Rehabilitation of Electrical Power Losses by Implementing High Voltage Distribution System

Arjun S. Solanki , R.K. Pal, Kulsum Aslam

Abstract— **This paper presents the comparison of existing low voltage distribution system with proposed high voltage distribution system. The electrical power system consists of generation, transmission and distribution systems. In recent years the nature of load has changed drastically and different electrical machinery i.e. motors, mercury lamps, switchgear, transformers, are running inherently at low power factor. In India, the average transmission and distribution losses have been officially indicated as 23% of the electricity generated, because of the fact of usage of existing distribution system. As for the low voltage in existing distribution system, current is high which leads to high power losses and also allow the hooking and hence power theft. Since loss reduction in distribution system is of keen importance and main reason behind these losses is the use of low voltage for distribution in existing system. Hence to overcome all these problems, implementation of high voltage distribution system is considered as the best move to enhance the performance of distribution system.**

***Index Terms*— Distribution transformer, High Voltage Distribution System, voltage profile.**

I. INTRODUCTION

This paper presents a new methodology for enhancing the distribution system performance by minimizing both technical and non technical losses. Most of the utility companies in developing countries are victims of major revenue losses due to technical and nontechnical energy losses. The non technical losses are like electricity theft, unauthorized connections, irregular billing and the technical losses are I^2R power losses. These losses affect the quality of supply in terms of voltage magnitude, and more tariffs imposed on genuine customers. In general, electric power is generated at the power stations which are located at the places quite away from the consumers. It is then delivered to the consumers through a large network of transmission and distribution.

This distribution system begins as the primary circuit which leaves the sub- station and ends as the secondary service which enters the consumer's meter. Electric power at 220 kV is transmitted by three phase, three-wire overhead system to the outskirts of the city and this power is then received by the primary sub-station which reduces the voltage level further to 66 kV. Now days, different schemes have been proposed to reduce the losses in the distribution system and hence, to increase the efficiency of electric devices and power distribution networks. The reason for high losses is the use of low voltage for distribution as in the low voltage system; the current is high and thus more losses.

The losses in a system are due to energy dissipated in the conductors and equipment used for transmission, transformation, sub-transmission and distribution of power. Thus by using high voltage for distribution we can reduce the losses as current in HVDS (high voltage distribution system) is low. Since the losses prevailing in the existing power distribution system can be classified as**:** a) Technical losses b) Non-Technical losses**.** Technical losses on distribution systems are primarily due to heat dissipation resulting from current passing through conductors and from magnetic losses in transformers. Technical losses occur during transmission and distribution and involve substation, transformer, and line related losses.

Commercial losses or the non-technical losses are power theft, insufficient metering and billing add heavily to the aggregate losses. Power companies are in loss because of losses in transmission and distribution system, unauthorized connection, theft and unwillingness to pay bills as some customers have attitude that our government is doing nothing for us, at least they can provide us free electricity and some customers are tired of poor quality of supply and thus do not pay their electricity bill.

It is possible to reduce the losses in a reasonably short period of time and that such investments have a high internal rate of return. The existing low voltage distribution network is unsuitable to cater Indian conditions, as voltage profile is poor; losses are high and on tapes are also high. Technical losses as well as on nontechnical losses can be minimized by using proposed HVDS method for distribution.

The main advantage of using high voltage for distribution is to reduce the theft of energy and decrease in unauthorized connection as the LT lines are virtually eliminated and even short LT lines required will be with insulated cables. This makes direct tapping very difficult and thus increases the authorized connection which will improve revenue. Also the current in the proposed method is low due to high voltage and thus low power losses.

Conventional Distribution System

The primary and secondary power distribution network, which generally concerns the consumer in India, is the distribution network of 11kV lines or feeders downstream of the 33kV substation. Each 11kV feeder which emanates from the 33kV substation branches further into several subsidiary 11kV feeders to carry power close to the load points (localities, industrial areas, villages, etc). At these load points, a transformer further reduces the voltage from 11kV to 415V

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to provide the last-mile connection through 415V line also called as Low Tension (LT) line to individual customers, either at 240V as single-phase supply or at 415V as three-phase supply.

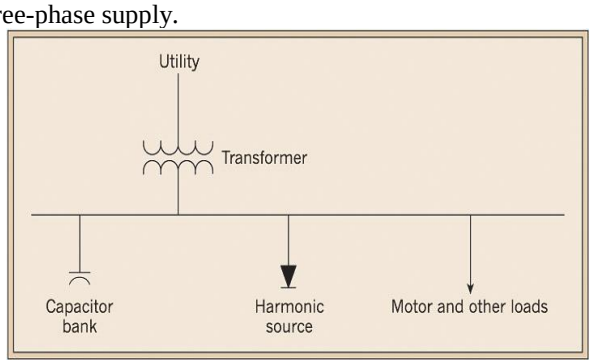


Fig 1. Conventional Distribution System Line Diagram

A feeder could be either an overhead line or an underground cable. In urban areas, owing to the density of customers, the length of an 11kV feeder is generally up to 3 kms. On the other hand, in rural areas, the feeder length is much larger even up to 20 kms. Low voltage distribution is done either by combination of three-phase four-wire, three phase five-wire, single phase three-wire and single phase two-wire low tension lines. This distribution system involves nearly 2:1 ratio of low and high voltage line lengths. Generally, in the process of supplying electricity to the consumers, energy losses occur due to technical and commercial losses.

