For AT&C loss reduction, measures such as (1) 100% distribution transformer (DT) metering in urban and rural areas, (2) energy audit at 11 kV level, and (3) feeder segregation were envisaged. The initiatives were to be completed by December 2019. The progress made by DISCOMs on these initiatives is presented in Annexure 1. According to the data available on the UDAY portal, the combined or average AT&C losses for all the states and UTs amounted to 18.2% in FY19, considerably higher than the targeted loss levels of 15%.

AT&C losses are a combination of technical losses and commercial losses—technical losses are the losses occurring in the process of power distribution through the network, while commercial losses are mostly due to operational deficiencies such as inaccurate billing, data and calculation errors, low collection of billed revenue, and power theft through illegal connections. In the prevailing situation, it is difficult to accurately estimate the relative proportion of technical and commercial losses in the total AT&C losses. To effectively reduce the AT&C losses as targeted, it is crucial to estimate the technical and commercial losses accurately. A process needs to be developed to locate the areas where losses are occurring and to identify the reasons for their occurrence—that is, whether losses are due to technical issues (network and maintenance), commercial reasons (inaccurate billing and collection), or unauthorised consumption (theft and pilferage).

2. Research Objective

Karnataka's distribution sector comprises five electricity supply companies, namely, Bangalore Electricity Supply Company Limited (BESCOM), Mangalore Electricity Supply Company Limited (MESCOM), Hubli Electricity Supply Company Limited (HESCOM), Gulbarga Electricity Supply Company Limited (GESCOM), and Chamundeshwari Electricity Supply Corporation Limited (CESC).

[1] PFC, "Report on Performance of State Power Utilities."

2 MOP, "Measures to Check Commercial Losses."

A brief profile of each DISCOM KERC, "20th Annual Report of Karnataka Electricity Regulatory Commission" is given in Table 1.

Table 1: Brief profile of Karnataka DISCOMs (FY17–18)

Particular	BESCOM	MESCOM	CESC	HESCOM	GESCOM	Total
Area (sq. km)	41,092	26,222	27,773	54,513	43,861	1,93,461
Districts (number)	8	4	5	7	6	30
Consumer (lakh)	112	23	31	46	29	241
Energy Sold (MU)	25,967	4,882	5,798	10,699	6,505	53,851
Demand (INR crore)	18,001	3,190	3,676	6,887	4,292	36,046
Collection (INR crore)	19,084	3,283	3,680	6,810	4,829	37,686

(Source: KERC Twentieth Annual Report 2018-19)

According to the Power Finance Corporation (PFC) methodology, AT&C losses at the 11 kV feeder level are calculated by identifying the difference between energy input at the origin of the feeder and output (energy billed) at the consumer end. For Karnataka DISCOMs, the target for the reduction of AT&C losses by FY 2019 was 14.2% "UDAY MoU". Karnataka has claimed to have almost achieved this target with reported AT&C losses of 14.85% in FY19 (Table 2).

Table 2: DISCOM-wise AT&C loss

DISCOM	AT&C loss (%) (as of 31 March 2020)
BESCOM	14.9
CESC	13.4
HESCOM	14.5
MESCOM	13.2
GESCOM	12.6

(Source: UDAY website)

While the loss reduction target appears to being achieved, the relative proportion of technical and commercial losses in the overall AT&C losses is not known.

An 11 kV feeder-level study is, therefore, required to validate the methodology adopted for loss calculation and to arrive at the relative proportion of technical and commercial losses in the overall loss figures. In this context, Center for Study of Science, Technology and Policy (CSTEP) undertook a study to analyse the loss calculation methodology and to identify causes for the losses in Karnataka, as well as to estimate the proportion of technical and commercial losses. For this purpose, we selected two DISCOMs—CESC and BESCOM—in Karnataka. Through the study, we sought to analyse AT&C losses in 20 selected feeders, 10 from each of the aforementioned two DISCOMs catering to various categories of consumers such as residential, industrial, commercial, rural, and agricultural.

3. Methodology

The Power Finance Corporation (PFC) methodology "PFC." involves estimation of transmission and distribution (T&D) losses and aggregate technical and commercial (AT&C) losses for the 11 kV feeder level, using the following formulas:

T&D losses = (Energy input at the feeder - billed consumption)/Energy input

AT&C losses = (1 - (BE × CE)) × 100

Where

Billing efficiency (BE) = (Energy billed/Energy input) × 100

Collection efficiency (CE) = (Revenue collected/Revenue demanded) × 100

In the two DISCOMs studied by CSTEP, AT&C losses are calculated on a month-on-month basis at the subdivision office level and then shared with the division office for consolidation. Figure 1 illustrates the process of AT&C loss calculation.

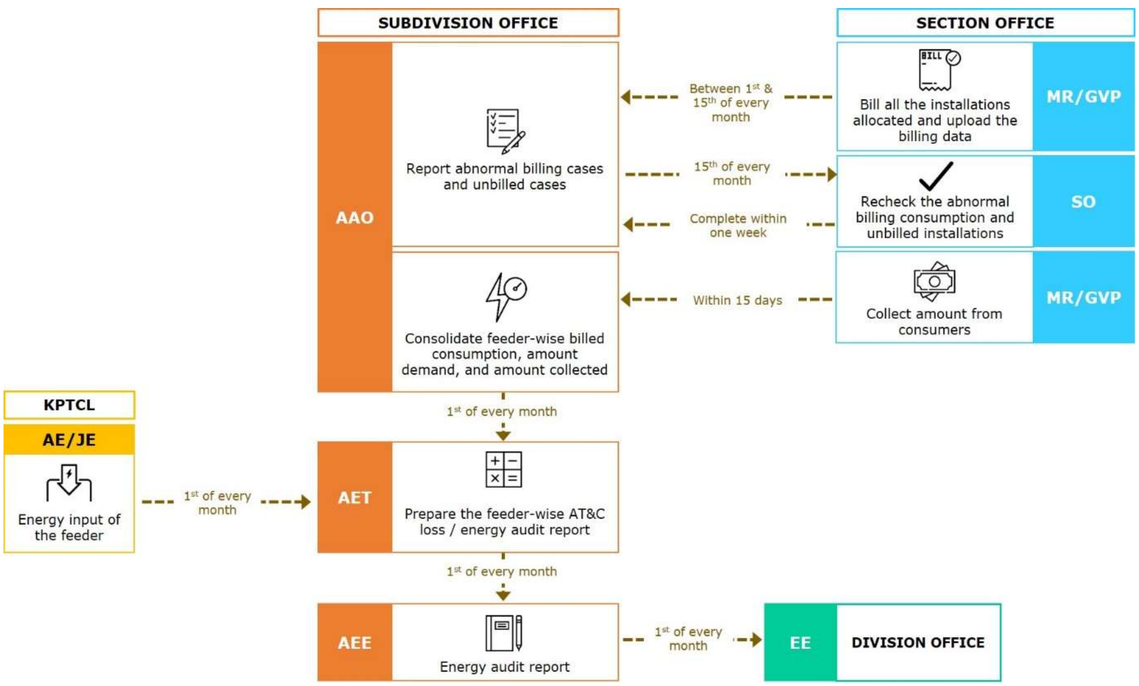


Figure 1: AT&C loss process

(Source: Stakeholder consultation, CSTEP Analysis)

Karnataka Electricity Regulatory Commission (KERC) developed an energy audit format in 2003 to determine technical and commercial losses separately. However, the format is not fully utilised by DISCOMs. The methodology adopted by DISCOMs provides only the extent of overall losses occurring in a feeder and does not help in identifying the causes and nature of the losses—whether they are technical losses caused by the line length, type of conductor used, etc., or commercial losses caused by data and calculation errors, defective metering, and billing "Energy Auditing.". If DISCOMs are able to identify the proportion of losses, factors causing such losses, and the points in the network where such losses occur (as required by KERC), they would be able to take appropriate steps to reduce the losses.

Therefore, the CSTEP team adopted a methodology to segregate the technical and commercial losses by separately computing feeder-to-DT and feeder-to-consumer losses, collecting data through primary research. In the feeder-to-DT stretch, instances of theft, and hooking/tapping are very rare because the high voltage (11000 volts) can cause any kind of line tampering to turn fatal. Therefore, the feeder-to-DT losses would be mostly line losses and transformer losses, which account for only technical losses (or high-tension losses) in the feeder.

Our team collected data for calculating DT-to-consumer losses where multiple consumers receive supply from each DT (low-tension losses). However, owing to shortcomings in the data provided (incomplete metering of DTs, lack of data on number of consumers connected to each DT, etc.), we could not utilise the data for comparing DT meter readings with the consumption recorded at the consumer level for each DT. Therefore, we opted for calculation of feeder-to-consumer losses, which include both technical and commercial losses, after which we analyse the following data to compute the technical and commercial losses separately:

- Energy input to feeder: The energy input is recorded at Karnataka Power Transmission Corporation Limited (KPTCL) substations on a monthly basis. We recorded the feeder energy input from substation meters every month from July 2018 to August 2019.
- Energy consumption at DT: We recorded DT meter readings for all the connected DTs (where DT meters were available) on a feeder the same day the feeder meter reading was done.
- Billed consumption data: We collected monthly consumer billing details from the subdivision and section offices.

For the purpose of this study, we have limited the loss analysis to the billing of energy consumed and excluded the revenue (collection efficiency) parameter. We excluded the revenue collected parameter as it depends on the actual payment pattern of the consumers. While most consumers pay their energy bills before the due date (about two weeks from the date of billing), many make late payments, often with a penalty/interest. For instance, government offices usually pay their bills, including arrears, on a quarterly basis. This makes it difficult to relate the actual revenue realised with the billed consumption for any given period/month.

The feeders were selected to include different feeder categories such as urban, Niranthara Jyoti Yojana[3] (NJY), industrial, and agricultural feeders, as feeder losses depend on the type of consumers they cater to. Further, another criteria adopted was to select feeders with significant loss figures in FY16–17.

