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Loss Reduction in Agricultural Feeders Through HVDS Concept

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Abstract - *In the past, the consumption of electricity is prime motto, as it is available in lot with a capacity to do work, but as the time spent, now time is to conserve the electricity not to consume the electrical energy. In fact, it has become essential ingredient for improving the quality of life and its absence is associated with poverty and poor quality of life. Sub-transmission and distribution systems constitute the link between electricity utilities and consumers. Efficient functioning of the segment of the electricity utility is essential to sustain the growth of the power sector and the economy of the country. So, the present situation is characterized by unacceptable high losses, power quality and reliability of supply, billing sector, revenue collection, frequent interruptions in supply and thus consumer dissatisfaction etc. Distribution Sector requires economical system to provide electrical energy at a suitable prize and at a minimum voltage drop to reduce the voltage regulation. So, we require the economical way to provide the electrical energy by State Electricity Boards to various consumers at minimum voltage drop and reduce the regulation of voltage. This paper presents the various aspects of High Voltage Distribution System commissioned for improvement of voltage drop profile in the distribution sectors for economical way to customer's satisfaction.*

***Key Words*: Annual Savings; feeder; High Voltage Distribution Sytem; Payback Period.**

1. INTRODUCTION

In agricultural area, India's power sector is characterized by inadequate power supply and financial insolvency. The efficiency of the existing distribution is generally low and the system losses are untenably high specifically at the long low tension (LT) networks. The delivery of power from sources to the consumer points is always accompanied with power losses. Such non-negligible amount of losses has a direct impact on the overall efficiency and financial issues of the existing distribution system. Therefore, method for losses reduction is essential for achieving the financial goals of distribution companies. To make it easier to investigate losses in electrical distribution system; it is helpful to divide different types of losses into two categories as Technical losses and Non-Technical losses. Reduction of technical losses leads to a real gain in energy and reduced capital-intensive investments. On the other hand, the reduction of non-technical losses improves the financial balance of the company concerned. Technical losses consist I2R losses which occur especially in overhead distribution lines. The electrical energy losses in distribution lines are wasted in the form of I2R losses. These I2R losses are current depending losses and mainly caused by the use of low voltage in distribution. As in the existing distribution system; the current is high due to low voltage and thus occurs more I2R losses [1,2]. Technical losses also include transformer losses. The transformer losses can be classified into two components, namely, no-load and load losses. No-load losses occur from the energy required to retain the continuously varying magnetic flux in the core and its invariant with load on the transformer. Load losses are a function of the winding current. It mainly arise from resistance losses in the conducting material of the windings and it varies with load. The other category, the non-technical losses mainly include electricity theft in existing distribution system. Electricity theft is done by direct hooking of loads in LT lines. Non-technical losses are also known as "Commercial losses". Mostly, non-technical losses are associated with LT lines. In some regions, the electrical energy is illegally taking from the nearest LT line. Electricity theft by direct hooking and making unauthorized connections are the most common and visible form of non-technical losses. Hence, these unauthorized load connections are the main sources of the non technical losses. In this paper, I^2R losses and payback period is determined.

1.1 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 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. 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. A 415V line should normally be restricted to about 0.5-1.0 km. In existing distribution systems, the voltage at buses reduces when moved away from the substation, also the losses are high. The reason for high losses is the use of low voltage for distribution as the current is high in the low voltage system

and thus more losses. Thus by using high voltage for distribution we can reduce the losses as current in high voltage distribution system (HVDS) is low. In the existing system pilferage is very easy because of lengthy bare LT conductor, and thus many unauthorized connections are tapped from the bare LT conductor.

2. Losses in Distribution System:

Mainly the Distribution losses are classified into two types as (i) Technical Losses and (ii) Non-Technical Losses.

Technical Losses include the losses due to the heat dissipation resulting from current passing through conductors and magnetic losses in transformers, Resistive losses in windings and the core losses, resistive losses in service line and losses in kWh meter. These losses cannot be eliminated but can be reduced. Non-Technical Losses are the losses which include, power theft by hooking the lines, unauthorized connections from the power line, loss at the loose connection ends etc. These losses can be eliminated by taking some precautions. Power losses are mainly classified into Transmission losses, Distribution losses and Theft and billing deficiencies. Distribution losses and theft losses are mainly because of transmitting power at low load voltage profile to more number of consumers using High rating kVA Transformer. It is clear that, Distribution losses are more when compared to Transmission losses. This is mainly because of the present existing Low Voltage Distribution Systems (LVDS).At present the distribution system is Low Voltage Distribution System (LVDS). Distribution system with low voltage employs four core cables and LT lines and multiple loads fed from a bulk power transformer resulting in losses.

