Technical Loss Evaluation in Distribution Feeders

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Abstract: **The first and foremost step needed for minimizing losses is to conduct energy audit to have a realistic assessment of different categories of losses and their probable causes. With the same objective, the study was carried out on an urban feeder and a rural feeder of Gujarat Electricity Board to assess the correct technical losses and from that to estimate the losses in the whole distribution system. This paper deals with a representative methodology for estimating the technical loss in the distribution system and accounting the energy mismatch in the feeder. The results of this study find an application in the system improvement schemes.**

I. INTRODUCTION

Electric power distribution is a vital link between utility and the consumer, thus playing a very important role in the entire power system network. Hence it is imperative to exercise utmost caution in planning the system with losses as low as possible and a better quality supply to the consumers. In the context of chronic power shortage and ever increasing prices of fuel, it assumes greater importance.

Transmission and Distribution (T&D) losses in India are much higher than those in any developed country. The losses can be as high as 35-40% or even more. Out of this Transmission and Distribution losses, the loss in the Distribution sector is very large. There are several reasons for this high amount of losses such as

- Improper planning of the entire distribution system
- Long feeders with very high LT: HT ratio
- Feeders highly loaded and improper conductor configuration
- Commercial losses etc.

There are several reasons for commercial loss and it is a purely non-technical loss consisting of theft, pilferage and billing inaccuracies. Other losses are technical in nature and there is always a scope for system improvement by minimizing these losses. This calls for a detailed study on an actual system to assess the quantum of technical losses and to investigate the root cause behind these losses. Proper evaluation of technical loss is the only way to estimate the commercial loss occurring in the system.

The subject study was carried out under the sponsorship of Gujarat Electricity Regulatory Commission in order to estimate the technical losses in a representative urban feeder and a rural feeder. The study considered urban feeder from Anand City Division and a rural feeder from Bharuch Circle for working out the methodology for evaluation of technical loss occurring in the representative feeder chosen. The objective behind the representative selection was to effectively work out a methodology, which can further be extended to all distribution feeders towards the evaluation of technical losses.

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II. BACKGROUND

This project was taken up on the grounds of the previous study carried out by ERDA on “Study on Metering System in the State of Gujarat” sponsored by Gujarat Electricity Regulatory Commission. The outcome of the study emphasized the importance to be focussed upon the technical parameters of distribution system apart from the metering practices and billing methodologies.

The above mentioned study report was based on the field survey carried out in different zones of GEB. This has pointed out certain sample feeders where losses reported are high in spite of the system improvement schemes worked out by utility. The other category noticed in the survey was that of rural in nature where actual energy accounting is not followed. Hence the above two categories are chosen for further studying on technical parameters. This is based on the fact that the only way to account commercial losses is by segregating the technical losses as the same can be correctly estimated.

Based on the above-explained norms, the feeders chosen are Anand City-2 feeder of Anand city division and Bhadbhut feeder of Bharuch division. In the case of Anand City-2 feeder system improvement schemes were already in progress in spite of which % losses reported was 35% (as per the records of 1999-2000). In the other chosen feeder namely, Bhadbhut feeder, it was noticed that that energy loss maintained in the feeder is a constant figure and also billed energy through metering is only 16% of the total energy.

Hence, the above two feeders are chosen for sample investigation.

III. STUDY METHODOLOGY

A. Technical loss evaluation strategy

Strategy followed in the case of technical loss evaluation is as follows:

1. Detailed Survey at selected Distribution Transformer Centers (DTC) for energy accounting
1. Evaluation of Technical loss (I^2R) for the selected DTC
2. Estimate the Commercial loss from 1 and 2
3. Extrapolate the strategy to other DTCs based on the number of consumers connected (categorywise), length of LT line and capacity of the transformer
4. Calculate the total technical losses due to LT (for the peak time)
5. Estimate the Transformer losses having found out the % loading on the transformer
6. Estimate the HT loss from load flow
7. Addition of 5, 6 and 7 gives total technical loss in the feeder during peak hours
8. Estimate Annual Technical Energy loss from the relation

Annual Energy loss = Peak Power Loss x Loss Load Factor

Loss Load Factor = $0.8 \times LF^2 + 0.2 \times LF$
Load Factor = Actual load/Maximum Load

9. Commercial loss = Total energy sent-(Total energy billed +Technical loss)

The above methodology is applied in the two feeders to estimate the theoretical loss in the feeder. The assessment of technical loss leads to the calculation of commercial loss due to bad metering.