For urban feeders, we selected feeders with AT&C losses of more than 20% in FY16–17. As data for FY16–17 was not available for one feeder (Kanteerava), we considered the loss data for FY17–18, which was 55%.

- For NJY feeders, we selected feeders with AT&C losses of more than 20%. One NJY feeder with a reported loss of 3% was also selected. This was done mainly to understand the reasons for such low losses in this NJY feeder.
- For industrial feeders, we selected feeders with AT&C losses of more than 10%. A feeder with 6% losses was selected to understand the process adopted in this feeder to minimise losses, as well as to share these practices with other feeders.

[3]A feeder supplying domestic and commercial load in rural areas after segregation of agricultural load.

- We selected one agricultural feeder to work out a methodology to compute the irrigation pump (IP) set consumption at the feeder, as per DISCOMs' requirement.

To compare the meter readings of the feeders and DTs, we took meter readings for both on the same day. Thus, to cover the entire feeder and the associated DTs in one day, we selected feeders having number of DTs in the range 30–90, with an average of 40 DTs per feeder.

For a feeder with a high energy input, even a small percentage reduction in AT&C losses would have a huge impact on the overall revenue earned from the feeder and consequently by the DISCOM. Therefore, we selected feeders with high, medium, and low annual energy inputs (low: <=3 MU, medium: 3–10 MU, high: >10 MU) to accurately understand the impact on AT&C losses.

After feeder selection, we conducted a survey of all the 20 feeders with the help of a Junior Engineer (JE)/lineman, allocated by the DISCOMs to support us during the field survey "Feeder Survey in Karnataka: Key Observations.". The survey was conducted from July 2018 to August 2019 for CESC feeders, and from September 2018 to August 2019 for BESCOM feeders. The field survey included the following tasks:

- Mapping of geographic information system (GIS) locations of selected feeders and associated DTs
- Studying the single-line diagrams (SLDs) of the selected feeders
- Ascertaining whether feeders and connected DTs were metered
- Recording the maintenance issues associated with feeders, DTs, and consumers' service lines
- Documenting tagging issues for feeder-to-DTs and DT-to-consumers
- Recording readings for feeder energy input and DT consumption to calculate losses

4. Analysis

As part of the study, we collected data for FY16–17 feeder-wise AT&C losses for both DISCOMs. CESC has a total of 1,571 feeders, of which 65% (1,016/1,571) feeders reported more than 15% AT&C losses. Similarly, BESCOM has a total of 4,276 feeders, of which 45% (1,894/4,276) feeders reported more than 15% AT&C losses.

As mentioned earlier, CSTEP chose 20 feeders in two DISCOMs catering to different types of loads/areas such as urban, industrial, NJY, and agricultural. A brief profile of the selected feeders is provided in Table 4. These 20 feeders have 783 DTs and 34,954 consumers connected to them. The annual energy input for all the feeders combined is in the range 70–98 MU from FY17 to FY19. The average losses for the 20 feeders, as reported by DISCOMs in FY16–17, amounted to 38%. This is reported to have reduced to 15% by FY18-19. Table 4 gives year-on-year losses in these feeders. However, the loss reduction achieved in consecutive years does not seem to have a definite trajectory. For instance, the losses in feeder 2 reduced from 23% in FY17 to 3% in FY18 but again shot up to 36% in FY19 with no specific reasons given, thus making it difficult to discern any systematic approach adopted by the DISCOMs. Thus, it becomes even more important to identify the reasons for such erratic trends in the loss figures of the 11 kV feeders.

Another major issue noticed across all the feeder categories during our survey was DT metering status and infrastructure. While DISCOMs provided us with the data for 723 DTs, we found 783 DTs in 20 feeders. Of these 783 DTs, 28% (219) were unmetered. Of the remaining 564 metered DTs, 113 (20%) meters were defective and did not record any supply data. DISCOM-wise DT meter status is presented in Table 3.

Table 3: DISCOM-wise DT meter status

DISCOM	Total DTs	Metered DTs	Unmetered DTs	Defective DTs
BESCOM	416	277	139	51
CESC	367	287	80	62

(Source: CSTEP Survey and Analysis)

For the DTs where meters were working and in good condition, DISCOM officials did not record readings for the purpose of any analysis or calculation of T&D losses. The main aim of DT metering is DT-wise energy audit so as to identify feeder-to-DT losses and DT-to-consumer losses and identify the exact point of leakage. Absence of DT meters, defective DT meters, and non-reading of DT meters make it difficult to conduct energy audit with accuracy.

In addition to the abovementioned factors, inconsistent and defective billing, data entry and calculation errors, and cases of theft were some other factors leading to high and inconsistent losses in these feeders. These factors are discussed in detail for each of the feeder categories.

4.1 Urban feeders

An urban feeder generally serves a mix of residential and commercial consumers in urban areas. Of the total DISCOM sale in Karnataka, the residential and commercial categories (taking five DISCOMs together) accounted for 36% (18,143 MU/50,933 MU) of the total consumption and 38% of the total revenue (INR 13,014 crore /INR 34,184 crore) in FY18. The urban consumers in Karnataka are usually disciplined and pay their bills promptly. Any factors leading to losses in these feeders mainly relate to inadequacies in billing and collection by the DISCOM staff.

To identify ground-level challenges in loss calculation, billing, and collection, we surveyed five urban feeders. These five feeders have around 15,000 consumers connected to them with the annual energy input at the feeder level in the range 1–10 MU. Table 4 lists the inconsistencies in the loss pattern of individual urban feeders in both CESC and BESCOM areas. ***While analysing the feeders, we found issues related to recording of energy input, billing, and data entry and calculation in all the five feeders.*** We discuss these issues in the context of one representative feeder for illustrating the nature of the issues affecting the feeders.

Table 4: Brief profile of selected feeders

	District/ Zone	Feeder name	No. of DTs as per data	No. of DTs as verified	No. of consumers	Annual energy input (MU)			AT&C loss (%)		
						FY16–17	FY17–18	FY18–19	FY16–17	FY17–18	FY18–19
CESC											
Urban											
Feeder 1	Hassan	Halli Mysore	35	32	1,372	0.9	1	1	23%	22%	13%
Feeder 2	Hassan	Vidyuth Nagar	66	56	1,242	1.6	1.6	1.9	23%	3%	36%
Feeder 3	Mandya	K M Doddi	62	62	5,898	0.3	8	8.4	37%	38%	40%
Sub-total			163	150	8,512	2.8	10.6	11.3	28%	21%	30%
NJY											
Feeder 4	Hassan	Malali NJY	35	41	1,501	0.8	0.9	0.9	21%	9%	39%
Feeder 5	Chamarajanagara	Gundegala	27	35	2,185	1.9	1.9	1.5	21%	73%	62%
Feeder 6	Hassan	Thatanahalli NJY	25	28	1,340	0.7	0.7	0.6	34%	31%	41%
Feeder 7	Mysuru	Mavathur	76	80	5,462	2.8	2.8	2.1	33%	-10%	27%
Sub-total			163	184	10,488	6.2	6.3	5.1	27%	26%	42%
Industrial											
Feeder 8	Mandya	Kleane Pack	3	3	3	21.7	21.97	17.07	6%	0%	-1%
Feeder 9	Mandya	Balaji Malt	1	1	1	14.8	13.69	15.07	12%	14%	10%
Feeder 10	Mysuru	Balaji	29	29	33	4.7	4.67	6.76	17%	7%	1%

Sub-total				33	33	37	41.2	40.33	38.9	12%	7%	3%
Total				**359**	**367**	**19,037**	**50.2**	**57.23**	**55.3**	**22%**	**18%**	**25%**
BESCOM											
Urban											
Feeder 11	BMAZ	F05 Hanumanthappa	43	52	6,876	10.8	11.5	N/A	72%	75%	7%
Feeder 12	BMAZ	F11 Kanteerava	4	13	279	N/A	5.5	N/A	N/A	55%	7%
Sub-total			47	65	7,155	10.8	17	N/A	72%	65%	7%
NJY											
Feeder 13	CTAZ	Kithaganahalli	48	52	2,495	2	N/A	2.7	3%	N/A	52%
Feeder 14	BRAZ	F-18 Beedikeri	32	36	827	1.7	1.8	N/A	43%	49%	13%
Feeder 15	CTAZ	AB Hatti	55	51	1,926	4.5	3.2	2.7	80%	52%	31%
Feeder 16	BRAZ	Kalvamanjali NJY	39	51	1,568	5	3.5	3.5	85%	76%	79%
Feeder 17	CTAZ	Haralipura	36	44	1,718	1.4	2	1.4	61%	20%	45%
Sub-total			210	234	8,534	14.6	10.5	10.3	54%	49%	44%
Industrial											
Feeder 18	BMAZ	K B Park	11	11	4	3.9	3.16	3.2	142%	153%	8%
Feeder 19	CTAZ	F-08 KIADB	29	29	54	2.5	2.4	2.8	16%	25%	20%
Sub-total			40	40	58	6.4	5.56	6	79%	89%	14%
Agricultural											

Feeder 20	BRAZ	Bagyadavanahalli IP	67	77	343	7.1	7.7	1.8	24%	35%	-5%
Total			**364**	**416**	**16,090**	**38.9**	**40.7**	**18.1**	**57%**	**60%**	**15%**
Grand Total			**723**	**783**	**3,5127**	**89.1**	**97.9**	**73.4**	**40%**	**39%**	**20%**

(Source: Feeder-level data as obtained from CESC and BESCOM, CSTEP Survey)

Feeder 1

F08 Halli Mysore is an urban feeder emanating from 66/11KV Halli Mysore Master Unit Sub Station (MUSS). The feeder mainly caters to the load in a semi-urban area of Hassan district under CESC with a mix of residential and commercial consumers.

Table 5 presents a brief profile of the Halli Mysore feeder as per the data verified by CSTEP in FY19.