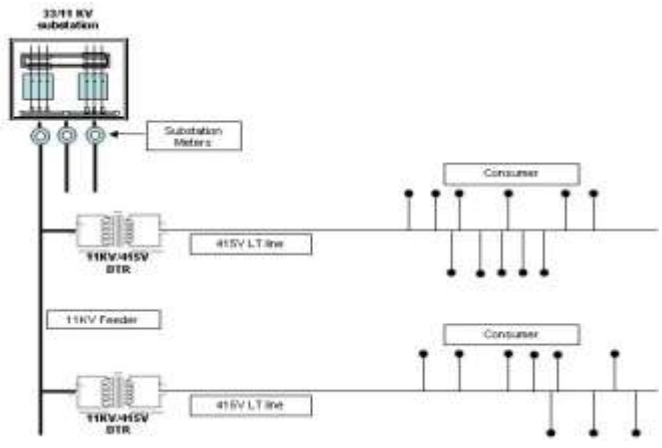

Fig.1 depicts a 100kVA rating Mother DTR converts 11kV into 415V and is supplied to the consumer loads near substation. A 100kVA DTR is supplying load to a particular area. In present system from Mother DTR to the loads, Low Tension lines are used by using the poles.

Commercial reasons for high distribution losses:

Commercial losses are near about 18% to 20% .Theses are related to theft of energy, meter reading, faulty meters and error in billing of customer and unmetered supply to customers. 99.95% of these losses occur on LT network.

3. Reasons for Higher Losses:

To understand the method to reduce the losses, it is necessary to look for various reasons for higher losses in the existing system. The main reasons are:

a. Lengthy distribution lines

b. Inadequate size of conductors

c. Over-rated distribution transformers and hence their under utilization

d. Low voltage (less than declared voltage) appearing at transformers and consumers terminals

e. Distribution transformer not located at load center on the secondary distribution system

f. Low power factor

g. Poor HT/LT ratio

h. Poor quality of equipments

i. Too many stages of transformations

j. Transformer Losses

k. Bad workmanship

l. Direct tapping by the non-customers

m. Pilferage by the existing customers

n. Defective metering, billing and collection functions.

4. Loss Reduction By High Voltage Distribution System:

To improve quality (Voltage profile) of electric supply and reduce losses in the system, HVDS can be used by the Discoms as an alternate to LVDS, in which 11 KV lines are extended upto or as nearer to the load center as possible, and small size transformers ranging from 10KVA to 100KVA etc, depending on load requirement can be installed to supply power to consumers. To avoid the pilferage of electrical energy due to theft by hooking the LT lines, LT line with insulated wires like Aerial Bunched Cables (ABC) can be installed through overhead or undergone system. This system requires more DTs, its associated accessories, more HT lines and less LT lines than LVDS system.

HVDS project is to reconfigure the existing Low voltage (LT) network as High Voltage Distribution System, wherein 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. 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. The prevailing low voltage in the LT line is also affecting the efficiency of the electric gadgets and breakdown is also very high. Also 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 scheme consists of converting the existing 3 phase 4 wires lines to 11 kV systems using the existing supports and providing intermediate poles wherever necessary and individual transformers are provided to both agricultural loads and loads other than agriculture. The length of the LT lines is restricted to less than 300 meters. HVDS is most effective method in reducing the technical losses and improving the quality of supply in power distribution system. In this system high voltage lines are extended to as nearer to the loads as possible and erect small size transformers. This system aims at LT less system or less LT and the unavoidable short LT lengths to be covered by insulated wires like ABC (Aerial Bunched Cables). The major advantages of using ABC in HVDS are that the faults on LT lines are totally eliminated, thus improving reliability and also theft by direct tapping is avoided. As the authorized consumers do not allow unauthorized tapping by another as their transformer gets overloaded or may get damaged, resulting in outage of power supply for longer durations.

Table -1: Sample Table format

S. No.	Transformer Rating (KVA)	No-Load Losses (Watts)	Full-Load Losses (Watts)
1.	16	60	275
2.	25	110	720

Fixed Value of No-Load and Full-Load Transformer Losses:

5.Comparision between LVDS and HVDS

Low Voltage Distribution System (LVDS) system For supplying the power to the consumers, it is generally a practice of Distribution company (Discom) to lay 11KV lines from 33/11Kv Substation, erect a 3phase 11kv/0.415KV Distribution Transformer (DT) substation at one convenient location, and then lay long LT lines up to the nearest load center to give connections to the consumers /households. In this case, DTs of various capacities, depending on load requirement are installed to supply the power to one or more than one consumers. If loads of consumers are less, then even more consumers would be supplied from one DT.