Causes Of Higher Losses

There are various reasons for higher losses in the existing system. The main reasons are:

- Lengthy distribution lines
- Inadequate size of conductors.
- Over-rated distribution transformers and hence their under utilization.
- Low voltage appearing at transformers and consumers terminals.
- Transformer Losses
- Low power factor
- Poor quality of equipments

II. TECHNIQUES FOR REDUCTION OF LOSSES

To reduce the distribution losses, many techniques are developed and some of the loss reduction approaches are given below

- Reactive Power Compensation
- High voltage distribution system (HVDS)
- High-efficient Transformers
- Aerial Bunched Cables (ABC)
- Conductor sizing
- Distribution Transformers Locating and Sizing

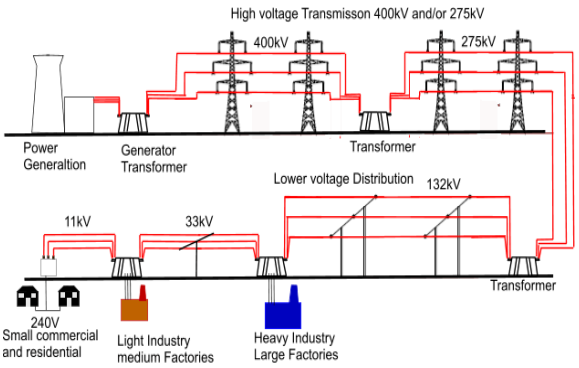
Here we are proposing the High Voltage Distribution System for the reduction of losses in the conventional distribution system. The HVDS is very effective for improvement of system stability, power factor, occurred losses etc. Switching over to three phase High Voltage Distribution System maintains better voltage profiles to different loads and reliability of supply to the consumers in domestic sectors. In HVDS, power is distributed mainly through high voltage lines i.e. 11 kV. This system employs the combination of 11 kV three-phase and single phase configuration of small capacity distribution transformers (5 KVA, 10 KVA, 15 KVA) extending supply to 8 to 10 consumers with least low tension lines, preferably insulated overhead cable system thereby, reducing losses, overloading, distribution transformer failure and improving the efficiency of the system.

This system selects 10 KVA copper wound transformers with no-load loss in order to provide mechanical stability to winding. So if any domestic consumer tries to get unauthorized/illegal power tapping connection, the home appliances are get damaged due to over voltage. Hence, with this approach there is no chance for power theft or unauthorized connections in the distribution system. When the electrical distributor operates with more voltage than the normal operating voltage, the I^2R losses in the distributor will be reduced considerably.

III. HIGH VOLTAGE DISTRIBUTION SYSTEM (HVDS)

In the following procedure Low Voltage Distribution System is converted into High Voltage Distribution System. Where in the 11kV line is taken as near to the loads as possible and the LT power supply is fed by providing appropriate capacity transformer and minimum length of LT line with an objective to provide better quality power supply, reduction of losses and better consumer service.

In the existing system, large capacity transformers are provided at one point and the connections to each load is extended through long LT lines. This long length of LT lines is causing low voltage condition to the majority of the consumers and high technical losses. In the HVDS project, long length LT mains are converted into 11 kV mains and thereby installing the appropriate capacity distribution transformer as near as to the end and the supply is provided to the consumer at suitable voltage level. HVDS is constructed by converting the existing low tension lines to single phase, two-wire high tension lines and replacing low tension three phase cross arm by 11 kV V-shape cross arm.



Simplified UK Electical Power Transmission system

Fig 2. HVDS Sytem

It must be provided with three insulators on which the wires are re-laid. Replacing bare conductors by Aerial Bunched Cable in theft prone areas can help to eliminate power theft. New insulators and hardware supports are erected wherever clearances are required. By converting these lines to HVDS, the current flowing through the lines shall reduce by 28 times and will bring down the technical losses in the LT line drastically. This can be explained by one single illustration that for a 100 KVA load the amperage at 11kV is 5 amperes where as it is 140 amperes at LT voltage of 415 Volts.

There is a tendency of unauthorized connections to hook to the LT lines which results in over loading of the transformers and failure of the transformers. The length of the LT lines is restricted to less than 300 meters. It is noticed that the investment on conversion from conventional system to HVDS is recovered by way of loss reduction within a period of 3 to 5 years in most cases. There are three types of High Voltage Distribution System namely, Single phase and single neutral , two phase two wire and three phase small rating transformer with three phase HV system.

