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Engineering

Analysis of AT&C Loss Reduction Techniques in 11 KV Electrical Distribution System (BSES Yamuna Power Ltd., Delhi)

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ABSTRACT In this paper discussion about the study analysis AT&C Loss reduction techniques uses in power distribution company BYPL Delhi. Also discussed major aspects of technical and commercial losses have been identify and on the behalf of that a number of loss reduction methods have been suggested. In the electrical system the power distribution is final and most critical link. Due to high AT&C loss the direct impact on the Discoms commercial viability and also on the stake holders who pay for the electricity in the form of tariff. Due to the high AT&C the distribution companies have not been able to undertake corresponding investments in infrastructure enhancement. This paper facilitate the improvement of overall efficiency and revenues of the power distribution system. It may provide further input to the energy planner and engineers.

KEYWORDS : T&D, AT&C, T&D, BYPL, ABR, BDV.

I. INTRODUCTION

The power sector is the backbone of the national economy of any country. Sufficient electrical power with a high degree of reliability and quality is also the key to Indian economic growth. India is the 3rd largest power producer in the world with the total power capacity of more than 2, 88,665 MW [5]. The Government of India has adopted the policy of providing access to uninterruptable quality power supply at affordable costs to all by the year 2012. The responsibility of translating this vision into reality vests with the power sector and particularly the power distribution sector. [7]

In last two decades, we have seen tremendous growth both in size and capacity of energy production in India. The optimum utilization of the generated power is not possible without the help of an adequate and efficient transmission and distribution system. But in India to meet desirable demand of consumer on urgent basis the distribution system has grown in an unplanned manner .This creates an inefficient distribution system and contribute high AT&C loss with poor quality and low reliability. This paper provides a comprehensive view of mythology of computation and analysis of AT&C losses of BSES Yamuna Power Ltd. (a joint venture company of reliance and Govt. of NCT Delhi)

II. ELECTRICAL ENERGY SCENARIO IN INDIA

The utility electricity sector in India had an installed capacity of 308.83 GW as of 30 November 2016 [5]. Renewable power plants constituted 28.9% of total installed capacity. The gross electricity generated by utilities is 1,106 TWh and 166 TWh by captive power plants during the 2014–15 fiscal [5] .The gross electricity generation includes auxiliary power consumption of power generation plants. India is the world's third largest producer and fourth largest consumer of electricity.

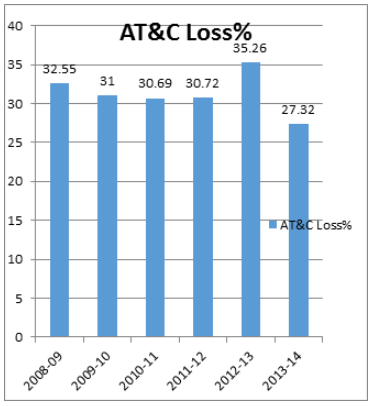

fig 1. AT&C loss of India [6]

During the fiscal year 2014-15, the per capita electricity generation in India was 1,010 kWh with total electricity consumption (utilities and non-utilities) of 938.82 TWh or 746 kWh per capita electricity consumption. Electric in agriculture was recorded highest (18.45%) in 2014-15 among all countries. The per capita electricity consumption is lower compared to many countries despite cheaper electricity tariff in India [5].

III. ENERGY SCENARIO IN DELHI

Following the privatization of Delhi's power sector and unbundling of the Delhi Vidyut Board in July 2002, the business of power distribution was transferred to BSES Yamuna Power Limited (BYPL) and BSES Rajdhani Power Limited (BRPL). These two of the three successor entities distribute electricity to 22.6 lakh customers in two thirds of Delhi. The Company acquired assets, liabilities, proceedings and personnel of the Delhi Vidyut Board as per the terms and conditions contained in the Transfer Scheme

BYPL distributes power to an area spread over 200 sq kms with a customer density of 7600 per sq km. It's 1.5 million customers are spread over 14 districts across Central and East areas including Chandni Chowk, Daryaganj, Paharganj, Shankar Road, Patel Nagar, G T Road, Karkardooma, Krishna Nagar, Laxmi Nagar, Mayur vihar,Yamuna vihar, Nand Nagri Karawal nagar.

