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ELECTRICAL ENERGY LOSS IN RURAL DISTRIBUTION FEEDERS- A CASE STUDY

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ABSTRACT

This paper presents the analysis of electrical energy loss in rural distribution feeders. Eastern Power Distribution Corporation Limited, APEPDCL of Andhra Pradesh State in India has been implementing some methods to reduce technical losses on rural distribution feeders. Statistical Data of two years on 80 rural distribution feeders of Visakhapatnam district has been analyzed and the results were presented. Field survey has been conducted to assess the exact conditions of feeder loading and distribution system configurations. The rural distribution feeders considered predominantly supply the agricultural loads. Month wise cumulative percentage energy loss, power factor, length of line and line capacity were taken into consideration for analysis. Data of some sample feeders was presented. Critical observations were summarized. Suggestions were given for further improvement of efficiency of the system and reduction of losses based on simulation studies carried out.

Keywords: agricultural sector, rural distribution feeders, energy loss.

1. INTRODUCTION

Every element in a power system offers resistance to power flow and consumes some energy while allowing current to flow through it. The cumulative energy consumed by all these elements is termed as Technical Loss. The distribution system in developing countries suffers from the problem of low voltage and high energy loss. The problem of the losses and voltage drop in distribution feeders dependent on each other and varies with the pattern of loading on the feeders. Total transmission and distribution losses are about 40-50%. The major part of the loss is taking place only in distribution sector which accounts for 80-90% of total T&D losses. Cost of power theft is Rs 20,000 Crores / year and the total loss incurred by all State Electricity Boards is Rs 26,000 Crores per year in India.

In India, there are forty power distribution companies in various states and Union Territories supplying power. As on March, 2005 the total transformer capacity of the distribution utilities is 330,829 MVA and total distribution line length of the forty distribution utilities is 6,081,878 km. Total electricity consumption is 381,359.5 Million Unit. To reduce the losses and to improve the system efficiency, a policy has been made [1]. The Policy initiatives for Distribution Reforms are aimed at system up-gradation, loss reduction (aggregate technical and commercial losses), theft control, consumer orientation, commercialization, decentralized distributed generation and supply for rural areas, introducing competition [2]. Power losses of primary distribution system shall be between 3-5%. The maximum limits of voltage variation at the customer premises as per the Indian Electricity Rule are +6% and -9% at high voltage and ±6% at low voltage.

Statistical Data of 80 rural distribution feeders is analyzed for two years from 2006-2008 of Eastern Power distribution corporation Limited (EPDCL). EPDCL caters services to five districts of northern Andhra Pradesh State in India. The analyzed rural feeders belong to one district Visakhapatnam.

2. LOSS REDUCTION TECHNIQUES IMPLEMENTED BY APEPDCL

To reduce distribution losses and also to prevent theft of electrical energy, high voltage distribution systems are implemented in EPDCL. The length of 415V, 3-phase, 4-wire is reduced and 11KV line length is extended up to very nearer to consumer premises. 100KVA and 200 KVA transformers are replaced by lower capacity transformers such as 25KVA, 15 KVA and 10 KVA transformers of 3-phase.

Regular maintenance works, re-organization of feeders and transformers to reduce overloading, replacement of conductors at appropriate places was carried out by APEPDCL.

Preventive maintenance on DTR structures and Low Tension (LT) Lines, rectification of defective air break switches and loose terminations at sub-stations, lines and DTRs, checking proper functioning of capacitors in Commercial / LT Industrial services have been taken up. DTRs are relieved of overloading by providing high capacity DTRs, removal of Idle DTRs, shifting of 11KV Feeder to the nearest available source. Feeders are relieved of overloading by bifurcating/ interlinking of lines on which load is greater than 100 Amps and length of the line is greater than 25 Km.

The works carried out on Power Transformers include setting up of proper tap position of on load tap changer and parallel operation during peak load. To make balancing of loads easier, 3 Phase DTRs provided in place of existing single phase DTRs and replacement of single phase 3 wires with 3 Phase 5 wires, where normal load balancing is unachievable. In-order to improve the voltage regulation, 2nd LT circuit is run for LT Line carrying

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greater than 75 Amp and Length greater than 5 km. The other works carried out include fixing of street light meter box at the 1st location of the DTR, providing 100 sq mm conductor for 11KV urban feeders and 55 sq mm for rural feeders and to ensure one vacuum circuit breaker per feeder.

