Reducing Losses of Distribution Network by High Voltage Distribution System

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ABSTRACT

There are inherent losses in transmission and distribution of electrical energy from generating station to the ultimate consumer. The energy losses occurring in the transmission and distribution system are known as T&D losses. Transmission and distribution losses are the difference between units injected into the system and the units billed to the ultimate consumer. T&D losses occur at several places in the distribution system. The main issue in sub transmission and distribution system or rather the issue confronting the power sector as a whole is the reduction of aggregate technical and commercial losses to acceptable limits. The strategy for improvement should, therefore be aimed at rectifying these deficiencies to ensure that the T&D system operate at optimum level of technical, commercial and financial efficiency.

The acceptable loss levels are in the range of 8.25 to 15.5% depending on configuration of the network, physical parameters of the network, level of loading and prevalent operating voltage levels.
Technical losses reduction can be achieved by various measures such as network reconfiguration, network reconductoring, load balancing, capacitor installation, employing auto voltage booster, laying additional link line, relocation of distribution transformers, addition of new distribution transformer, improving joints, increasing HT:LT ratio, adoption of high voltage distribution system (HVDS) and regular maintenance of distribution network.

The HVDS programmed aims at reduction in T&D losses and providing reliable and quality power supply to the agricultural consumers. On implementation, the project shall also help in arresting theft of energy, minimizing failure of distribution transformers, energy conservation due to high end use efficiency, and improved voltage profile for the consumers. Aerial Bunch Cable provides higher safety and reliability, lower ower losses and ultimate system economy by reducing installation, maintenance and operative cost. This system is ideal for rural distribution and specially attractive for installation in difficult terrains such as hilly areas, forest areas, coastal areas etc.

The case study is for Parvalia Sadak 33/11kvSubstation, district Bhopal. In this study the losses are calculated with and without HVDS system followed by comparison of losses in both the systems and percentage improvement by the application of HVDS system.

INTRODUCTION:

The entire power system is all about handling the power at four levels:

1. Generation
2. Transmission
3. Distribution and
4. Utilization level

But handling power at these levels is not an easy task to perform as the above various levels are associated with the losses of power. T&D loss is the difference between units injected into the system and the unit billed to the ultimate consumer and is generally expressed as the percentage of units injected.

$$\text{T\&D Loss}(\%) = \frac{(\text{Energy input - Energy billed})}{\text{Energy input}}$$

Losses can come from two sources:

1) Technical losses, those that result from the heating of conductors and coils and from the excitation of the windings of transformers and other devices, and
2) Non technical losses, those associated with inadequate or missing revenue metering, with problems with billing and/or collection systems, and/or with consumer pilferage.

REMEDY FOR THESE LOSSES:
The remedy for the above mentioned losses is mentioned in this paper and is the “HVDS” system. Which means ”HIGH VOLTAGE DISTRIBUTION SYSTEM”.HVDS presents one of the least cost options for reducing the distribution losses and for providing reliable and quality supply to the consumers.

Defining the T&D Loss:T&D loss is the difference between units injected into the system and the unit billed to the ultimate consumer and is generally expressed as the percentage of units injected.

Transmission and distribution losses occur on account of technical and commercial reasons. The losses occurring on account of technical factors are known as technical losses. The losses occurring on account of non-technical factors or commercial factors are known as commercial losses.

TECHNICAL LOSSES
There are two sources of these losses:
A. the load losses: consisting of the I^2R and I^2X losses in the series impedances of the various system elements

(e.g., lines and transformers); when the system is unloaded (i.e., I=0), the load losses are obviously nonexistent and b) the **no-load** losses: which are independent of the actual load served by the system.
The majority of the no-load losses are due to the transformer core losses resulting from the excitation current.
Transformer core (no-load) losses were estimated from
1) the number of transformers for each region of the system;
2) the average transformer KVA capacity, calculated from available information; and
3) the magnitude of core losses in typical transformers.

TECHNICAL LOSSES IN EQUIPMENTS LINE LOSS:
Line losses are the losses in conductor cables. It causes sags and temperature rise in conductors which further aggravate the loss.