Table 5: Halli Mysore feeder profile

Feeder name	No. of DTs	Feeder length (km)	Consumers	T&D loss in FY19 (%)
F08 Halli Mysore	32	10.9	1,372	15.4

(Source: Feeder-level data as obtained from CESC, CSTEP Survey)

Category-wise trend

The feeder has a total of 1,372 consumers connected to it (Table 6). Domestic consumers (79%) constitute the highest share of installations, followed by LT3-commercial (18%) and LT1-BJ/KJ[4] (13%). The remaining 3% is comprised of LT5-industrial, and LT6-water supply and street lights (WS & SL) categories.

Table 6: Category-wise consumer number, consumption, and demand for Halli Mysore feeder

Tariff	Total consumers		Annual consumption (FY19)		Annual revenue demand (FY19)	
	No.	%	MU	%	INR lakh	%
LT1 (BJ/KJ) (domestic)	181	13	0.04	4	3.3	5
LT2 (domestic)	900	66	0.43	48	25.5	36
LT3 (commercial)	246	18	0.21	23	22.5	32
LT5 (industrial)	29	2	0.11	12	10.3	15
LT6 (water supply and street light)	16	1	0.12	13	8.4	12
Total	1,372	100	0.9	100	70	100

(Source: Feeder- and category-wise demand collection and billing data as obtained from CESC, CSTEP Analysis)

In FY19, the total consumption billed for all the consumer categories under this feeder was 0.9 MU. The consumption by domestic consumers was highest at 52%, followed by commercial (23%) and WS & SL (13%). The total revenue demand for the quantum of energy sold amounts to INR 70 lakh. Domestic, commercial, and WS & SL categories account for 85% of the total revenue of the feeder. Therefore, any significant deviation in the billing of these three consumer categories would impact the overall revenue earning of the feeder and reflect in its T&D losses.

Loss trend analysis

[4] Bhagya Jyoti/Kutir Jyoti: Receiving free supply up to 40 units per month

We analysed month-on-month T&D losses of this feeder (Figure 2) to understand the reasons for high losses and their point of occurrence—that is, whether losses are at the feeder-to-DT level or DT-to-consumer level. The feeder-to-DT losses are considered purely technical losses as only an HT line is drawn to DTs and no LT consumer is connected till this point. The HT lines have lower losses than LT lines owing to their higher current-carrying capacity. On the other hand, feeder-to-consumer losses include both technical and commercial losses. Technical losses vary because of the type of conductors used, line length (HT/LT), and transformation losses in DTs, and commercial losses vary because of defective metering, inaccurate billing, faulty meters, data entry, and calculation errors.

Figure 2 depicts the T&D losses of the Halli Mysore feeder from feeder to DT (computed by CSTEP from the data collected during the survey) and feeder to consumer (as per billing data provided by the DISCOM). Since there was no record of DT meter recording in the sub-division office, we recorded meter readings of all the DTs connected to the feeder from August 2018 to July 2019. We found a consistent pattern of feeder-to-DT losses of 4% for nine months except for August 2018, September 2018, and December 2018). In these three months, we could not record the consumption of 14 DT meters because of faulty and defective meters. Further, in August and September, around 14 DT meters were faulty, resulting in higher loss calculation of 31% and 16%, respectively. Because of our requests, a meter-replacement drive was conducted by DISCOM officials. However, in December, two meters were still found faulty, resulting in slight deviation from the consistent line losses of 4%. The line losses for the period of October 2018 to July 2019 were as follows:

$$\text{Feeder energy input (Oct 2018 to July 2019)} = 9,68,680 \text{ kWh}$$

$$\text{Energy input from all DTs (Oct 2018 to July 2019)} = 9,29,657 \text{ kWh}$$

$$\text{Feeder} - \text{DT loss (kWh)} = (9,68,680 - 9,29,657) = 39,023 \text{ kWh}$$

$$\text{Feeder} - \text{DT loss (\%)} = 39,023/9,68,680 = 4\%$$

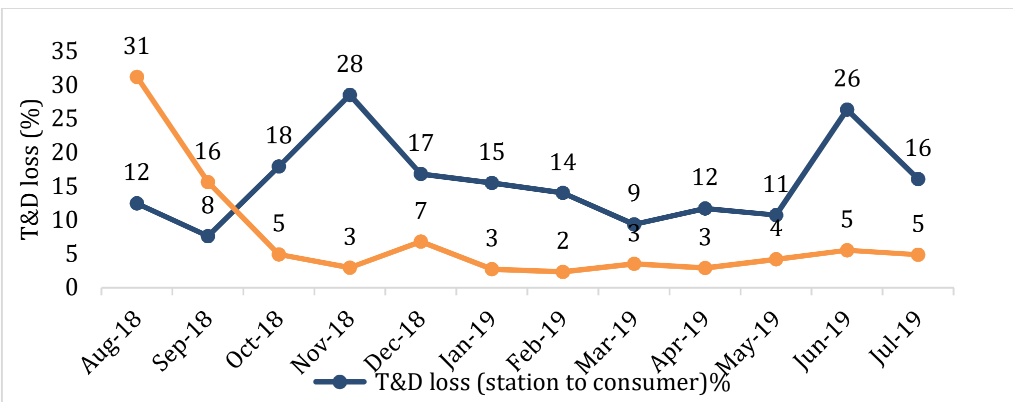


Figure 2: Halli Mysore month-wise T&D losses

(Source: CSTEP Survey and Analysis)

The average feeder-to-consumer loss for this feeder, as calculated by CSTEP, was 15.4% (1, 76,637 kWh) for FY18–19. As per data recorded by CSTEP, the total energy input to the feeder in FY18–19 was 11, 45,180 kWh, and the billed consumption at the consumer end was 9, 68,543 kWh.

$$\text{Feeder} - \text{consumer loss (kWh)} = (11,45,180 - 9,68,543) = 1,76,637 \text{ kWh}$$

$$\text{Feeder} - \text{consumer loss (\%)} = 1{,}76{,}637/11{,}45{,}180 = 15.4\%$$

The technical loss component in the total losses will be feeder-to-DT losses (already calculated as 4%) and LT line losses. As per various publicly available reports and papers, the LT line losses are in the range 4%–6% for an 11 kV feeder (Jha, 2002). Therefore, considering another 4% for LT line losses, the total technical losses in the feeder are estimated to be 8% (91,614 kWh). Therefore, the remaining 7.4% (85,023 kWh) losses in the feeder are the estimated commercial losses occurring because of inaccurate billing, data entry errors, defective metering, and theft. Following are some of the observed instances of the above mentioned reasons for commercial losses:

a) *Inaccurate billing:* Gram Vidyut Pratinidhis (GVPs) bill the installations by recording meter reading using a handheld billing instrument. To ascertain the accuracy of billing by GVPs, we conducted spot-checking for 96 installations (in the month of June 2019) in this feeder and found mismatch between the GVP reading and CSTEP reading in 13 installations (14% of total installations) (Table 7). For two LT6 water supply installations, no meters were connected. Although the concerned GVP was aware, he was billing the installations on an average consumption basis. Similarly, there were three more installations where the meter was not recording and billing was done on an average basis. For the remaining eight installations, GVP recordings were either higher or lower than the CSTEP readings, with no explanations forthcoming.

Table 7: Spot-checking in CESC area

RR no.	Tariff	CESC (GVP) reading (kWh)	CSTEP reading (kWh)
C1	Street light	874	8062
C2	Water supply	4213	4309
C3	Domestic	61	332
C4	Commercial	281673	283566
C5	Street light	788	2
C6	Water supply	28001	3168
C7	Commercial	2526	57
C8	Commercial	2105	836
C9	Water supply	3100	No meters
C10	Water supply	23960	No meters
C11	Street light	8180	MNR
C12	Commercial	3546	MNR
C13	Commercial	2212	MNR

(Source: Consumer billing data as obtained from CESC, CSTEP Survey)

We also conducted spot-checking in the month of August 2019 for 77 domestic installations (connected to three DTs) in one of the urban feeders (Kanteerava) in the

BESCOM area. We found issues related to data entry, and inaccurate tagging in nine installations (12%) of the surveyed feeder (Table 8). Four out of the nine installations were physically connected to this feeder but were accounted under another feeder. For the other five installations, there was a mismatch between the billing data recorded by the CSTEP team and by DISCOM officials.

Table 8: Spot-checking in BESCOM area

RR no.	Tariff category	BESCOM reading (kWh)	CSTEP reading (kWh)
B1	Domestic	N/A	264
B2	Domestic	N/A	131
B3	Domestic	N/A	158
B4	Domestic	271	3661
B5	Domestic	N/A	375
B6	Domestic	58	106
B7	Domestic	147	60.9
B8	Domestic	2208	7
B9	Domestic	131	200

(Source: Consumer billing data as obtained from BESCOM, CSTEP Survey)

b) *Data entry errors*: During the survey, we recorded feeder energy input from the feeder meters installed at the substation. We found a mismatch in the data recorded by DISCOM officials in their energy audit report vis-à-vis the actual reading from the meter. In case of the Halli Mysore feeder, we recorded the feeder energy input in October 2018 as 90,660 kWh, while the energy audit reports showed the energy input in the same month to be 83,000 kWh. The energy consumption was consistent at 74,421 kWh as per billing data obtained from the DISCOM. The mismatch in accounting the energy input led to reporting of reduced losses from 18% to 10%. Similarly, the feeder energy input for the period July 2018 to June 2019 as recorded by the CSTEP team was 1.13 MU, whereas DISCOM data reflected 1.05 MU, a difference of 85000 kWh. This difference in the energy input represents misreporting of DISCOM losses. Similarly, in two other feeders in the CESC area, we recorded 24 readings for energy input from July 2018 to June 2019 (one reading in each month for two feeders). Of these 24 recordings, 63% (15/24) readings did not match DISCOMs' readings (Annexure 2).

c) The difference in the energy input recorded was 46% with DISCOM recording showing 2.8 MU while CSTEP recorded found the input to be 4.4 MU. This leads to the conclusion that energy audit reports are prepared on the basis of estimated numbers with feeder energy input readings adjusted to reflect normative loss levels in a feeder.

d) *Defective metering*: During our survey, we also came across various installations in the Halli Mysore feeder that had faulty meters and were billed on an average basis. Two out of 16 LT6 water supply and street light installations (surveyed by CSTEP) had faulty meters. An installation with a faulty meter could be billed on an average of past 6 months' bills till the meter is replaced (within 10 days as per the KERC standards of performance regulation "KERC Standards of Performance Regulation."). However, for the said installations, the average billing was being done for 4–6 months without replacing the meter. The LT6 installations have an average monthly consumption in the range 1,000–6,000 kWh. Billing such installations on an average basis would not reflect accurate consumption, thus resulting in revenue losses for the feeder and DISCOM.