3. DATA OF RURAL DISTRIBUTION FEEDERS

Cumulative percentage energy loss on different feeders of APEPDCL for different months is presented in Table-1 and Tables 2 [3]. April, 2006 to March, 2007 is considered as one financial year. Cumulative loss means, total of month wise energy loss of that financial year starting from March divided by total input energy supplied to the 11 KV feeder month wise. Feeder wise power factor, regulation, length of trunk line and spur line HT and LT side of 11 KV/ 415 V of the Distribution Transformer have been observed on all the 80 feeders under consideration, the observations are presented in the following section.

Table -1. Cumulative percentage loss on feeders.

11 KV rural feeder	M. Koduru	Madugula Rural	Tharuva	Pedana-ndipalli
Jan 06	14.50	13.67	11.20	14.32
April 06	13.51	12.86	10.71	13.27
Aug 06	9.65	10.43	9.63	11.63
Dec 06	7.93	8.04	7.47	8.93
Feb 07	6.3	7.43	7.14	8.17
April 07	4.50	1.30	4.9	6.35
Aug 07	7.25	5.79	8.3	8.34
Dec 07	11.86	10.72	12.1	12.39
March 08	12.99	12.31	14.1	13.59

Power factors on various 11 KV rural feeders as on April, 2007 and April, 2008 have been compared in Table-3. Length of trunk line and spur line on HT and LT side have been tabulated in Table-4.

Table-2. Cumulative percentage loss on feeders.

11 KV rural feeder	Jutta-da	Venkan-napalem	Jaitava-ram	Thur-uvolu
Jan 06	14.1	14.61	14.62	15.01
April 06	12.25	14.26	12.14	14.4
Aug 06	9.80	9.98	9.53	12.41
Dec 06	8.05	8.82	9.08	8.78
Feb 07	7.07	8.31	8.05	7.5
April 07	5.10	6.98	5.32	5.10
Aug 07	7.69	9.70	19.15	21.41
Dec 07	10.61	10.79	13.17	16.38
March 08	11.36	10.56	13.27	14.88

Table-3. Power factor on various 11 KV rural feeder as on April, 2007 and April,2008.

#	Name of 11 KV feeder	Power factor as on April 2007	Power factor as on April 2008
1	Madugula -Rural	0.82	0.84
2	Seetayyapeta	0.8	0.84
3	Tharuva	0.82	0.81
4	Pedanandipalli	0.85	0.84
5	Juttada	0.82	0.87
6	Venkannapalem	0.81	0.88
7	Jaitavaram	0.85	0.88
8	Thuruvolu	0.78	0.89
9	Lakshmipuram	0.8	0.85
10	VJR peta	0.8	0.86

ARPN Journal of Engineering and Applied Sciences

Table-4. Length of various feeders on LT and HT side of the distribution system in km.

Name of feeder	Length of trunk line on HT side	Length of spur line on HT side	Length of trunk line on LT side	Length of spur line on LT side
M. Koduru	25	27	10	15
Kinthali	30	45	120	83
Tharuva	30	20	120	60
Pedanandipalli	25	25	90.75	50
Juttada	8	27.4	81	161.6
Venkannapalem	7	11.8	31	61.43
Jaitavaram	9	11.3	24	8.5
Thuruvolu	20	21	30	25
Govada rural	3.7	1.4	8.4	6.2
Gavaravaram	8.75	14.9	61.1	121.4
Rajam	10.2	18.4	4	1.9
Chakipalli	10.2	18.4	70.2	139.5

Data of one subdivision is presented in Table-5 as it is not possible to accommodate the data of all subdivisions.

Table-5. Percentage loss at chodavaram sub-division during 2006-07.

#	Month	Percentage loss
1	January 2006	11.68
2	April 2006	9.76
3	August 2006	7.90
4	December 2006	7.13
5	February 2007	6.29

4. OBSERVATIONS MADE

The average power factor on rural feeders during 2006-07 is 0.82125 but, the power factor during 2007-08 is found to improve to an average of 0.853. Regulation data of 2007-08 was not available but, the average regulation during 2007-08 is found to be 5.5%. Studies on 11 KV feeders have revealed that often the rating of DTR is higher than the maximum KVA demand on the feeder. Over rated transformers draw an un-necessary high iron loss. In addition to these iron losses, the capital costs locked up is high.