LOSS IN MID-SPAN JOINTS (OR ANY JOINT) AND AT TERMINATION:
Contacts of joints due to improper installation and looseness.
Contacts of joints due to inadequate surface area of contact loss in

LOSS IN TRANSFORMERS (TYPICALLY DTS):
The losses are due to loose connections of bushings, bend in jumpers, high no load loss depending upon the type of core used and high copper loss.

LOSS IN SERVICE CABLES AND ONNECTIONS:
Undersized service cables, Loss in joints of service cables at the poles\junction boxes, Use of inappropriate fasteners without spring washers at the crimped joints.

LOSS DUE TO HIGH IMPEDANCE FAULTS:

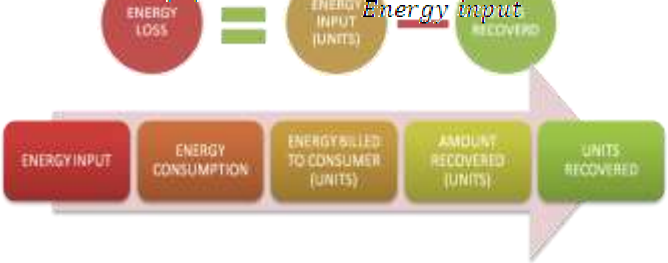
Tree touching, creepers, bird nesting, Insulator breakages and tracking on surface of the insulator.

LOSS IN RE-WIRED FUSES\JUMPERS:
Loose connections
Inadequate size of fuse wires- often a source of hot spots.

COMMERCIAL LOSSES
Commercial losses are caused by pilferage, theft, defective meters, and errors in meter reading and in estimating un-metered supply of energy.

CALCULATING AT&C LOSS:

$$AT\ \&\ C\ Loss(\%) = \frac{Energy\ input - Energy\ realized}{Energy\ input} \times 100$$



$$Energy\ realized = Energy\ billed \times Collection\ efficiency$$

$$Collection\ efficiency(\%) = \frac{Amount\ realised}{Amount\ billed} \times 100$$

REASONS FOR COMMERCIAL LOSSES:
1. Loss at consumer ends meters.
2. Tampering or bypass of meters.
3. Pilferage of energy.
4. Energy accounting systems.
5. Errors in meter reading
6. Errors in bills
7. Receipt of payment

DISTRIBUTION LOSS REDUCTION AND EFFICIENCY IMPROVEMENT
1) Low Investment In T&D
The investment in T&D system in our country has generally been then that on generation ratio 1:07.

2) Large Scale Rural Electrification
Large scale rural electrification programmed undertaken in the country resulted in long LT lines and extension of distribution network. . This has resulted in high line loss.

3) Too Many Transformation Stages:
Too many transformation stages result in higher component of transformation losses.

4) Low Power Factor
Due to pumping load in rural areas, and air conditioners coolers and industrial loads in urban load areas the system has a low power factor which result in higher losses.

5) Improper Load Management
Improper management of the load has led to the overloading of conductor and transformers in the system causing higher losses.

6) Distribution Transformers Not Located At Load Center
Often distribution transformers are not located centrally with respect to consumers. Consequently the overall length of the distribution network increases and the consumers obtain an extremely low voltage even though a reasonably good voltage level is maintained at the transformer secondary

7) Low Quality Of Equipment, Poor Construction And Inadequate Maintenance
Poor quality of equipment result in increased technical losses .poor workmanship leads to distribution losses.

8) Factor Contributing To High Commercial Loss.
Theft of existing power connection Non-performing and under-performing meters.
Defective metering Meter reading errors. Tardy billing and poor revenue collection
Lack of accountability, incorrect estimation of energy consumption in respect of Unmetered connection

9) Theft Of Power By The Existing Customers
It is the predominate cause of loss revenue to the electrical utilities. Almost all categories of consumers are involved in this. Pilferage of power by consumers contributes to losses.

10) Direct Tapping By Non Consumer
Direct tapping of power by non consumer is widely prevalent. This is mainly in domestic and agriculture

categories. Geographical remoteness mass basis for theft, poor law enforcement capability and inaction on the part of utility are helping this phenomenon.