In view of the above analysis and discussions, the urban feeder should have losses in the range 8%–10% (permissible technical loss of 8% and permissible commercial loss of 1%–2%). However, all the urban feeders surveyed by CSTEP showed inconsistent loss patterns in the last three years, ranging from 3% to 75%. This was due to the issues mentioned above. For instance, in Feeder 2, the loss figure reduced from 23% in FY16 to 3% in FY17 and then increased to 36% in FY18. A discussion with officials revealed that because of fault in DTs, the consumers were supplied power from other transformers. However, such changes were not recorded in the energy audit reports owing to inaccurate tagging of the consumers. Similar issues were witnessed in BESCOM feeders, resulting in inconsistent patterns of losses. In another feeder in the CESC area (KM Doddi), it was found that the feeder catered to an urban locality near an irrigation area. High losses in this feeder were stated to be due to illegal connection of IP sets to the urban feeder. Since energy consumption by IP sets is not recorded in the energy audit reports of the urban feeder, it led to high losses. It is, therefore, necessary to have effective energy audits and better administrative control for accurate measurement and reduction of losses in urban feeders.

4.2 Industrial feeders

In FY18, the industrial consumption supplied by all DISCOMs in Karnataka was 18% of the total consumption (9,205 MU/50,933 MU). The revenue generated from the industrial consumers category is second highest at 23% of the total revenue generated (INR 7,919 crore/INR 34,184 crore). Since industrial consumers are high-paying consumers, it is critical that the power supplied to this category is billed accurately and revenue collected promptly. To enable DISCOMs to cover their costs in supplying power to the consumers, KERC had hiked tariff by 15–30 paisa for the industrial consumers in FY19. In this context, it becomes extremely important for DISCOMs to have last-mile accountability of the energy supplied to these consumers.

The industrial feeders supply power predominantly to small- and large-scale industrial units. To understand the issues related to billing, collection, and power supply in an industrial feeder, we surveyed five industrial feeders in the areas of CESC and BESCOM, with 95 consumers connected to the five feeders. The annual energy input for the last three years has been consistent in the range 45 MU–48 MU. However, the AT&C loss figures, as reported by DISCOMs, for these feeders fluctuated unusually from an average 39.5% in FY17–18 to 7% in FY19. It is evident from the inconsistent pattern of losses that there are issues related to loss calculation resulting from deviations in data entry and technical faults in the feeders, which were not recorded in the audit reports as per the format. For instance, the Kleane pack feeder losses reduced from 6% in FY16–17 to 1% in FY18–19. The feeder showed 6% losses in FY16–17 because of data entry and calculation errors in the energy audit reports, when it would otherwise have losses close to the permissible value of 1%. This is because the Kleane pack feeder caters to only three consumers with efficient network planning and use of HT cables. The Balaji Malt feeder caters to only one industrial consumer, and the losses were in the range 12%–14%. We found that the use of low-capacity conductors in the feeder and 15-km feeder length was resulting in high losses. On the basis of CSTEP's recommendations, the officials shifted the load to a nearby substation, which reduced the losses to <1%. Similarly, in the Balaji feeder, the losses reduced from 17% in FY16–17 to 1% in FY18–19. This is because a few water supply installations and IP sets were connected to the feeder. The officials bifurcated the feeder to convert it into a dedicated industrial feeder, and this resulted in reduced losses of 1% in FY18–19. The data entry and calculation errors in the energy audit reports of the KB park feeder in the BESCOM area resulted in high abnormal losses of 142% and 153% in FY16–17 and FY17–18, respectively. The analysis revealed that owing to cable fault in the KB park feeder, energy was imported from another feeder to cater to its consumers. However, the energy import did not reflect in the energy audit reports, resulting in erroneous reporting of losses. To identify challenges in industrial feeders and to understand their impact on the overall calculation of T&D losses in a feeder, we discuss the issues in the context of a representative feeder from the five selected industrial feeders.

Feeder 19

An industrial feeder in the BESCOM area, F08-KIADB Hanagawadi originates from 66/11 KV Harihara MUSS and supplies power to an industrial park. Table 9 shows a brief profile of this feeder. Six HT and 24 LT industries are connected to the feeder. The remaining 24 LT connections belong to categories such as domestic, commercial, water supply, street light, and temporary supply (Figure 3).

Table 9: F08-KIADB Hanagawadi feeder profile

Feeder name	No. of DTs	Feeder length (km)	No. of consumers			T&D loss (%) FY19
			Industrial		Other	
			HT	LT	LT	
F-08 KIADB Hanagawadi	29	5.5	6	24	24	5.1

(Source: Feeder-level data as obtained from BESCOM, CSTEP Survey)

Category-wise trend

The total consumption in this feeder was 2.3 MU for the period Jan–Jun 2019. The HT and LT industries constituted 99% of the total consumption (HT: 89.2% and LT: 9.8%). The remaining 1% was shared amongst LT-3 (0.1%), LT-2 (0.1%), and LT-6 (0.8%) consumer categories (Figure 4). The industrial category, being the high-paying consumer category, had the largest revenue share for this feeder. Of the total INR 223 lakh of revenue for this feeder, industrial consumers alone accounted for INR 221 lakh.

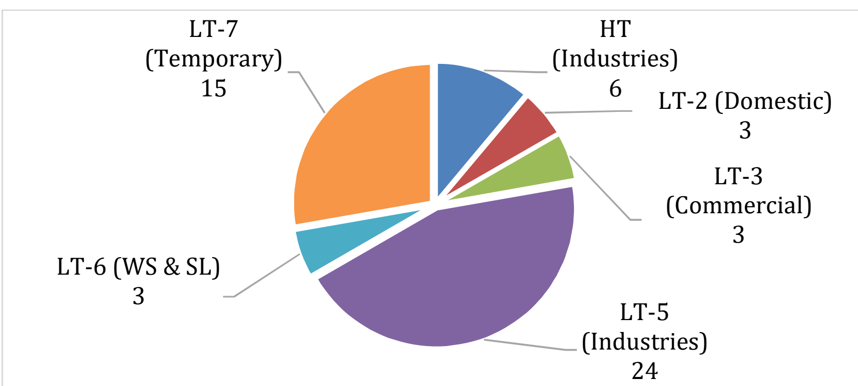


Figure 3: Category-wise consumers for Hanganwadi industrial feeder in FY19

(Source: Category-wise consumer data as obtained from BESCOM)

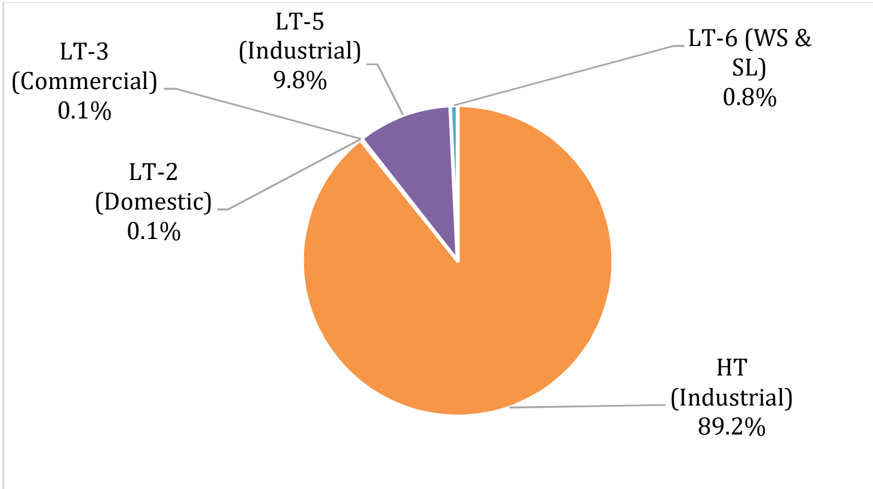


Figure 4: Category-wise consumption for Hanganwadi industrial feeder in FY19 (%)

(Source: Category-wise billing data as obtained from BESCOM, CSTEP Analysis)

Loss trend analysis

The losses in an industrial feeder should generally be less than 5%, since it caters to the consumers connected through HT lines with the feeder emanating close to the load centres.

As per DISCOM data, the T&D loss for the KIADB feeder for the period Jan–Jun 2019 was 13%, with energy input equalling 14,62,200 kWh and billed consumption equalling 12,58,628 kWh. However, the feeder meter readings recorded by the CSTEP team showed the feeder energy input to be 22, 04,200 kWh. Discussions with DISCOM officials and verification by the CSTEP team revealed that this feeder was exporting energy to a nearby NJY feeder that was undergoing maintenance. However, the quantum of energy exported was not known as there were no boundary meters connected between the two feeders. Therefore, the feeder loss of 13% was calculated using the estimated exported energy figures (Table 10).