The meters are not connected on all the distribution transformers. The consumption is estimated on all those transformers on which meters are not connected. This method of estimation may lead to error in estimation of energy loss.

Supply voltage is varied by more than 10% in many distribution feeders. A reduced voltage in case of induction motor resulting in higher currents drawn for the same output.[4] For a Voltage drop of 10%, the full load current drawn by induction motor increase by about 10-15 %, the starting torque decreases by 19% and the line losses in the distributor increases by about 20%. By reducing the length of LT line, and by laying HVDS line, this problem can be effectively solved.

In some LT distribution feeders, it is found that the power factor ranges from 0.70 to 0.75. Low power factor contributes to high distribution losses. [5, 6] For a given load, if the power factor is low, the current drawn is high and consequently, the loss is proportional to square of the current. Capacitors were not connected to all the agricultural pump sets or even if connected are not in working condition.

In Rural areas, 11 KV, 415V lines are extended over long distances to feed loads scattered over large areas. This results in high line resistance and therefore high power losses in the line. The percentage cumulative loss is low on almost all the feeders during February, 2007 but, it is not true for March, 2008. Loss depends on the energy supplied and in turn it depends on rainfall and availability of water in canals. More is the availability of water in canals, lesser is power consumed as the dependency on pumps would be less. There is a chance that percentage of energy loss increases with increase in energy supplied.

5. SUGGESTIONS FOR IMPROVING EFFICIENCY

Rating of the distribution transformer should be judiciously selected to keep the losses in the permissible limits. For the existing distribution system, the appropriate capacity of distribution transformer may be taken as very nearly equal to the maximum demand at good power factor.

Meters should be connected on all distribution transformers for accurate calculation of energy loss. The low voltage problem on distribution feeders may be corrected by operating an on-load-tap changing in the high voltage side of the power transformers situated at 33/11KV substations and providing a combination of switched capacitors and automatic voltage regulators on 11 KV feeders.

Line losses in LT distribution lines may be considerably reduced by installing shunt capacitors of optimum rating at vantage points as decided during load stations. The optimum rating of capacitor banks for a distribution system is 2/3rd of the average KVAR requirement of that distribution system. The vantage point is at 2/3rd the length of the main distributor from the transformer. The loss reduction by connecting capacitor during peak loads, found to be 6-7% from simulation studies carried out. The released capacity could be supplied to the additional consumers [2].

By connecting the capacitors across all individual inductive loads it is observed from simulation studies that 10% voltage improvement 20% reduction in current and reduction of losses up to 9% can be achieved depending upon the extent of PF improvement [6].

Simulation studies have shown that by having Express feeders, the voltage profile can improve and loses can be reduced by around 25% and by implementing HVDS, it can further reduce by approximately 20-30%. There can be a total benefit of 50% loss reduction. Implementation of high voltage distribution Systems is not carried out on all rural feeders which can be taken on war footing.

The size of the conductor should be selected on the basis of KVA X KM capacity of standard conductor for a required voltage regulation [7,9]. Length of the 11KV and 415 V corresponding to different loads is presented in Table-6 and Table-7.

Table-6. Length of 11 KV line corresponding to different loads.

Size and code	**KVA-KM for 8% drop at 0.8 pf.**	**Max. length of line** (km)	**Connected load** (kw)
50 mm^2ACSR	10,640	30	355
30 mm^2ACSR	7,200	20	360
20 mm^2ACSR	5,120	15	341

Table-7. Length of 415 V line corresponding to different loads.

Size and code	**KW-KM for 8% drop at 0.8 pf.**	**Max. length of line** (km)	**Connected load** (kw)
30 mm^2 ACSR	11.76	1.6	7.35
20 mm^2 ACSR	7.86	1.0	4.86
13 mm^2 ACSR	5.58	1.0	5.58
30 mm^2 AAC ANT	12.06	1.6	7.54
16 mm^2 GNAT	6.96	1.0	6.96

The values in Tables 6 and 7 are for a conductor temperature of 60^0C. For 50^0C, the above values shall be about 3% higher and for a 70^0C, it is 3% lower.

6. CONCLUSIONS

The distribution losses can be reduced by proper selection of transformers, feeders, proper re-organization of distribution network, placing the shunt capacitor in appropriate places. The distribution companies should be ready for initial investment keeping in view of future savings in energy. HVDS should be implemented at a faster rate. Training of the operating personal would result in improved system operation.

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