DEVELOPMENT OF H.V. DISTRIBUTION SYSTEM

The salient design features of the system are indicated below: The scheme envisages running 3 phase 4 wire 11 kV line (i.e. 3 phases and one neutral) from a 33/11 kV sub-station. 11 kV single phase 2 wire branches are extended and one 230-0-230 V or 6.35 kV/240V distribution transformer is erected to feed single-phase loads. Since single- phase motor capacity is limited to 15 HP, motive power loads of above 15 HP are given by extending main line.

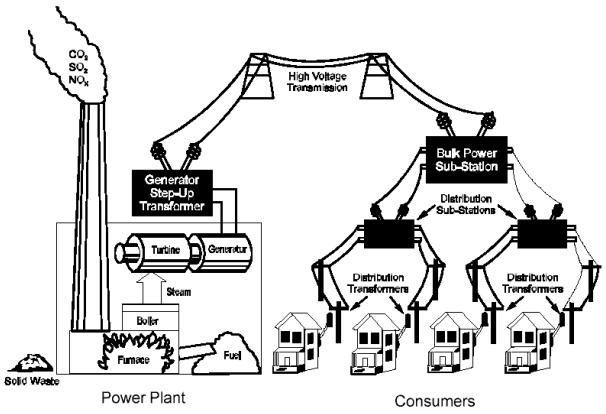


Fig 3. HVDS Implementation

MERITS OF HVDS

The advantages of H.T. distribution system are as follows

- Smaller size conductors can be employed.
- No frequent fuse blow outs.
- Negligible transformer failures.
- Excellent voltage profile.
- Reduced losses.
- Unauthorized hooking of loads is not possible as LT lines are short and insulated.
- High quality of power supply earns total consumer satisfaction.
- Reduction in line losses since HV line is taken.
- Due to reduction in KVA capacity, voltage drop on low voltage lines is negligible
- Improving voltage profile by minimizing the voltage fluctuations.
- Failure of agriculture DTRs are minimized as LT overhead line is avoided.
- Less burnout of motors because of good voltage and less fluctuations.

Since losses are reduced considerably, power can be supplied to additional loads without any further investment on infrastructure.

IV. METHODOLOGY

In this section, problem for calculation of losses in power lines and distribution transformer for both existing LT system and proposed HVDS system are discussed. To understand it clearly, losses in both the cases and their comparison is shown in tabular form.

To determine power losses in the LT line, we require value of resistances for conductor, here rabbit conductor of 50 mm^2 is used, voltage on LT side is 400V and 11kV for HVDS.

Table I: Transformer Losses

S. No.	KVA Rating	No Load Losses or Iron Losses (W)	Load Losses or Cu Losses (W)
1	5	40	150
2	10	40	225
3	15	60	275
4.	25	110	720

CALCULATION OF POWER LOSSES, LOSS REDUCTION, ANNUAL SAVING AND PAYBACK PERIOD

Power losses in the line is calculated for each branch and then total power loss is calculated by taking the summation of each branch as given by (1).

$Pi = 3 \times I2 \times R \times L$ … (1)
Total loss, $PT = PL + PO + P$ … (2)
Total Loss per annum, $Pa = (PT \times 8 \times 365) \div (1000)$ … (3)

Reduction in Losses = Losses in existing low voltage system – Losses in HVDS … (4)
Annual Savings = price of a unit × reduction in Losses … (5)
Payback Period = (Capital Outlay ÷ Annual Savings) … (6)

Where,

Pi = power losses of the branch ‘i’
P = Total power losses in line
PL = Transformer load losses
PO =Transformer no load losses

Pa = Total Loss per annum
Number of hours = 8
Number of days in a year = 365
Price of a unit is taken as Rs 5

Table II: Detail of Line Length and Transformer in Existing System and Proposed System

S.No.	Parameters	Existing LT System	Proposed HVDS System
1	Length of HT	0	1.32 km
2	Length of LT	1.32 km	0
3	Number of transformer	100 KVA – 1 no.	6.5 KVA- 4 no. 10 KVA- 5 no. 16KVA- 2 no.

V. CONCLUSION

The above used HVDS scheme for reduction of losses is one the most suitable technique in distribution of electrical power. The HVDS scheme has generated a learning curve, leading to formulation of new strategy of energy conservation and reduction of transmission and distribution losses and also the reduction in cases of power theft. By using HVDS a continuous watch is kept on reduction in input units and increase in billed units and the amount of energy saved is calculated terms of money.

- Increase in energy saving and reduction in losses.
- More reliable and thus reduces the number of outages.
- The chances of unauthorized connections and theft of energy are reduced.
- It will improve the power quality.
- Prevent unauthorized loads by the consumers.

Finally after all these studies we can conclude that, for long term prospect switching to HVDS from LVDS is an economical, efficient method. However initial cost is more because of use of more number of transformer, but this cost is compensated in a short span of time.

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