Table 10: T&D loss calculation based on estimated energy export

Feeder energy input (Jan–Jun 2019)	Energy exported (Jan–Jun 2019)	Net energy input (Jan–Jun 2019)	Billed consumption (Jan–Jun 2019)	T&D loss (Jan–Jun 2019)
22,04,200	7,42,000	14,62,200	12,58,628	13%

(Source: Feeder input as obtained from BESCOM, CSTEP Survey and Analysis)

Since the accurate quantum of energy exported was not known, the loss calculated using the feeder energy input would have been an assumed figure. Therefore, we recorded DT meter readings of all the 29 DTs and collected billed consumption data to calculate the loss levels. We calculated the losses as 1.1% (Table 11), with supply recorded at the DT level as 12, 72,313 kWh and billed consumption as 12, 58,628 kWh. The lower loss figure is because of DTs being located close to the load centres with minimal secondary network lines (Figure 5). Considering additional 4% losses from feeder-to-DT, the total losses in the Hanganwadi industrial feeder amounted to 5.1%, which is within the permissible limit.

Table 11: T&D loss from DTs to consumers

DT consumption energy input (CSTEP)	Billed consumption	T&D loss (CSTEP)
12,72,313	12,58,628	1.1%

(Source: Billed consumption as obtained from BESCOM, CSTEP Survey and Analysis)

To accurately ascertain the feeder-to-consumer losses, boundary meters are required to be installed where supply from more than one feeder is given to any area, so that the accurate amount of energy exported is known.

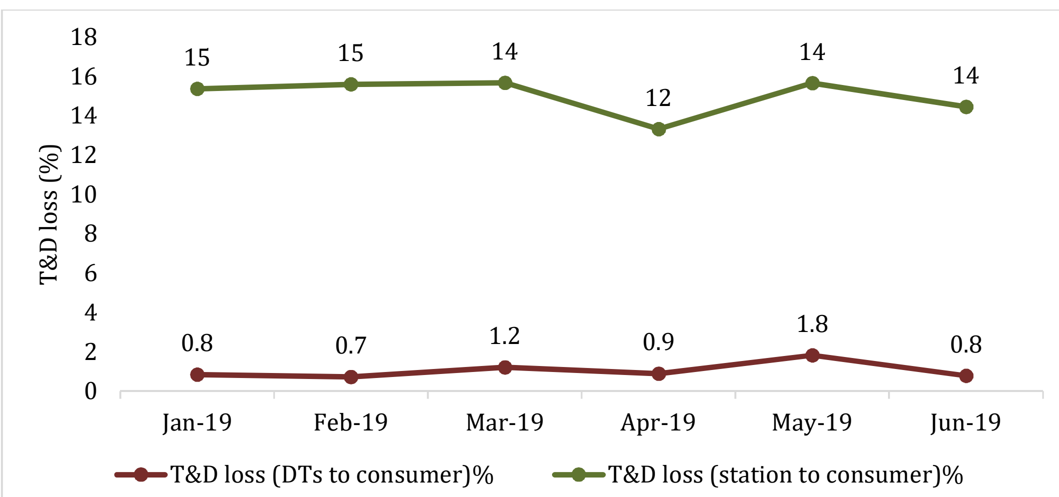


Figure 5: FO8-KIADB Hanagawadi loss trend

(Source: CSTEP Survey and Analysis)

It is evident that data entry errors and lack of boundary meters resulted in higher (assumed) losses for several industrial feeders.

4.3 NJY feeder

Niranthara Jyothi Yojana (NJY) was initiated by the Government of Karnataka in October 2010. The objective of the scheme was to provide 24-hour, 3-phase power supply to non-agricultural loads (domestic, commercial, water supply, street light, rural industries, milk dairies, etc.) in rural areas, by segregating the agricultural loads. Thus, an NJY feeder serves a mix of residential and commercial consumers in rural areas. We surveyed nine NJY feeders (Table 4) catering to a load of around 19,000 consumers in various areas of Hassan, Chamarajanagara, Mysuru, and Bangalore Rural districts covering both CESC and BESCOM areas. Over the last three years, the feeders received energy input in the range 15 MU–20 MU. The average losses for the nine feeders were in the range 38%–43% as reported by DISCOMs for the three years. Some of the reasons for high losses in NJY feeders are unauthorised connection of IP sets, theft, inconsistent billing, and data entry errors. We discuss the reasons for high losses for one representative feeder.

Feeder 6

Malali NJY is an NJY feeder emanating from 66/11 KV Malali MUSS in Hassan district of the CESC area. The feeder caters to the load of nine villages in Hariharapura. Table 12 presents a brief profile of the Malali NJY feeder as per the data verified by CSTEP.

Table 12: Brief profile of Malali NJY feeder

Feeder Name	No. of DTs	Feeder length (km)	No. of Consumers	T&D loss in FY19 (%)
Malali NJY	42	30	1,501	32.7

(Source: Feeder-level data as obtained from CESC, CSTEP Survey)

Category-wise trend

The feeder has a total of 1,501 consumers connected to it (Table 13). The highest share is that of residential consumers (92%), followed by LT6-WS & SL (3%) and LT3-commercial (3%). The remaining 2% is shared between LT5-industrial and LT7-temporary. The category-wise consumption in this feeder varies with the number of consumers connected, with the domestic category consuming the highest share of 51%. Two categories—namely, domestic and LT-6 (WS and SL)—account for 80% of the revenue share for this feeder.

Table 13: Category-wise consumer number, consumption, and demand for NJY Malali feeder

Tariff	Total consumers		Annual consumption (FY19)		Annual demand (FY19)	
	No.	%	MU	%	INR lakh	%
LT1 (BJ/KJ) (domestic)	715	92	0.16	51	10.7	46
LT2 (domestic)	671		0.16		10.1	
LT3 (commercial)	52	3	0.06	10	6.0	13
LT5 (industrial)	9	1	0.02	3	2.1	5
LT6 (water supply and street light)	48	3	0.23	37	15.7	34

LT7 (temporary installation)	6	1	0.01	2	0.8	2
Total	1,501	100	0.63	100	45.4	100

(Source: Feeder- and category-wise demand collection and billing data as obtained from CESC, CSTEP Analysis)

We observed sudden spikes in the month-on-month consumption figures for water supply and street light installations, resulting in abnormal T&D loss calculations for the feeder. Figure 6 shows the month-on-month consumption for all consumer categories connected to this feeder. As seen in the figure, LT6 has the most inconsistent pattern of billing. In September 2018, the billing is done for 34,998 kWh, while in November 2018, it is done for 11,507 kWh.

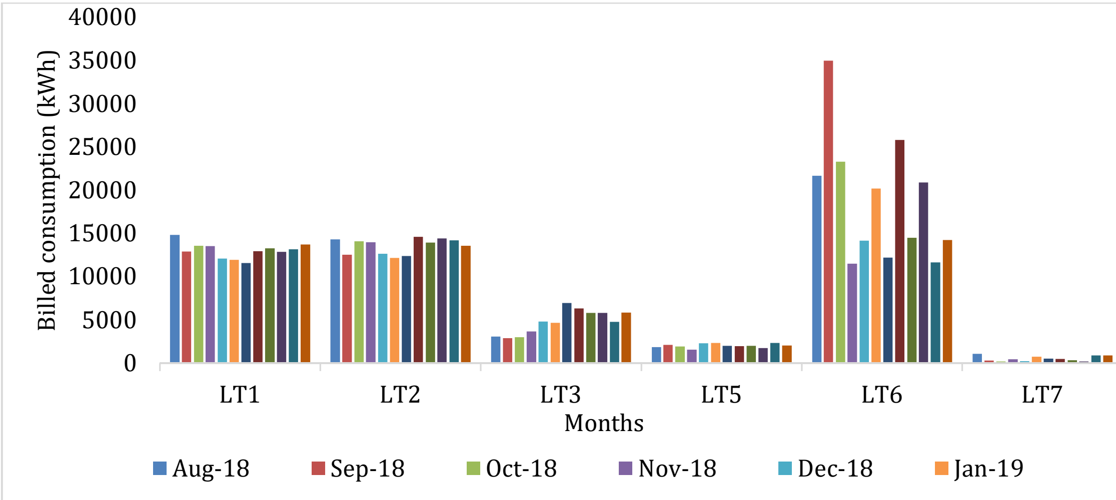


Figure 6: Category-wise month-on-month consumption for NJY feeder

(Source: CSTEP Survey and Analysis)

Loss trend analysis

We analysed month-on-month T&D loss trends for this feeder. Figure 7 depicts the T&D losses of the Malali NJY feeder from feeder to DT (as computed by CSTEP) and feeder to consumer (based on data provided by the DISCOM).

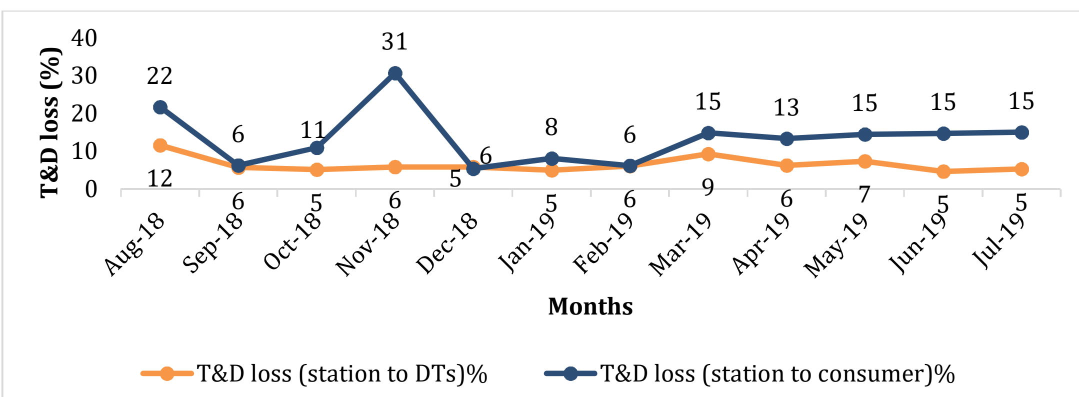


Figure 7: Malali NJY loss trend

(Source: CSTEP Survey and Analysis)

We could not find any record of DT meter readings with the DISCOM officials for this feeder although meters were installed for all the DTs. Therefore, for the purpose of T&D loss analysis, we recorded meter readings at the substation and for all the DTs connected to the feeder from August 2018 to July 2019. From the readings recorded by CSTEP, the feeder-to-DT loss was found to be 6% in all the 12 months except in August 2018 and March 2019 when the loss was 12% and 9%, respectively. In August 2018, a meter replacement drive was carried out by DISCOM because of which we could not record meter readings of 11 DTs. In March 2019, two meters were found faulty and readings were not available for calculating the feeder-to-DT loss. Our calculation of losses for the period September 2018 to July 2019 is given below:

$$\text{Feeder energy input (Sep 2018 to July 2019)} \ = \ 8,672{,}00 \text{ kWh}$$

$$\text{Energy input from all DTs (Sep 2018 to July 2019)} \ = \ 8,142{,}55 \text{ kWh}$$

$$\text{Feeder} - \text{ DT loss (kWh)} = (8,67{,}200 - 8,14{,}255) \ = \ 52{,}946 \text{ kWh}$$

$$\mathbf{Feeder - DT\ loss}\ (\%) \ = \ \mathbf{52,946/8,672,00} \ = \ \mathbf{6}\%$$

Hence, the total technical losses for this feeder amounted to 10% (93,970 kWh) (6% feeder-to-DT loss and 4% secondary line loss, as explained earlier).

