High Voltage Distribution System (HVDS)-An Alternate for Improvement of Voltage Drop Profile

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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.***

Keywords: Low voltage distribution system (LVDS), High Voltage Distribution system (HVDS), Aerial Bunched Cables (ABCs), Annual savings, Payback period, voltage profile.

I. INTRODUCTION

HVDS system is to reconfigure the existing Low voltage (LT) network as High Voltage Distribution System, wherein the 11kV line is taken as neat to the loads as possible and the LT power supply is fed by providing appropriate capacity transformers and minimum length of LT lines with an objective to provide quality power supply, reduction of T&D losses and better consumer services. In the existing system of LT system, large capacity transformers are provided at one point and the connections to each load is extended through the LT lines. This long length of LT lines is causing low voltage conditions to the majority of consumers and high technical losses. In the HVDS projects, long length LT mains are converted into 11kV mains and thereby installing the appropriate capacity distribution transformer as near as to the end point and the supply is provided to the consumer at suitable voltage level. By converting the LT lines into HVDS system, the current flowing through the lines shall reduce by 28 times and will bring down the technical losses in the LT lines drastically.
HVDS system is the most effective method in reducing the technical losses and improving the power quality of supply in power distribution network. In this system, high voltage lines are extended to as nearer to the loads as possible and erect the small size transformers. HVDS system aims at LT less system or less LT lines and the unavoidable short LT lengths to be covered by insulated wires like ABC (Aerial Bunched Cables) [1]. The major advantages of using ABC in HVDS are that the faults on LT lines are totally eliminated. As the authorized consumers do not allow unauthorized tapping by another consumer as their transformer gets overloaded or may get damaged, resulting in outage of power supply for longer durations. It is noticed that the investment on conversion from conventional low voltage system into HVDS is recovered by way of loss reduction within a period of 3 to 5 years in most cases. Intiatives: AT&C loss REDUCTION [2] There are two technological interventions for T&D loss reduction used in the distribution systems:

1. Energy Audit upto the DT level: prioritizing focus.
2. HVDS and LT ABC Implementation: Technology interventions for theft prevention.

These are methodologies used in the distribution sectors controlled by State Electricity Boards, but the time consumption are more and thus, the result are not satisfactory and upto the desired level.

II. REASONS FOR HIGHER T&D LOSSES

It is found that around 30% of losses are occurred during the transmission and distribution of power in our country. So, it is necessary to look for various reasons for higher losses in the existing LT system. The main reasons are:-

1. Lengthy distribution lines.
2. Inadequate size of conductors.
3. Over-rated distribution transformers and hence their under utilization.
4. Low voltage (less than declared voltage) appearing at transformers and consumers terminals.
5. Distribution transformer not located at load centre on the secondary distribution system/
6. Low power factor.
7. Poor HT/LT ratio.
8. Too many stages of transformation.
9. Higher transformer losses.
10. Bad workmanship.
11. Direct tapping by the non-customers.
12. Pilferage by the existing customers.
13. Defective metering, billing and collection functions.

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Technical losses	Commercial losses
• Ill maintained equipment and substations, ageing transformers. • Inadequate investments for infrastructure improvements. • Overloading of system elements like transformers, feeders, conductors etc. • Insufficient reactive power compensation e.g. inappropriate capacitor banks. • No re-configuration of feeder lines and distribution transformers so as to reduce the length of LT lines and • Non usage of smaller size energy efficient distribution transformers	• Theft and pilferage. • Low metering efficiency. • Non-reading of meters. • Faulty meter reading. • Inefficient billing. • Under billing. • Faulty bill distribution. • Software errors. • Prolonged disputes. • Inadequate revenue collection. • Revenue accounts not updated regularly and • Insufficient collection avenues.

III.ADOPTION OF HIGH VOLTAGE DISTRIBUTION SYSTEM (HVDS) [3]

Adoption of HVDS by converting existing LVDS to HVDS reduce the technical losses appreciably. This can be explained by one single illustration that for a 100kVA load, the amperes at 11kV is 5Amps whereas it is 140Amp. at LT voltage of 415Volts. The loads in rural areas are widely dispersed and to feed a small load. LT lines run for long distances. Prior to introduction of HVDS 11kV 3-Φ lines were being run up to large sized 3-Φ transformers 11kV/433V from which lengthy 3-Φ LT lines were run. Such a system is not suitable especially for rural areas, as voltage profiles are weak, poor, losses are high and outages in supply are also high. HVDS envisages running 11kV lines right upto a cluster of 6-10 customers, employing small sized distribution transformers (15kVA) and extending supply with nil LT lines. In case of LT lines of 415V, 3-Φ, efficiency of the electric gadgets is also affecting 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 transformer. So, HVDS scheme consists of converting the existing 3-Φ 4-wires lines to 11kV systems using the existing supports and providing intermediate poles wherever necessary and individual transformers are provided. The length of LT lines is restricted to less than 300meters, whereas in HVDS system 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 systems.