B. Sampling procedure

It is highly appreciated if energy accounting is carried out at all DTCs connected in the feeder. However, the parameter to be focussed upon is the practical feasibility and time span required for the exercise to be completed. In this context, an intelligent sample selection procedure is followed which shall comprise of different factors that are important for general performance study of the chosen feeder. Hence the sampling strategy applied to the DTC was based on

a) Capacity of transformers connected
b) Loading on the transformer and LT length associated with the DTC
c) Consumption level and category of the consumers connected

IV. FEEDER ANALYSIS

Anand City-2 feeder is urban in nature whose recorded details as well as technical parameters are as given in Table-1 and Table-2 respectively.

Table-1 Recorded Information on Anand City-2 Feeder

Data	**Anand City-2**
Division	Anand City
Sub Division	Anand City-2
Sub Station	Anand
Residential	6444
Commercial	3949
Industrial	115
Agriculture	1
Others	71
Total Consumers	10718
Energy Sent	14981973
Energy Billed	11383911
% Loss Reported	24.02%*

* This figure is based on the records of 2000-2001. It is to be noted that due to a concerted meter replacement programme implemented on this feeder, the losses have been reduced from 35% in 1999-2000 to 24% in 2000-2001.

Technical particulars for the feeder is as given below:

Table-2 Technical Particulars for Anand City 2 Feeder

	Rating	Nos
(11 / 0.433) kV Distribution Transformers	25	1
	63	7
	100	30
	200	15
	500	1
	HT	2
Connected Load in KVA		7516
LT / HT Ratio		3.54

Bhadbhut feeder is rural in nature whose recorded details as well as technical parameters are as given in Table-3 and Table-4 respectively.

Table-3 Recorded Information on Bhadbhut Feeder

Data	Bhadbhut Feeder
Division	Bharuch
Sub Division	Bharuch Rural
Sub Station	Nandewar
Residential	2682
Commercial	98
Industrial	7
Agriculture Metered	22
Agriculture Non-metered	6
Total Connected Load in Agriculture (HP)	381
Others	14
Total Number of Consumers	2936
Energy Sent Out (in MUs)	6.98
Metered Energy (in MUs)	1.18*
Ag Assessed (in MUs)	5.02**
Total energy accounted	6.20
% Loss Reported	11.17

* Energy metered in this feeder is only 16.8% of the total energy sent.

** Agriculture assessed units do not match with the connected Agriculture load even under the assumption of continuous supply is given for the connected consumers. Hence Energy accounting records appear to be incorrect.

Table-4 Technical Particulars for Bhadbhut Feeder

(11/0.433) kV DT		Numbers.
	25	0
	63	29
	100	11
	200	3
	500	0
Connected Load KVA		3527
HT Length	Main	24.19
	Tap	26.639
	Total	50.829
LT Length	Total	51.219
LT / HT Ratio		1.007

V. Description on Field Study

A. Load Profile

Loading pattern on the feeder were collected to estimate the duration of peak load, intermediate load and light load and also for normal and holidays.

Measurements at sampled DTCs were carried out during morning peak hours.