As per the data recorded by the CSTEP team, the average feeder-to-consumer loss, as calculated by CSTEP, was 32.7% (3, 07,379 kWh) for FY18–19.

$$\text{Feeder energy input (Aug 2018 to July 2019)} \ = \ 9{,}39{,}700 \text{ kWh}$$

$$\text{Billed Consumption (Aug 2018 to July 2019)} = \ 6{,}32{,}321 \text{ kWh}$$

$$\mathbf{Feeder - consumer\ loss}\ (\%) \ = \ (\mathbf{9,39,700 - 6,32,321})/\mathbf{9,39,700} \ = \ \mathbf{32.7}\%$$

However, DISCOM data showed the losses as 13.6% because of the assessed consumption added to the metered consumption. This assessed consumption included the estimated/assumed consumption by unmetered/unauthorised installations (the number of which is not recorded by DISCOM) served by the feeder. During our field visits, we found that in six instances, IP sets were illegally connected to the Malali feeder for drawing power. Since the IP sets were unmetered and the number of IP sets with an illegal connection was not determined, the officials were unable to estimate the accurate consumption by the IP sets. Therefore, they added it as assessed energy under the feeder.

$$\text{Feeder energy input (Aug 2018 to July 2019)} \ = \ 9{,}39{,}700 \text{ kWh}$$

$$\text{Billed Consumption (Aug 2018 to July 2019)} = \ 6{,}32{,}321 \text{ kWh}$$

$$\text{Assessed Consumption (Aug 2018 to July 2019)} = \ 1{,}79{,}300 \text{ kWh}$$

$$\mathbf{Feeder - consumer\ loss}\ (\%) \ = \ (\mathbf{9,39,700 - 8,11,621})/\mathbf{9,39,700} \ = \ \mathbf{13.6}\%$$

The assessed consumption was 22% of the total consumption, which is very high considering that all the consumers other than the illegal IP sets were metered.

Further, we observed huge variations in month-on-month feeder-to-consumer loss figures, as shown in Figure 7. Following are some of the observations made on the variations in the DISCOM and CSTEP loss data:

a) *Inconsistent billing*: During our survey, we found month-on-month variations in the billing data for all consumer categories for this feeder, especially LT-6 installations. For instance, in September 2018, the total consumption of LT-6 installations was 34,998 kWh, while it reduced to 11,507 kWh in November 2018. The DISCOM officials could not provide any explanation for the inconsistencies in the billing pattern. A lack of ownership and accountability for billing the consumers was apparent in such cases. The feeder had 48 LT-6 installations, accounting for 36% of the total revenue (without arrears) for the feeder. The CSTEP team spot-checked all the 48 installations in June 2019 (close to the date of GVP reading them) to identify the deviations in meter readings. Of the 48 installations, we observed deviations in 15 installations (Table 14) where GVP had recorded either lower or higher readings. For one installation, there was no meter connected but GVP estimated the consumption on an average basis and billed as such. Such deviations resulted in ineffective energy audit and revenue loss for the DISCOM.

Table 14: Spot-checking of LT6 installation in Malali feeder

RR no.	Reading (GVP) (units)	Reading (CSTEP) (units)
C14	19,099	16,593
C15	4,966	26,617.9
C16	10,260	16,351
C17	3,245	3,458.5
C18	4,769	6,223.3
C19	5,878	5,918
C20	5,766	6,217
C21	12,980	13,125
C22	48,156	49,035
C23	47,973	48,540
C24	1,200	2,073
C25	198	1,359.3
C26	2,650	2,768
C27	444	660.7
C28	47,131	No meter

(Source: Consumer billing data as obtained from CESC, CSTEP Survey)

b) *Data entry and calculation error*: During our survey, we analysed the energy audit reports for this feeder. We found data mismatch between the readings recorded by CSTEP (from the substation meters and demand collection balance reports) and DISCOM data in the audit report. We recorded the feeder energy input in November 2018 as 80,300 kWh, while the energy audit reports showed the energy input as 77,300 kWh for the same month. Further, the energy consumption recorded by CSTEP was 55,581 kWh, while the audit report showed the total consumption as 67,008 kWh. The DISCOM officials explained the discrepancy as a data entry error. Since this “error” reduced the losses from 31% to 13%, no validation of the data appears to have been conducted (Table 15).

Table 15: DISCOM and CSTEP calculation of T&D loss in NJY feeder

DISCOM calculation	CSTEP calculation
Feeder energy input (Nov 2018) = 77,300 kWh	Feeder energy input (Nov 2018) = 80,300 kWh
Total consumption (Nov 2018)= 67,008 kWh	Total consumption (Nov 2018)= 55,581 kWh
T&D loss = (77,300 - 67,008)/77,300 = 13%	T&D loss = (80,300 - 55,581)/80,300 = 31%

(Source: Feeder-level data as obtained from CESC, CSTEP Analysis)

During the billing of consumers, meter readers usually come across cases of faulty meters and unmetered installations. In such situations, the officials estimate the energy consumed by these consumers. This is shown as "assessed energy" in the energy audit reports. The total energy consumed is the sum of metered sales and assessed sales. While analysing the feeder audit report, we found that the assessed energy was very high—22% of the total sales. However, the billing report showed all the 1,501 installations as metered and there was no mention of any IP set connections in the billing report. ***In the absence of any definite number of unmetered installations, there was no basis for accepting the assessed energy as 22% of the total energy sales. Moreover, there was no verifiable basis for knowing as to where the revenue from this assessed energy was being accounted.***

c) *Unauthorised connection of IP sets*: The idea of the NJY scheme was to segregate agricultural load from non-agricultural load to provide 24-hour uninterrupted power supply to non-agricultural loads and 6–8 hours of supply to agricultural load. However, to realise such uninterrupted power supply, IP sets should be hooked to the LT lines in the NJY feeder. However, we noticed six instances where IP sets were connected to this NJY feeder. This energy consumption by unauthorised IP sets was unaccounted for and resulted in skewed loss calculation for the feeder as the DISCOM added such consumption under assessed energy.

d) *Theft*: We visited the feeder 16 times during the survey period. During these visits, the team witnessed theft in 12 instances where one–two domestic installations would be involved in meter tampering or illegal tapping/hooking to LT lines.

Therefore, although the feeder showed high losses, the DISCOM reported the losses incorrectly. ***The high losses in the feeder are reduced in calculation due to assumed unaccounted energy consumption by IP sets and theft.***

4.4 Agricultural feeders

In FY18, the agriculture sector accounted for 38% of the total electricity consumption in Karnataka KERC, "Tariff Orders 2018.". The sector receives free supply from DISCOMs to meet its irrigation needs. The DISCOMs, in turn, receive subsidy from the state government to recover their cost of supplying free power to this sector for only up to 10 HP motor IP sets. ***However, in practice, most IP sets avail themselves of the subsidy regardless of the motor capacity.*** Since most of the IP sets in Karnataka are unmetered, DISCOMs claim subsidy from the government on the basis of estimated consumption by IP sets. The subsidy burden in Karnataka has increased by 85% from INR 4,993 crore in FY13 (Tariff Order 2013) to INR 9,250 crore in FY19 "KERC Tariff Orders 2019.", raising concerns regarding the estimation methods used by DISCOMs. ***Further, the DISCOMs can get twin benefits by showing higher consumption in the agricultural sector—claim higher subsidy from the government and show lower loss levels.*** However, the ballooning of the subsidy burden on the state government, which may be partly masking the operational inefficiencies under estimated agricultural consumption, is not sustainable in the long run. Thus, CSTEP surveyed one agricultural feeder to devise a framework for assessing IP set consumption more realistically.

Feeder 20

F01 Bygadadenahalli is an agricultural feeder originating from 66/11 kV Anekal MUSS in the Chandapura division of the BESCOM area. Table 16 presents a brief profile of the feeder.

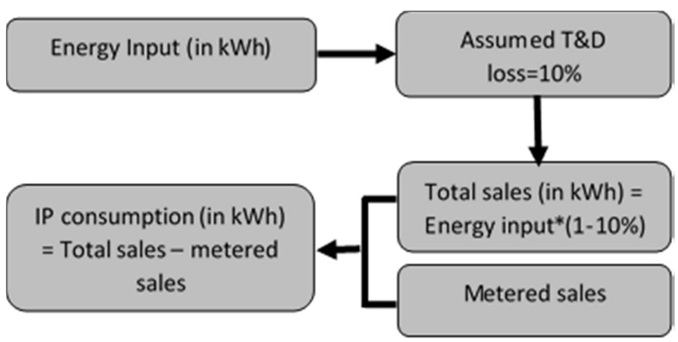
Table 16: F01 Bygadadenahalli feeder profile

Feeder Name	No. of DTs	Feeder length (km)	No. of consumers (IP sets)	T&D loss (%)
F01 Bygadadenahalli	77	18.75	277	14.7

(Source: Feeder-level data as obtained from BESCOM, CSTEP Survey)

Figure 8 illustrates the methodology adopted by DISCOMs to calculate the total IP set consumption from this feeder. The DISCOMs assume 10% technical losses in the feeder (Tariff Orders 2019), based on which the total sales are computed. In the case of any metered installations connected to the feeder, the metered sales from these consumers are subtracted from the total sales. The difference between the total sales and metered sales is the IP set consumption in the feeder.