IV. Concept of AT&C Losses

AT&C (Aggregate Technical & Commercial Losses- The aggregate T&D loss and loss due to non-realization of billed demand is termed as aggregate technical and commercial loss

$$AT\&C\% = \frac{(\text{Energy Input} - \text{Enenrgy Billed}) \times 100}{\text{Energy Input}}$$

AT&C loss is a transparent measure of the overall efficiency of the distribution business as it measures technical as well commercial losses. The AT&C Losses are presently in the range of 6.57% to 48% in various states .The national average AT&C of the distribution companies in the year 2002-03 was 36.63 % and has reduced to 22.24% in the year of 2013-14 [2].As the T&D loss was not able to capture all the losses in the network, Concept of Aggregate Technical and commercial losses introduced. The commercial losses are mainly due to low metering efficiency, Theft and pilferages. This may be eliminated by improving meter efficiency, Fix the responsibility of the personnel as Feeder manager it may help considerably in reduction of AT&C loss.

In India, the fact is that all energy supplied to a distribution utility does not reach the end consumers. A substantial amount of energy is lost in the distribution system by way of technical losses. These inherent losses in transmission and distribution of electrical energy

from the generating stations to the ultimate consumers should be reduced by eliminating or minimizing the causes of losses. T & D loss is the difference between units injected into the system and the units billed to the ultimate consumers, which is generally expressed as percentage of units injected. It is generally calculated for a period of one financial year [7]. The transmission and distribution (T & D) losses in our country, which were around 15% up to 1966-67, increased gradually to 23.28% by 1989-90. After a brief spell of reduction in T & D losses to 21.13% (1994-95), there has been an upswing and the losses reached a level of 33.98% during 2001-02. Since then, a reducing trend has been observed as T & D losses have come down to 32.54% during 2002-03, 32.53% during 2003-04 and 31.25% during 2004-05.Similarly the reduction trend in the past four years was decrement like in 2011-12 was 23.92 %, 2011-12 was 23.65%, 2012-13 was 23.04%, and 2013-14 was 21.96% as per GOI Ministry of power CEA. [7][1]

V. Concept of T&D Losses

BRPL distributes power to an area spread over 750 sq. km with a customer density of ~3000 per sq km. It's over 2.2 million customers are spread in 19 districts across South and West areas including Alaknanda, Khanpur, Vasant Kunj, Saket, Nehru Place, Nizamuddin, Sarita Vihar, Hauz Khas, R. K Puram, Janakpuri, Najafgargh, Nangloi, Mundka, Punjabi Bagh, Tagore Garden, Vikas Puri, Palam and Dwarka.

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Since taking over distribution, BSES' singular mission has been to provide reliable and quality electricity supply. BSES has invested over Rs 7200 crores on upgrading and augmenting the infrastructure which has resulted in a record reduction of AT&C losses. From a high of 63.1 % AT&C losses in BYPL area in 2002 the losses have come down to 15.7%** in FY16, a reduction of over 46%. Similarly, in BRPL area AT&C losses have been reduced from 51.54% to 11.9%** in FY16, a reduction of over 39%. [8]

T&D Loss (Transmission & Distribution Loss)- Percentage difference between the energy input and energy billed over the energy input.

1. Collection Efficiency (CE)- This is the percentage of the Amount Collected over Amount billed [2]

$$\text{Collection Efficiency}(\%) = \frac{\text{Amount Collected} \times 100}{\text{Amount Billed}}$$

2. Average Billing Rate (ABR) - It is the average billing amount per unit of energy billed.

$$\text{ABR}\% = [(\text{Amount Billed})/(\text{Energy Billed})] \times 100$$

$$\text{Energy collected} = (\text{Amount collected})/ABR$$

$$T\&D = \frac{\text{Energy Input} - \text{Energy Billed}}{\text{Energy Input}} \times 100$$

VI. Technical Loses

Technical loss is inherent in electrical systems, as all electrical devices have some resistance and the flow of current causes a power loss (I2R loss). Integration of this power loss over time, i.e., I2R.dt is the energy loss. The summery of different types of technical losses is given:

a) Line Loss

- Loss in conductor/Cables where lower size conductors are used. This causes sags and temperature rise in conductors which further aggravate the loss.
- Loss in higher loaded phase wire due to unbalance loading
- Losses due to current in neutral for cases of unbalanced where neutral wires of lower size are used (like 3 ½ core cables, and neutral wires of size lower than phase wires),
- Loosening of strands (in multi-strand conductors like ACSR, AAC, AAA, etc.)

b) Losses in mid span Joints at termination.