11) Unmetered Connection

Power supply to agriculture pumped some categories of domestic consumer are metered and charged at flat rate basis. Correct estimate of consumption cannot be maintained hence it causes losses.

12) Defective Metering

Tampered slow running damaged, stalled meter are a cause of huge losses to the utility. The electromechanical meter tend to get sluggish over a period of time and record much less consumption than actual

13) Meter Reading Error

Reading is inadvertently noted wrongly. For a good number of services the meter reader at times notes nil consumption without any comment.

14) Trade Billing And Poor Revenue Collection

Non receipt, late receipt of bills, receipt of wrong bills, wrong reading connection, table reading and wrong calculation.

METHODS USED FOR REDUCTION OF LOSSES IN DISTRIBUTION SYSTEM

The transmission and distribution losses occur on account of technical and commercial losses. These losses can be minimized by using various techniques such as short term measures and long term measures.

SHORT TERM MEASURES

- Reducing the length of LT lines by relocation of distribution sub stations/installations of additional distribution transformers (DTs).
- Installation of lower capacity distribution transformers at each consumer
- Premises instead of cluster formation and substitution of DTs with those having lower no load losses such as amorphous core transformers.
- Installation of shunt capacitors for improvement of power factor.

Augmentation of conductor, cabling work, Changing of service line, Installation of meters outside the consumer premises, (APDRP/ADB) Schemes which are presently in operation.

NETWORK RECONFIGURATION

Though network reconfiguration, consumers can be fed by multiple sources by switching. Hence it gives an option to handle the increased demand and increases the system reliability. Network reconfiguration among feeders is effective only when the voltage between nodes is short.. Network reconfiguration within a feeder is effective only when the zigzag factor is high.

NETWORK RECONDUCTORING

The recommended practice is to find out whether the conductor is able to deliver the peak demand of the consumer at the correct voltage, that is, the voltage drop must remain the allowed limit specified in the electricity act 2003.networking reconductoring is the replacement of the exiting conductor on the feeder with an optical conductor size for optimal length of the feeder.

AERIAL BUNCHED CABLES

The use of ABC has the following advantages.

Maintenance cost associated with these types of cables is reduced because clearing tree branches form the lines need not be as frequent. These types of conductors are safer then bare conductors.

ARMOURED CABLE ON POLE

It is experienced that stringing an armoured cable on a messenger wire provides better security against hooking proper sized conductor in neutral in distribution system a smaller size of neutral conductor is often used. This makes the neutral wire susceptible to high loss and breakdown. The recommended practice is using a conductor of the same size as that of phase conductor. In case of cabled system the recommendations is to use a 4 core cable than 3 core cable as the neutral must have the same capacity as that of the phase wires.

PREVENTIVE LEAKAGE AT INSULATORS

Leakage at insulator, cracking of insulator, and flashover across insulators often cause outage and result in loss of revenue Use of appropriate material for insulator helps in reducing insulator failure.

AUTOMATIC VOLTAGE BOOSTER

The use of automatic voltage booster is similar to that if the series capacitor AVB is 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 the receiving end. An AVB has a total boost of 10% in four equal steps. The loss reduction is directly proportional to voltage boost.

BETTER MANAGEMENT OF DISTRIBUTION TRANSFORMER AUGMENTATION/ADDITION OF DISTRIBUTION TRANSFORMER

Distribution transformers have to be augmented by installing additional transformer or increasing the capacity of the transformer when the maximum demand is near its rating. It is always better to add a transformer than to augment it.

RELOCATION OF TRANSFORMER AT LOAD CENTRE

The location of transformer and type of transformer in the distribution system is decided to ensure that losses are kept within the optimum limits. Often distribution transformers are not located centrally with respect to the consumer. The farthest consumer obtain an extremely low voltage even though reasonably good voltage levels are maintained at the transformer secondary this again leads to higher line losses.

LOW VOLTAGE APPEARING AT TRANSFORMER AND CONSUMER TERMINAL

Whenever the voltage applied to induction motors varies from the rated voltage its performance is affected against permissible voltage regulation of 5% in practice the supply voltage varies by more than 10% in much distribution system. A reduced voltage in the case of induction motor results in higher current drawn for the same output. For a voltage drop of 10% the full load drawn by the induction motor increases.