Steps taken during energy accounting at DTCs are as follows:

1. LT mapping for the DTC with category wise consumers connected
2. Initiate the energy recording from the DTC with 15 minutes interval current recording

3. Collect initial energy readings from the connected consumers
4. Collect final energy readings from the connected consumers
5. Survey for 3 and 4 activities indicate the meter status and the difference of 4 and 3 gives the energy consumed as recorded by meters.
6. Record the final energy meter reading from the DTC
7. Difference of 6 and 2 gives the total energy sent out from the DTC
8. Calculate I^2R loss after lumping the total connected load at DTC at the centre of gravity of the LT line
9. Difference of 7 and 8 gives sum of energy indicated by the meters and the commercial loss due to illegal usage of energy, bad metering or due to the inherent error in the meters etc.
10. Subtract 5 from 9 to get the commercial loss

Verify the accounting in step 10 through the sampled consumer accuracy check.

LT loss for the rest of the system is estimated based on the category wise consumers connected at DTC and also by taking into consideration of the LT length of the system. Extrapolation strategy worked out is as follows:

a. Collect the no. of consumers connected category wise at each DTC
b. Calculate the total connected load at the DTC based on the sampled transformer centers data
c. Calculate the current corresponding to the connected load which will be the average current
d. For the similar cluster of consumer categories, assume the load pattern is same as that obtained for sampled DTCs
e. Having obtained the load pattern, calculate I2R loss for the same period of time (as the LT length is known)

Average Power loss = Peak Power Loss x Loss Load Factor
Whereas
Loss Load Factor = $0.8xLF^2+0.2xLF$
And Load Factor = Average Load/ Maximum Load
Diversity Factor = Connected load/ Maximum load

B. Voltage regulation

Voltage regulation is estimated through the actual survey findings as well as through the empirical relations. The calculation is based on the concept of equivalent distance

Good voltage regulation is observed in the case of urban feeder because this is a short feeder. Capacitors are already installed in sub-station; i.e. 15 units of 168 KVAR each. However, based on loading on the feeder, it is not recommended to install capacitors for the present loading condition.

In the case of rural feeder, feeder is lightly loaded with operating voltage level of 22 kV. Hence, in that case too, voltage regulation is found to be good.

C. Estimation of Commercial Loss

Estimation of Technical losses makes it possible to evaluate the loss due to commercial factors having known the energy billed. In this study, commercial loss occurring in the system is estimated by extrapolating the results obtained for the sampled transformers.

VI. SUMMARY OF RESULTS

Urban Feeder

Estimated details on distribution losses for urban feeder is reported in Table 5.

Table 5: Technical & Commercial Loss

Energy Accounting	***Energy in MUs***
LT Tech Loss/Year	0.577
T/R Loss/Year	0.297
HT Tech Loss/Year	0.187
Total Technical Loss/Year	1.06
% Tech. Loss/Year	7.08
Commercial Loss	2.50
% Comm. Loss/Year	16.66
Total Loss/Year	3.55
Energy Sent out	14.98
% Loss/Year	23.74*

* This figure is quite close to the recorded information on loss (24.02%) maintained by the division office

Rural Feeder

Summarized details on technical and commercial losses for urban feeder is reported in Table 6.

Table 6: Technical & Commercial Loss

Energy Accounting	Energy in MUs
LT Tech Loss/Year	0.91
T/R Loss/Year	0.13
HT Tech Loss/Year	0.12
Total Technical Loss/Year	1.16
% Tech. Loss/Year	16.55
Commercial Loss	2.35
% Comm. Loss/Year	33.63
Total Loss/Year	3.50
Energy Sent out	6.98
% Loss/Year	50.18*

VII. CONCLUSION

Distribution losses of two representative feeders are estimated and reasons for high % energy mismatches appearing in the feeder are analysed. It is observed that an acceptable LT/HT ratio exists in the two feeders and for the same reason % technical losses and % voltage regulation estimated of the feeder are within the acceptable ranges. However the % energy mismatch estimated in the rural feeder is high which has to be reduced by paying much attention to billing tools.

The approach utilized here can be extended to other radial feeders for theoretical loss estimation and % voltage regulation.

VIII. REFERENCES

1. Turan Gonen, " Electric Power Distribution System Engineering", McGrawHill Book Company