- Contacts of joints due to improper installation and looseness,
- Contacts of joints due to inadequate surface area of contact.

c) Losses in transformer

- Loose connections at brushings,
- Bend in jumpers at connectors where the strands are not tightly held,
- High no-load loss depending on type of core used,
- High no-load loss in repaired transformers, where the core has not been properly tightened,
- No-load loss in case a large number of lightly loaded Dts,
- High copper loss for transformers operating at sub-optimal loading which is not commensurate with the designed optimal loading.

d) Losses in service cables and connections

- Under sized service cables,
- Loss in joints of service cables at the poles or junction boxes,
- Use of inappropriate fasteners without spring washer at the crimped joints.

e) Loss due to high impedance faults

- Tree touching, creepers, bird nesting,
- Insulator breakages and tracking on the surface of the insulator

f) Losses in re-wired fuses/ jumpers

- Loose connection
- Inadequate size of fuse wires – often a source of hot spots

VII. Commercial Losses

Commercial losses are caused by non-technical or commercial factor namely pilferage theft, defective meters, errors in meter reading, estimating un-metered supply of energy etc.

a) Loss at consumer end meters

- Poor accuracy of meters,
- Large error in capital CTs / Pts,
- Voltage drop in PT cables,
- Loose connection in PT wire terminations,
- Overburdened CT.

b) Tampering / bypass of meters

- Where meter without tamper-proof-tamper-deterrent/tamper-evident meters are used,
- Poor quality sealing of meters,
- Lack of seal issue, seal monitoring and management system,
- Shabby installation of meters and metering systems,
- Exposed CTs/ PTs where such devices are not properly securitized.

c) Pilferage of energy

- From overhead bare conductors,
- From open junction boxes (in cabled systems),
- Exposed connection/ joints in service cables,
- Bypassing the neutral wires in meters.

d) Energy accounting system

- Lack of proper instrumentation (metering) in feeders and DTs for carrying out energy audits,
- Not using meters with appropriate data login features in feeders and DT meters,
- Lack of a system for carrying out regular (Monthly) energy accounting to monitor losses,
- Errors in sending end meters, CTs and Pts,

- Losses connections in PT wires (which results in low voltage at feeder meter terminals),
- Energy accounting errors (by not following a scientific method for energy audits).

e) Errors in meter reading

- Avoiding meter reading due to several causes like house locked, meter not traceable, etc.
- Manual (unintentional errors) in meter reading,
- Intentional errors in meter reading (collusion by meter readers),
- Coffee shop reading,
- Data punching errors by data entry operators,

f) Error in bills

- Errors in raising the correct bill,
- Manipulation/changes made in meter reading at billing centres – lack of a system to assure integrity in data
- Lack of system to ensure that bills are delivered.

g) Receipt of payment

- Lack of system to trace defaulters including regular defaulters
- Lack of system for timely disconnection,
- Care to be taken for reliable disconnection of supply (where to disconnect).

Table 1. Practical Calculation of AT&C Loss %

S.No	Descripton	Equation	Base Line Year (0000)
1.	Input Energy(MU)	E1	100
2.	Energy Billed(MU)	E2	95
3.	Amount Collected (Rs. Cr.)	AC	93
4.	Amount Billed (Rs. Cr.)	Ab	100
5.	T&D Loss %	(E1-E2)%	10%
6.	Collection Efficiency %	(Ab/ Ab)*100	93%
7.	ABR(Rs./Kwh)	Ab/ E2	11.11
8.	Energy Collected	AC /ABR	83.70
9.	AT&C %	(E1-E2)/E1*100	16.30%

VIII. Scope of T&D Loss reduction

The causes of high technical losses are varied and require different remedial measures to be implemented to bring them down to acceptable levels. The following measures help out to reduce the T&D losses.

- Network Reconfiguration – It gives an option to handle the increased demand and increases system reliability. It is effective when voltage drops between the nodes to be linked is rich and the distance between the nodes is short. Within a feeder it is effective only when the zigzag factor is high. [7]
- Network Reconditioning – The size of conductor/ cable determines the current density and the resistance of the line. A lower conductor size can cause high I2R losses and high voltage drop which causes a loss of revenue as consumer's consumption and hence revenue is reduced.
- Preventing Leakages at Insulators -Cracking of insulator and flashover across insulators often cause outages and result in loss of revenue. Use of appropriate material for insulators, depending on the nature of pollution, and designed protected creep age path helps in reducing insulator failure. Preventive actions are regular inspection and hot line washing.
- Automatic Voltage booster – it is similar to that of the series capacitor as an on-load tap changer it boosts the voltage at its point of location in discrete steps. This, in turn, improves the voltage profile and reduces the losses in the section beyond its point of location towards the receiving end. It has a total voltage boosts of 10% in four equal steps and the loss reduction is directly proportional to voltage boosts.
- To manage better Distribution Transformers – the following measures can be taken in this regard:

a) Augmentation/ addition of distribution transformers;
b) Relocation of distribution transformers nearest at load centers;
c) Low voltage (less than declared voltage) appearing at transformers consumers terminals;
d) Guarding against loss in transformers through oversized transformers operating at low loading, undersized transformers, unbalanced loads in secondary side, connector at bushings, low oil level/ oil leakages, hot spots in core, use of energy efficient transformers etc.