GUARDING AGAINST LOSS IN TRANSFORMERS

Distribution transformers are expected to convert up to 95-98% of the input power into usable output power. When the transformer is very lightly loaded, the no load loss of the transformer becomes a prominent part of the input energy and leads to a high percentage loss. Specifying a low core loss DT can prevent high energy loss. Factor contributing towards losses in transformers are:

- Oversized transformers operating at low loading:
- Undersized Transformers:.
- Unbalanced loads in secondary side: causes neutral shifting also over fluxing due to higher voltage
- Connectors ay bushings: causes oil leakage on HT/LT bushing, and with pollution deposits electrical leakage start at the bushing.
- Low oil level: Transformer oil serves the dual purpose of insulation and cooling .leakage of transformer oil and contamination of oil with moisture can reduce the insulation resistance of oil. Sludge formation in oils can adversely affect the cooling and lead to higher temperature and losses.
- Hot spot in core: Hot spots can develop in the core due to the loosening of the core bolts .hot spots in core can lead to eddy current and higher core losses .gas chromatography can be used to detect such potential hazards.
- Use of energy efficient transformers: helps in preventing distributions losses. Recently distribution transformers withy amorphous core have entered the Indian market and few utilities have installed these. The core losses get substantially reduced.

LOAD BALANCING AND LOAD MANAGEMENT

It has been observed that the load on all three phases of a distribution line and among the feeders is not balanced. This results in increased current in the heavily loaded line losses. If the loads on each phase or among feeders are redistributed the losses will be reduced.

CAPACITOR INSTALLATION

The use of capacitors to correct for poor power factor is well established and cost effective means of reducing distribution system losses and maximizing the revenue. Capacitor banks can be installed close to a low power factor load. Shunt capacitors can be connected in the following ways:

1. Across individual customers
2. Advantage point on LT and 11kv feeder
3. At distribution transformer
4. 33/11KV substations.

ADOPTION OF HIGH VOLTAGE DISTRIBUTION SYSTEM

Adoption of HVDS by converting existing LVDS to HVDS reduces the technical losses.

LONG TERM MEASURES

The basic objective of strengthening and improvement of sub transmission and distribution system in the long term are to:

1. Ensure quality and reliability of supply to the consumer.
2. Bring down the technical losses to an optimal minimum level phase the system expansion to match the growing power demand in the area under study.
3. The sub-transmission and distribution system must be properly planned in the long term to ensure that the losses are within acceptable limits.
4. Several software tools are available for conducting system studies the improvement plan should cover.
5. Augmentation of the transformer capacity at existing 66 or 33/11KV substation.
6. Rearranging/reconfiguring the 33/66KV feeders by using higher size conductor and or increasing the number of feeders.
7. Establishment of new power substation near to the load center.
8. Feeder strengthening, addition of new 11KV feeder and reconductoring of existing feeders.
9. Addition of distribution transformer and L.T. lines.
10. Adoption of modern technologies.

DEMAND SIZE MANAGEMENT

Energy efficiency programme reduce energy use both during peak and of peak period typically without affecting the quality service provided. Peak load reduction includes interruptible load tariffs, time of use rates, direct load control and other load management programmes. Load shape flexibility can be achieved by programmes that modify price cycle of equipment or interruption service in response to specific changes in power cost or resource availability. These approaches include real time pricing and time of use rates for pricing period that have flexible hours. Load building programme are designed to increase use of high efficiency electrical equipment or shift electricity sales. Usage of prepayment meters will significantly improve the revenue collection of the utilities. There are number of ways in which repayment assures revenue collection/protection.

The prepaid meters assures revenue upfront that is before the electricity is consumed. In case a credit is given (in prepaid) there is a zero time gap between consumption and payment. This reduces the cash collection cycle. Errors in meter reading, billing and data entry are altogether eliminated the meter dispenses only that amount of electricity for which it has been paid for Punching error by consumes (on case of key pad based prepayment meter)are also eliminated as the meter does not accept erroneous keying. Prepayment eliminates the meter reader and bill distributors thereby not only eliminating potential sources of corruption but also the costs incurred by utilities towards their meter reader and supervisor and the work force and related costs in running the billing centres the activity starts and ends in the cash collection, which happen through user friendly dispensation centre and consumer do not have to queue at utility offices to pay their bill.