Disadvantages with LVDS

i. Poor tail end voltages/poor voltage regulation.

ii. High technical losses due to more line losses in longer LT lines.

iii. More scope of power theft due to accessibility of bare LT lines

iv. Frequent jumper cuts and fuse blow outs at DT level due to over loading etc.

v. Fault in a single high capacity DT like in LVDS affects the entire consumers connected to it, and this causes a total outage, poor availability and reliability of power supply to the consumers in the area.

vi. Difficulty to augment the DT capacity (in case the existing DT is overloaded) due to non-availability of space (for DT beyond 200KVA capacity). To accommodate bigger size DTs, changes would be required in DT mounting structure or DT to be installed on Plinth structure.

vii. To avoid the pilferage of electrical energy due to theft by hooking/ tapping the LT lines, conversion of longer LT overhead lines with bare conductors to Aerial Bunched Cables (ABC) through overhead or underground system is more expensive.

High Voltage Distribution System(HVDS):

To improve quality (Voltage profile) of electric supply and reduce losses in the system, HVDS can be used by the Discoms as an alternate to LVDS, in which 11 KV lines are extended upto or as nearer to the load center as possible, and small size transformers ranging from 10KVA to 100KVA etc, depending on load requirement can be installed to supply power to consumers. To avoid the pilferage of electrical energy due to theft by hooking the LT lines, LT line

with insulated wires like Aerial Bunched Cables (ABC) can be installed through overhead or undergone system. This system requires more DTs, its associated accessories, more HT lines and less LT lines than LVDS system.

Advantages of HVDS:

i. Low technical losses due to reduction of LT lines

ii. Loss due to theft/tapping can be reduced /eliminated in smaller length of LT lines & by use of ABC conductors with less expense.

iii. Improved voltage regulation at consumer end due to low voltage drop resulting from less loading and shorter line length.

iv. Fault in any single DT will cause an outage for a limited numbers of consumers connected to it, leading to improved availability and reliability of power supply to the other consumer consumers in the area.

v. Reduced physical zone of supply and number of consumer through a lower capacity DT will lead to development of community consciousness and ownership feeling. This will be helpful in timely maintenance of transformer and curb on theft.

vi. Ease of augmentation of DT capacity in case of increase of load.

vii. Help in reducing the demand in distribution, transmission and generating system when used in large scale by Discoms.

The selection of the HVDS over LVDS should be based on Cost-Benefit Analysis arrived at by comparing two systems under similar conditions for entire useful life.

6. Results and Conclusions:

Calculation of Payback Period of Network Reconductoring

The total cost of network reconductoring i.e thickening the conductor is estimated in equation. The total capital outlay include the cost of material ,Cost of labour charges ,cost of transportation charges and also the cost of storage and handling. Here, the reduction in losses, annual savings and payback period are determined by the following formulas:

In this scheme, total capital outlay is estimated as = 506852.99

Reduction in losses(watts)= [Total losses in existing distribution system-Total losses of proposed HT distribution system]

= 15820.2029 - 3497.61

= 12322.59 Watts

Reduction in losses per annum in terms of units = (12322.59 x 8 x 250)/1000

= 31640.4 units

Annual savings = price of a unit x Reduction in losses per annum in terms of units

= 2.00 x 31640.4

= 63280.8 Rs.

Payback Period = (Total Capital Outlay / Annual Savings)

= 506852.99/63280.8

= 8.0095 years

Hence, the output result of the reduction in losses, annual savings and payback period are calculated.

7. CONCLUSION

By comparing the two methods for reduction of losses we found that HVDS method has more payback period than Network Reconductoring but losses are reduced much greater than network reconductoring. HVDS scheme has led to the formulation of new strategy of energy conservation and minimisation of transmission and distribution losses by reducing the power theft. The adoption of HVDS has been indicated as the necessary factor in efficient energy distribution and developing the proper utilization of electricity and efficient distribution of energy in agricultural sector thereby, tackles the problems faced by the farmers. It reduce thefailure of transformers, burning of agricultural pump sets and curtailment of demand through retrofitting of energy-efficient pumps. This in turn, reduced the wastage of energy and optimization of power intake, thereby promoting the environmental concerns and because of reduced consumption, the farmer gets benefited by the reduction in his monthly expenditure on electricity. It is concluded that the use of distribution transformer of small rating for two or three consumers has reduced the outages, transformer and power losses due to low current and pilferage to a great extent. Also, the accountability of the farmer has increased resulting in moral ownership of the transformer dedicated to single pump.

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