Figure 8: DISCOM methodology for calculating IP set consumption



(Source: Stakeholder discussion, BESCOM Tariff Order 2019)

The methodology adopted by DISCOMs does not provide an accurate picture of the IP set consumption in the feeder as it is based on feeder meter readings and assumed losses of 10%. DISCOMs also do not seem to have the accurate number of IP sets connected to each feeder. While the DISCOM data showed 67 DTs and 289 IP sets connected to the Bygadadenahalli feeder, we found 77 DTs and 277 IP sets. Of the 277 IP sets, only 188 were in a working condition. The difference of 101 IP sets connected to the feeder will impact specific consumption as well as the subsidy claim from the government.

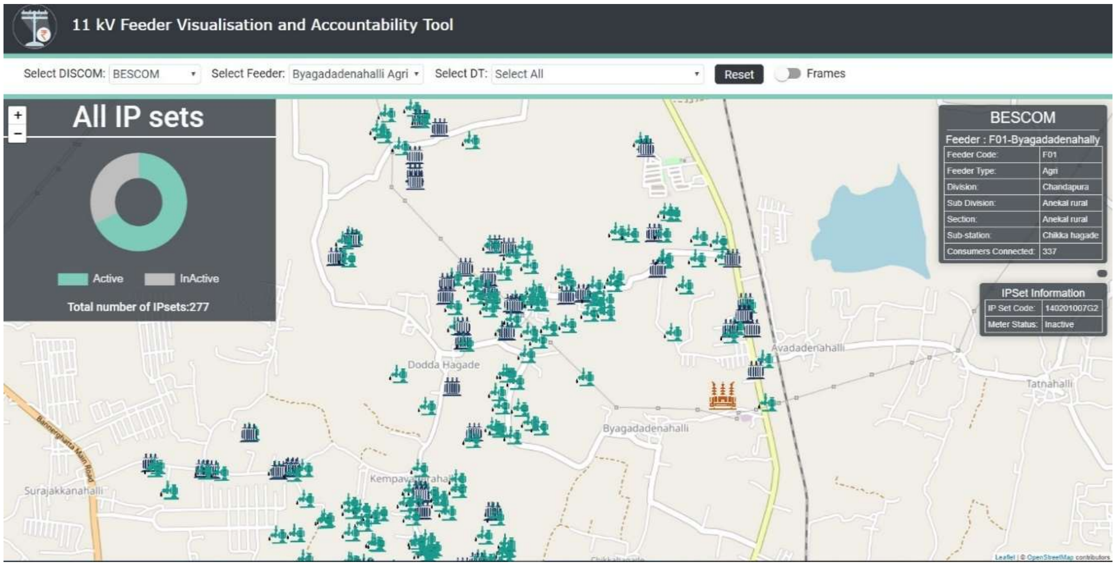


Figure 9: GIS mapping of Anekal feeder

(Source: CSTEP)

KERC has been issuing directives to DISCOMs for conducting energy audits at the distribution transformer centre (DTC)/feeder level for proper assessment of distribution losses and to enable detection and prevention of commercial losses. KERC, in its tariff order of FY19, directed DISCOMs to compute the IP set consumption by deducting the actual losses at each feeder from the meter readings recorded at the 11 kV substation (feeder energy input) and the supply recorded at the DT level. However, DT metering in agricultural feeders is not completed yet. Of the total 77 DTs connected to the feeder, only 25 DTs are metered. Of these 25, only 5 DT meters were in a working condition. These, however, were placed high above the ground and we could not record readings. We tried to take readings through the online platform as the meters could be remotely accessed; however, our analysis showed abnormal results with the online readings including negative losses. In FY19, DISCOMs assumed a normative 10% loss to compute the IP set consumption, without there being any metered DTs. KERC has shown its disagreement with this methodology and mentioned that DISCOMs should consider the actual losses for each of the IP feeders.

In order to calculate the actual losses in the feeder, we simulated the feeder network on a load flow simulation software (ETAP). We considered two scenarios for the simulation

- Scenario 1: Simulate both active and inactive IP sets
- Scenario 2: Simulate only active IP sets

Scenario 1

In the load flow software, we modelled all the loads (i.e., IP sets) connected to the feeder as per the network. We considered a total of 277 IP sets (both active and inactive). Assuming each IP set's capacity as 10 HP[5], the total load amounted to 2,770 HP or 2.03 MW.

$$\text{Load} = 2{,}770 \times 0.746 = 2.03 \text{ MW}$$

[5] This is assumed on the basis that DISCOMs would provide free supply to consumers with less than or equal to 10 HP capacity of IP sets.

We also modelled the line length in the feeder along with its specifications such as resistance and impedance. The conductor type was also modelled as an input in the software. After feeding all the inputs in the software, we ran the simulation. On the basis of the line specifications and added load, the software computed the loss in the feeder as 0.35 MW or 14.7% in percentage terms.

Table 17: T&D loss considering both active and inactive IP sets

Particular	Value
Load (MW)	2.03
Generation (MW)	2.38
Loss (MW)	0.35
T&D loss in % (Loss/Generation × 100)	14.7%

(Source: ETAP results, CSTEP Analysis)

Scenario 2

In the second scenario, we considered only active IP sets. Assuming each IP set capacity as 10 HP, the total load amounted to 1,880 HP or 1.40 MW. We ran the simulation by modifying the load to 1.4 MW but keeping all other specification same as in the first scenario, and found feeder losses to be 12%.

Table 18: T&D loss considering only active IP sets

Particular	Value
Load (MW)	1.42
Generation (MW)	1.62
Loss (MW)	0.20
T&D loss in % (Loss/Generation × 100)	12%

(Source: ETAP results, CSTEP Analysis)

Taking the number of active IP sets to be 188, the specific consumption/IP/annum of each IP set is

$$\text{Specific consumption per IP per year} = \left(\frac{2{,}06{,}448}{188}\right) \times 12 = 13{,}177 \text{ units}$$

The specific consumption per IP set per annum taking into account 188 active IP sets amounts to around 13,177 units/IP set/annum as against 7,324 units/IP/annum approved by KERC in FY 2018 for BESCOM. It shows that pump capacity is more than 10 HP, but subsidy is allowed only for 10 HP.

Underestimation of losses on agriculture feeders significantly inflates the assessment of consumption by IP sets, leading to higher subsidy claims from the government. Table 19 shows wide variations in DISCOMs' and CSTEP's calculations of T&D losses and subsidy claim for the Bygadadenahalli feeder. If this subsidy claim is extrapolated to all the 25 lakh IP sets in Karnataka, the state government would be able to save around INR 645 crore of subsidy per annum in Scenario 1 and INR 404 crore in Scenario 2. The subsidy claim for 25 lakh IP sets is calculated on the basis of the average commission determined tariff (CDT) KERC, "20th Annual Report of Karnataka Electricity Regulatory Commission" for all the DISCOMs in Karnataka (Annexure 4).

Table 19: Subsidy savings for agriculture feeder

Particular	Unit	DISCOM	CSTEP (Scenario 1)	CSTEP (Scenario 2)
Energy input (X)	kWh	2,34,600	2,34,600	2,34,600
Total IP set	No's	289	277	188
T&D loss (L)	%	10%	14.7%	12%
Total sales (P) = X × (1 - L %)	kWh	2,11,140	2,00,114	2,06,448
Average CDT	INR/unit	5.4	5.4	5.4
Subsidy claim	INR/month	1,140,156	1,080,616	1,114,819
Subsidy savings in select feeder	INR	-	714,485	304,042
Annual subsidy savings for 25 lakh IP sets	INR crore	-	645	404

(Source: Feeder input as obtained from BESCOM, CSTEP Survey and Analysis)

5. Suggested measures to reduce losses

From our survey of 20 feeders in CESC and BESCOM areas (Annexure 3), we found that the distribution sector in Karnataka has several positive aspects that would enable DISCOMs to reduce their AT&C losses. These are (1) most of the DTs and consumers are metered, (2) most categories of consumers pay their bills promptly, (3) very few instances of theft/hooking take place, and (4) a system is in place to compile data on energy input and energy consumed. With a few additional improvements in the system, Karnataka could achieve AT&C losses of less than 10% at the DISCOM level. Integration of technology to reduce manual interventions and a more stringent administrative control could help in enhancing the DISCOMs' performance by reducing the AT&C losses. In light of the problems identified in this study, the following implementable measures are suggested for reducing losses within a comparatively short period of about a few months.

1. **Feeder-wise Revenue Accounting and Monitoring of Energy Sales (FRAMES):** The CSTEP survey revealed that in order to show the losses as being lower than actual, the officials tend to introduce an element of "assessed" energy consumption for unmetered installations. To prevent officials from incorrectly estimating the energy consumption, we recommend that Feeder-wise Revenue Accounting and Monitoring of Energy Sales (FRAMES), a framework developed by CSTEP, should be used to monitor the revenue and energy sales at the feeder level. FRAMES seeks to enforce revenue accountability at the feeder level. In this framework, feeder-wise target revenue and energy sales are determined and DT-wise energy supply and consumption are monitored every month. Since the target revenue is calculated on the basis of energy input and tariff applicable to the consumers connected to the feeder, the field staff will not be able to calculate losses on the basis of assessed energy. DISCOMs should designate field officials at the level of AE/JE as Feeder Managers with sales and revenue accountability for specific feeders. The Feeder Manager should be held responsible and accountable for any deviation between target and actual revenue and sales, as well as for monitoring energy input and

consumption at each DT level. FRAMES would help Feeder Managers to introduce a system of random checking of consumer meter readings to monitor non-payment/delayed payment by consumers, which could help in improving collection efficiency. FRAMES can help each Feeder Manager in improving the operational and commercial accountability of the DISCOM at the level of each feeder. Thus, with the implementation of FRAMES, it is estimated to reduce the losses around 4–5%, where losses are more than 15% at feeder level and around 3% for feeders with losses less than 15%. Overall, this would help Karnataka DISCOMs to reduce an average of 2% losses at state level with increase in energy sales of 1,077 MU and financial implications of 700 crore per annum.