- Load Balancing and Load Management – if the loads on each of the three phases of a distribution lines or among feeders are redistributed, the losses will be reduced. The best method to identify load balance is to construct current duration curves for all three phases. Distribution automation along with SCADA (Supervisory Control and Data Acquisition System) is an important tool for load management which should be introduced.
- Capacitor Installation – the use of capacitors to correct for poor power factor is a cost effective means of reducing distribution losses and maximizing the revenue. In most LT distribution circuits, it is found that the power factor (PF) ranges from 0.65 to 0.75. For low PF the amount of current drawn increases to meet the same kW demands of load. Overall improvement in the operating condition can be brought about by reducing the system reactance. System conductor losses are proportional to the current squared and, since the current is reduced in direct proportional to the power factor improvement the losses are reduces in proportional to the power factor improvement.

$$V_{3Ph} = \frac{\sqrt{3}\, I(Rc\ Cos\ \emptyset + Xc\ Sin\emptyset)L}{1000}$$

V_{3ph} three phase voltage drop (V)
I is the nominal full load or starting current (A)
Rc is Ac resistance of the cable (Ω/Km)
Xc is the ac reactance of the cable (Ω/Km)
Cos ∅ is the Load Power Factor (pu),
L length of the Cable

Table 2. Reduction in Cable size [9]

Multiplying Factor for the cross sectional area of the cable core	1	1.25	1.67	2.5
Power Factor(Cos Θ)	1	0.8	0.6	0.4

- Improving joints and connections – Improper joints are a source of energy loss in both overhead and underground systems. The conductivity of joints should not be less than an equivalent length of the conductor. Joints should be capable of carrying maximum fault current without failure or deterioration for the time required for the protective system to operate.
- Increase in HT/LT ratio – It is well known that for high HT/ LT ratio, the losses will be low. The losses for a given quantum of power supplied by a line are inversely proportional to the square of its operating voltage. Higher the operating voltage, lower will be the line losses. Therefore, by increasing the HT lines the losses will be reduced.
- Preventive maintenance – These components of the distribution system are necessary to reduce/ eliminate breakdowns. It can be minimized by careful design and healthy installation practices. The following activities should be undertaken for preventive maintenance:

a. Maintenance of overhead lines,
b. Correction of bent poles,
c. Rewinding transformer,
d. Monitoring transformer tank temperature,
e. Use of protective devices,
f. Improved bushings,
g. Transformer oil BDV testing,
h. Repairing of broken parts. Like Leads, sockets
I. Protection revival

j. Megger results, earthing measures

The activities for preparation of a long term plan are listed below:

a. Data collection regarding existing loads, operating conditions, forecast of expected loads, etc. from grid sub-station up to consumers level;
b. Mapping of existing system;
c. Financial analysis.
d. Load forecast;
e. Plan for upgrading the network;
f. Technology options including integration of features for modernization of system;
g. Evaluation of various alternatives for least cost optimal solution;
h. Firming up of scope of works;
I. Preparation of cost estimation;
j. Phasing of works and their cost;