Another advantage of prepayment meter is its capability to return unused amount to consumer; this feature helps in tracking changes in temporary ownership of connection consumer an aspect that is never possible in credit metering.

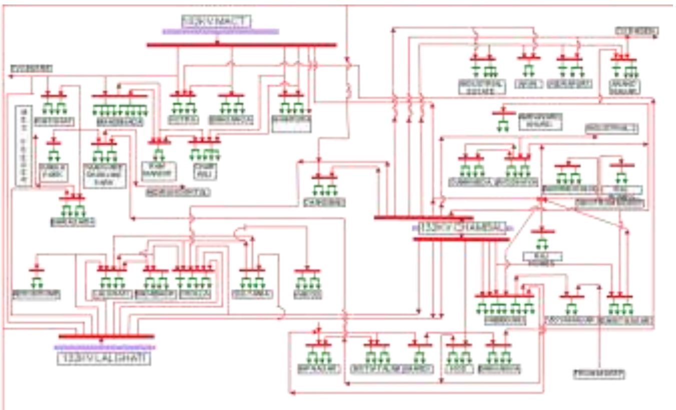
Prepaid metering is the state of art for single and three phase whole current metering and should be implemented by utilities desirous of protecting their revenue between the different choices of types of prepayment meters eye pad based technology is far superior to other methods such as smart cards as the latter is prone to tampers and are inconvenient to consumers.

11KV FEEDER AS PROFIT CENTER

Bhopal & Gwalior are two big cities in the Madhya Pradesh having a complex distribution system and the expectations of the consumer in these cities regarding quality of supply and general services is very high.

In Bhopal City, there are 49 Nos. of 33/11 KV Sub-stations and 150 Nos. of 11KV feeders feeding 2.40 lakh consumers of different categories. In Gwalior City, there are 27 Nos. of 33/11KV Sub-stations feeding 1.5 lakh Nos. of consumers and having 107 Nos. of 11KV feeders.

SINGLE LINE DIAGRAM OF SECC BHOPAL



The process and the structure are as follows:

NOMINATION OF FEEDER INCHARGE

City Circle is divided into four Divisions: headed by Executive Engineer

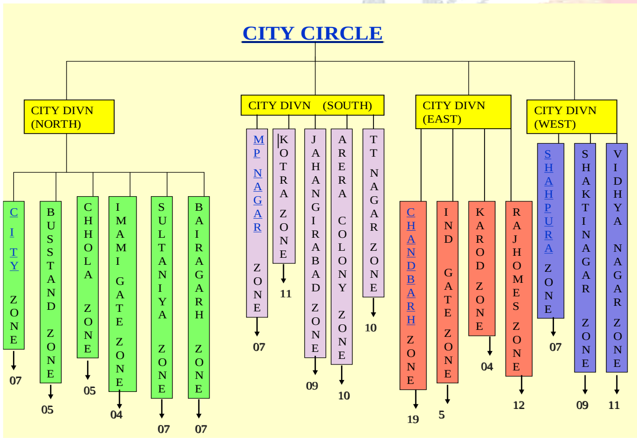
Each Division is divided into Sub-Divisions (Zones) headed by Assistant Engineer.

Each Zone has 2-3 Junior Engineers.

Each Assistant Engineer/Junior Engineer is in charge of 2 to 4 Nos. 11 KV feeders.

CITY CIRCLE BHOPAL

Prior to implementation of 11KV feeder-wise analysis and entrusting it to Junior Engineer/Assistant Engineer. The Geographical area of city was divided in to different category of consumers and accordingly recorded was maintained, which neither efficient nor



was possible to account for the division-wise quantum of losses.