2. **Computing accurate IP set consumption through agricultural feeder mapping:** DISCOM officials consider 10% as the normative T&D losses in agricultural feeders to assess the IP set consumption. This is because DISCOMs do not monitor the number of active/working IP sets connected to a feeder. Since the government pays subsidy to DISCOMs for the power supplied to IP sets, DISCOMs assume normative losses, resulting in overstated IP set consumption and higher subsidy claim from the government. As revealed by CSTEP analysis, the actual T&D losses in IP feeders are significantly higher than the normative losses. Moreover, consumption by pumps of capacities higher than 10 HP is also included in the subsidy claim. Agricultural feeders (or IP feeders) should be mapped by conducting field surveys tracing the 11 kV line and geo-locating the DTs and IP sets for obtaining a visual representation of the feeder and associated DTs, and IP sets. This would avoid any estimation on the number of IP sets connected to each feeder and DT. Once the IP feeder is mapped and DT meter readings are recorded, the data could be used to compute the technical losses in the feeder. This could be further used for accurate assessment of IP set consumption on the basis of computed T&D losses. In the long run, it would be necessary to install meters for all IP sets and other consumers even if the supply is free, so that the subsidy payment from the government is more accurately determined. *Additionally, no IP set connection should be allowed in* **non-agricultural feeders.** If for any reason, the connection has to be allowed, it should be metered for accurate energy accounting and monitoring.

3. **GIS-based energy audit:** An effective energy audit requires various prerequisites such as 100% metering of feeders, DTs, and consumers, as well as accurate tagging of feeder to DTs and DTs to consumers. During this study, we identified incorrect tagging of DTs and consumers in all the selected feeders. We found that although DTs were physically connected to one feeder, the accounting (i.e., billing and collection) was done with another feeder. Additionally, inaccurate recording of the consumer meters by GVPs significantly contributes to commercial losses in the distribution network. The survey also revealed the poor status of DT metering and associated infrastructure. Although DISCOMs have installed new DT meters for remote monitoring of DTs' energy consumption, there were no records of DT-wise energy consumption data. In addition to resulting in inaccurate calculation, this creates loopholes in the entire energy audit process and leaves room for data manipulation. To bridge these data gaps, DISCOMs should make use of a GIS-based energy audit platform. The electrical network laid over a visualisation platform is useful not only for the management of assets but also for mapping consumers to conduct robust energy auditing and efficient network planning. Further, the comparison of feeder-to-DT input with consumer billing on a monthly basis will help in identifying abnormal technical losses in the feeder. Moreover, the tool would facilitate DT-wise energy audits by ensuring DT-wise consumer mapping and metering.

The GIS-based energy audit tool would become a centralised energy auditing portal that can bring all the feeders (urban and rural areas) under one platform. This would make it convenient for the officials to track the loss-making feeders and would also help in mitigating the issues arising from the use of different energy audit portals for rural and urban areas.

4. **Closer verification of GVPs billing:** Inaccurate recording of the consumer meters by GVPs significantly contributes to commercial losses in the distribution network. Therefore, DISCOMs need to ensure closer supervision/cross-verification of GVP billing by supervisory staff to ensure a correct billing.

6. Conclusion

Most of the DISCOMs in India face the challenge of high AT&C loss, thus, suggested measures in this study could be applicable in all the DISCOMs in the country. With the varying condition of each state's distribution sector, the measures could be modified to align with the requirements of each state's DISCOM. The measures suggested above can help in reducing the AT&C losses to nearly 10%, with DISCOMs taking steps in the long run to strengthen the distribution network by adopting measures such as high-voltage distribution system (HVDS) for urban areas and agricultural pump sets, installation of smart meters at DTs and for large consumers, prepaid meters for low-density consumption categories such as rural residential consumers, etc. Above all, DISCOMs need to introduce a strong system of monitoring supply at the DT and feeder levels on a daily basis to correlate it with the billed consumption and revenue. This will involve some changes in the structure of the field-level organisations of DISCOMs and appropriate training programmes for the field-level staff to ensure better commercial accountability. On the whole, DISCOMs can meet the challenges facing them in reducing AT&C losses if they devise and implement a well-thought-out strategy.

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8. Annexures

Annexure 1: Progress against UDAY targets as per UDAY portal in CESC and BESCOM

Initiative	CESC dashboard (as of Dec 2019)		
	Target	Progress	(%)
AT&C losses (%)	15	11.52	-
Feeder metering (urban)	442	442	100
Feeder metering (rural)	1000	1000	100
DT metering (urban)	20213	15999	79
DT metering (rural)	34361	28100	82
Smart metering above 500 kWh	0	610	100
Smart metering above 200 and up to 500 kWh	0	1876	100
Feeder segregation	427	408	96
Rural feeder audit	1000	1000	100
Initiative	**BESCOM dashboard (as of Dec 2019)**		
	Target	**Progress**	**(%)**
AT&C losses	15	16.24	-
Feeder metering (urban)	1585	1585	100
Feeder metering (rural)	2877	2877	100
DT metering (urban)	44162	49863	100
DT metering (rural)	66263	40918	62
Smart metering above 500 kWh	NA	NA	0
Smart metering above 200 and up to 500 kWh	NA	NA	0
Feeder segregation	932	966	100
Rural feeder audit	2877	2877	100

(Source: UDAY Portal)

Annexure 2: Data entry error in urban feeders of CESC

Month	DISCOM reading (MU)	CSTEP reading (MU)	Difference (MU)	Difference (%)
Vidyuth Nagar				
Jul 18	0.1	0.356	-0.26	-73
Aug 18	0.09	0.342	-0.26	-76
Sep 18	0.09	0.3866	-0.29	-75
Oct 18	0.11	0.365	-0.26	-71
Nov 18	0.10	0.4106	-0.31	-75
Dec 18	0.13	0.4262	-0.30	-70
Jan 19	0.43	0.4164	0.01	2
Feb 19	0.15	0.3684	-0.22	-60
Mar 19	0.13	0.4468	-0.32	-72
Apr 19	0.44	0.4436	0.00	0
May 19	0.44	0.4356	0.00	0
Jun 19	0.38	0.3802	0.00	0
Total	2.6	4.8	2.2	46
Halli Mysore				
Jul 18	0.080	0.087	-0.01	-11
Aug 18	0.077	0.087	-0.01	-11
Sep 18	0.09	0.090	0.00	0
Oct 18	0.09	0.09	0.00	0
Nov 18	0.08	0.093	-0.01	-11
Dec 18	0.07	0.096	-0.02	-21
Jan 19	0.10	0.09	0.00	0
Feb 19	0.08	0.095	-0.01	-11
Mar 19	0.09	0.111	-0.02	-18
Apr 19	0.10	0.101	0.00	0
May 19	0.10	0.101	0.00	0
Jun 19	0.09	0.093	0.00	0
Total	1.1	1.1	0.1	9

(Source: Data obtained by CESC and BESCOM, CSTEP Survey)

Annexure 3: CSTEP survey readings of selected feeders

Feeder type	Feeder	Survey period	Energy input (MU)	DTs' consumption (MU)	Total consumption (MU)
CESC					
Urban	Halli Mysore	Aug 18–Jul 19	1.15	1.07	1.01
	Vidyuth Nagar	Jan 19–May 19	2.11	1.28	1.42
	KM Doddi	Jan 19–Jun 19	4.56	2.37	2.77
NJY	Malali NJY	Aug 18–Jul 19	0.94	0.88	0.82
	Gundegala NJY	Jul 18–Mar 19	1.19	0.97	0.79
	Thatanahalli NJY	Aug 18–Jul 19	0.81	0.54	0.47
	Mavathur NJY	Jul 18–May 19	2.89	0.00	2.42
Industrial	Balaji Ind	Jul 18–Jun 19	5.85	5.83	5.83
	Balaji Malt	Jul 18–Jun 20	14.73	13.25	13.25
	Kleane Pack	Jul 18–Jun 21	16.89	16.57	16.57
BESCOM					
Urban	Hanumanthappa	Jan19–Jun 19	7.43	3.07	6.96
	Kanteerava	Jan19–Jun 19	1.57	1.46	2.26
NJY	Beedikeri	Jan19–Jun 19	0.93	0.23	0.79
	Kittaganahalli	Jan19–Jun 19	1.70	0.14	1.40
	AB Hatti	Jan19–Jun 19	3.12	0.08	0.68
	Kalvamanjali	Jan19–Jun 19	2.05	0.16	1.76
	Haralipura	Jan19–Jun 19	0.94	0.35	0.80
Industrial	KB Park	Jan19–Jun 19	4.40	6.18	4.25
	KIADB-Hanagawadi	Jan19–Jun 19	1.46	1.36	1.43
Agricultural	Byagadadenahalli	Jan19–Jun 19	1.11	0.05	0.96

(Source: CSTEP Survey and Analysis)

Annexure 4: Commission-determined tariff (FY 19)

DISCOM	**Commission-determined tariff, CDT (INR/kWh)**
BESCOM	3.7
MESCOM	5.31
CESC	5.5
HESCOM	6.24
GESCOM	5.71
HUKERI RECS	6.05

(Source: KERC Twentieth Annual Report 2018-19)

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