IX. Commercial Loss reduction Techniques used in Electrical Utilities

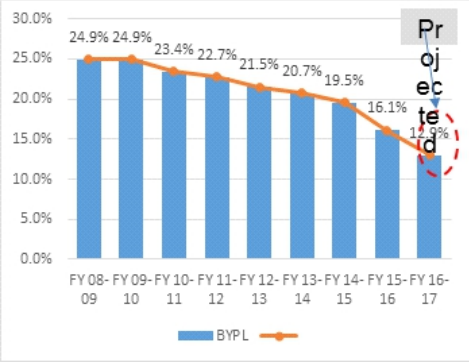
- Enforcement team conduct frequent raids at the high loss pockets to avoid direct theft in the early morning and late nights including day time.
- Relocate the energy meters outside the premises.
- Replace the very old meters those warranty discarded by the manufacturer.
- Frequently Discoms conduct accuracy check of the meter at the consumer end to avoid any type of tempering.
- Use of arial bundled or armored LT cable in place of bare conductor to avoid direct hooking.
- The energy meter should be housed in a separate box sealed and made inaccessible to the consumers. The fuse cut-outs should be provided after the meter;
- Multi-core PVC cables should be used as service mains instead of single core wires,
- Severe penalties may be imposed for tampering with metering seals, etc.;
- Theft of electricity should be publicized as a social and economic crime and people should be informed of the provisions in electricity laws in this regard.
- Constant nil consumption cases reported without any comment;
- Progressive readings recorded in disconnected services;
- Adoption of wrong multiplication factors (MF) for billing as the change in MF in not intimated to the billing agency.
- It is often considered as a low skill, labor oriented activity. It must be given due importance to against revenue loss.
- Correct billing and timely delivery of bills go a long way in improving the revenue collections. The normal complains viz. non-receipt / late-receipt of bills, wrong bills, wrong reading status, wrong calculations etc. should be avoided.
- The electricity Act, 2003, visualizes the role of users associations, co-operatives, panchayats and franchisees in electricity distribution management be successfully inculcated to develop a sense of belonging to and stake in the entity. [10]
- Close the Distribution box and sealed with the checknut to avoid direct hooking and also installed away from the consumer premises.
- Conduct social awareness program by utility with the consumers /RWA/MLA /Schools/ colleges.
- Make the straight through joints at the location where DB boxes open continuously.

X. Conclusion

In BYPL, The loss reduction drive has been started aggressively since FY14-15. All the activity which are mentioned in this paper are using in BRPL and BYPL but we have discussed only BYPL as per data.

- Average loss reduction by BYPL from FY 08-09 to FY 14-15 is 0.7% in 6 years
- Reduction of T&D in FY 14 -15 is 1.2%
- Reduction of T&D in FY 15 -16 is 3.4%
- Expected Reduction of T&D (based on reduction trend till Jan 17) in FY 16 -17 is 3.2%
- Average loss reduction by BYPL in last 3 FY is 2.6%

Fig. 2 Loss trend of BYPL [9]



References

1. GoI, Planning Commission, Five-Year Plan Power & Energy: Energy Policy& Rural Energy, New Delhi, 2015.
2. IGNOU, School of Engineering and Technology, Power Distribution Sector (BEE-001), New Delhi, 2015.
3. GoI, Ministry of Power, Policy Document on Electricity for All, New Delhi, 2014.
4. Report on the Performance of State Power Utilities 2011-12 to 2013-14.
5. https://en.wikipedia.org/wiki/Electricity_sector_in_India
6. GoI ministry of Power Central electricity authority executive summary Feb 2016
7. http://ijmer.com/papers/Vol2_Issue5/BD2532923297.pdf
8. http://www.bsesdelhi.com
9. https://www.electrical4u.com/electrical-power-factor/
10. Gurpreet Singh Rakhra "Analysis of Commercial & Administrative Losses in Radial Distribution System", Electrical Engineering Department, Punjab Technical University Punjab, India.
11. Best Practices in Distribution Operation & Management, Level C & D - Volume 2.
12. Tejinder Singh, " Analysis of Commercial losses and its economic consequences on power system", Thapar University Patiala Panjab
13. Soham Ghosh, "Loss Reduction and Efficiency Improvement: A Critical Appraisal of Power Distribution Sector in India", International Journal
14. Modern Engineering Research (IJMER), Vol.2, Issue.5, Sep-Oct. 2012 pp-3292-3297
15. L. Ramesh, S.P.Chowdhury, S.Chowdhury, A.A.Natarajan, C.T.Gaunt," Minimization of Power Loss in Distribution Networks by Different
16. Techniques", International Journal of Electrical and Electronics Engineering 3:9 2009
17. Saunders, M. et al (2000), research Methods for Business Students, Prentice Hall, and Pearson Education.
18. Report on "Loss Reduction Strategy" by FORUM of Regulator, September, 2008.
19. "Methodology for Establishing Baseline AT&C losses" by Power Finance Corporation Limited, 4th September, 2009.
20. Mrinalini Prasad (November 2006), Decoding India's T&D Loss, Cover Story, Electrical Monitor, Mumbai.
21. V.K. Mehta and Rohit Mehta (2008), "Principles of Power System", S. Chand Publication.
22. Devender Singh (16th December 2009), A Strategy to Cut Mounting Power