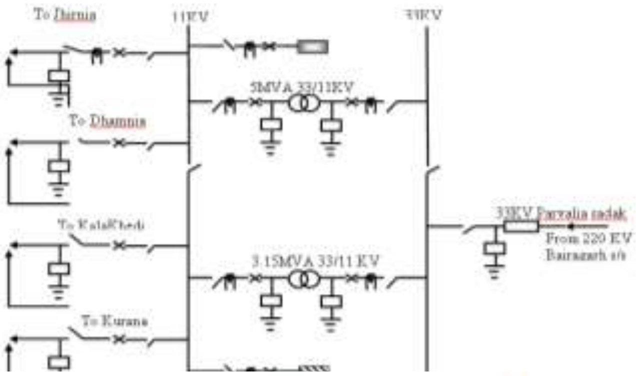
Fig: City Circle Bhopal

This disadvantage with the system was;

It was not possible for the Administration to fix the accountability for the losses. The identification of the loss/low loss was not possible. Remedial measures for above could not be identified. Time taken in meter reading and bill distribution was very high. Revenue and technical responsibilities were resting on different officers. Disconnection and Re-connection was not effective. Analysis of demand raised/sale and realization thereof for different categories was possible as a whole Division/Circle.

STUDY CASE – I(Parvalia Sadak 33/11kvSubstation)

Here is given the case study of the PARWALIA SADAK which comes under the BAIRAGARH ZONE of the CITY CIRCLE BHOPAL, Which accounts many data which helps us to set a detailed comparison of a region on the performance of before and after the installation of the HVDS. A close examination reveals that the losses are approximately reduced up to 14% which were earlier 74%.



LINE DIAGRAM OF MUGALIA HAT

LINE LOSS REDUCTION STATEMENT OF 200 KVA, MUGALIA HAT VILLAGE:

DTR Meter installed on dated 27.06.06 and second reading taken on 29/06/06. On the basis of 3 day Consumption line loss calculated which comes 74.05%. Than the Work carried are as under :-

LT Less Scheme for P.Sadak D/C - Schedule

		Quantity	Rate	Amount
No. of villages	25		(In lacs)	(In lacs)
Perm. Pump	1389			
Temp. Water Source	1168			
Existing LT	297 km			
Existing Xmer	179			
Proposed Xmer				
63 KVA		21	0.55	11.55
25 KVA		262	0.32	83.84
16 KVA		208	0.32	66.56
10 KVA		204	0.32	65.28
DP structure		552	0.46	253.92
Proposed				
LT to 11 KV Conversion		182 KM	0.76	138.32
Xmer metering		722	0.14	101.08
				720.55
Credit Material				
Conductor		7 MT	0.5	3.5
Xmer 11/0.4 Kv				
200		37	1.1	37.37
100		54	0.6	32.4
63		21	0.5	10.5
				83.77
	Net Cost			636.78
				0.2548

Particular	I Circuit		II Circuit		Total	
	Before	After	Before	After	Before	After
No of consumers	49	56	51	79	100	135
Input to village /month (Units)	8850	3180	9420	5430	18270	8610
Billed units /month	2550	2685	2190	4710	4740	7395
% Line loss	71.19	15.57	76.75	13.25	74.05	14.11
Load on Xmer R-	82	07	101	58	193	66
In Amp Y-	37	30	16	29	60	59
B-	09	21	30	15	40	66
N-	05	02	05	02	05	02

The Comparision for the whole year is given as under .

S.No	Particular	2005-06 (June to May)	2006-07 (June to May) as on May '07	% Improvement
1	No of consumers	100	162	(+) 62%
2	Input to village	219240	122338	(-)44.2%
3	Billed units	56880	97603	(+)41.72%
4	% Line loss	74.05	20.22	(-)53.83%
5	Amt. Billed in Rs	142200.00	244007.00	(+)71.6%
6	No of defaulters	46	28	46% to 17%
7	Arrears (Rs. in Lacs)	1.96	0.54	138% to 22%

CONCLUSION:

The various technical and commercial losses that occurs during the transmission or distribution of electrical energy can be well minimized up to tolerable limits using the "HIGH VOLTAGE DISTRIBUTION SYSTEM". It improves the system efficiency with its reliable operation and hence maximum power transfer capability of the system can also be maintained since the losses due to the flow of reactive power and also the losses accounted due to the theft/pilferage is not possible in the case of HVDS system

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