ADVANTAGES OF HVDS SYSTEM

1. LV system losses can be minimized to the lowest level.
2. Pilferage can be minimized by introducing this system.
3. Comparative analysis of reconfiguration of existing LV distribution system with HVDS concepts.
4. The registered customers will feel ownership and take responsibility.
5. Failure will be minimal because of no over loading and no middling of LT lines.
6. In the event of equipment failure only limited number of customers will get affected instead of maximum customers in original system.
7. Customer has sense of ownership.
8. Prevention of unauthorized loads is more effective.
9. Considerable reduction in the line losses are there and consequent there is savings in power purchase cost.
10. No additional generation capacity is needed for giving new loads due to reduction in power drawls.
11. Since the losses are reduced considerably, power can be supplied to additional loads without any further investment of infrastructure.

HVDS envisages running 11kV right upto a cluster of 6 to 10 customers or 2 to 3 pump sets, employ small sized distribution transformers (15kVA) and extend supply to these customers with least LT lines. Thus keeping the above parameters, HVDS system can be classified as:-

1. Single phase single neutral HVDS system.
2. 2-phase 2-wire system and
3. 3-phase HVDS system.

1-Φ HVDS system: In this practice, 1-phase high voltage 11kV line is taken near to consumer and it is taken near to consumer & stepped down to lower voltage. 1-phase transformer is connected between phase & neutral (earth). 1-Φ system is mostly used on domestic areas. Neutral point/ line can be drawn from the substation otherwise multi grounding can be done near to transformer to provide the power supply to consumers. Loads can be connected to transformer by using LT Air bunched cable to avoid theft due to authorized tapings. 1-Φ HVDS system can be applicable for:-

- Medium / Low density areas where 1-phase consumers are spread.
- Areas where building clearance is difficult.
- Areas where roads are narrow.
- Absence of proper planned civil layout.
- Areas where no difficulties in multi grounding is there.
- Areas where no difficulties in laying new neutral line from substation are there.

1-Φ HVDS system was first attempted as 1-phase system, running one phase of 11kV and one neutral wire from 33/11kV substations, install small sized 5, 10 or 15kVA single-phase transformers 6.3kV/230-0-230V and changing all 3-Φ pump sets to –Φ pump sets. Fig. 1 shows the 1-Φ HVDS system for rural residential consumers.

FIG. 1

3-Φ HVDS system: Existing LT lines are upgraded to 11kV and small capacity 3-Φ Distribution Transformers (15kVA) are employed. The 3-Φ load is feed by the 3-Φ small capacity transformer. This results in improvements in tail-end voltage, reduction of losses etc. in this practice, 3-Φ high voltage 11kV line is taken near to consumers and it is stepped down to lower voltage. Depending on requirement of loads, 3-Φ or 1-Φ supply is used in Industrial areas. The raring of transformers used are 400kVA, 315 kVA, 250 kVA, 160 kVA, 100 kVA, 63 kVA and 25 kVA. Loads are connected by using LT Air bunched cables for to avoid unauthorized tapings.

3-Φ HVDS system can be applicable for:-

- Medium / Low density areas where mixed load conditions 3-phase or 1-phase consumers are spread.
- To avoid theft due to unauthorized tapings.
- Design of Low loss system.
- Requirement for higher reliability of system.

As the physical survey of the urban and rural distribution feeders, it was found that the following parameters cause the extensive increase in the losses & decrease in revenues generation:-

- Lengthy overhead lines.
- Over rated Transformers installations.
- Under-sizing of conductors.
- Poor maintenance of the lines and installed transformers in the urban areas.
- Magnetostiction and oil leakage in the transformers.
- Poor combinational conductor laying in the urban areas.
- Installations of many transformers to feed many consumers in one vicinity.
- Poor/ No Tap changing installed on the feeders.
- Poor jointing and termination of the consumers.
- Inefficiency in power factor improvement.

The comparison of existing Low voltage distribution system with proposed high voltage distribution system (HVDS) in terms of losses in the agricultural feeders had been investigated and with the feasibility of the proposed work, the annual savings of Rs. 86.325 lakhs with a payback period of 2.27 years was computed [4]. The HVDS system had also improved the voltage profile in the distribution system as per IEC regulations from 407.57V to 414.16V to the last consumer on the agricultural feeder. In the distribution system,

(i) 8% voltage drop is allowed between primary of 1st transformer & end of secondary of last transformer with maximum load on circuit.

(ii) Regulators are set up to provide a voltage at primary of 1st transformer of about 4% more than normal voltage.

The size of secondary distribution is to be designed for voltage drop is such that it is within the limits to maintain voltage at last consumer's premises the limit.

The methods of reduction of losses and maintaining the voltage profile constant in Distribution system by implementing HVDS over LVDS had been studies with the MATLAB simulation applied on Distribution System [5]. The voltage profile is seen as constant profile throughout with different RL loads and different ratings of Induction motors, located at different distances from the distribution transformers (DTRs) such as nearer to 100kVA transformer, at some distance, located far away and at the extreme corner of the DTRs. The rating of the distribution transformers (DTRs) should be judiciously selected to keep the losses in the permissible limits. For the existing LVDS system, the appropriate capacity of distribution transformer may be taken as very nearly equal to the maximum demand at good power factor, but the voltage profile at the extreme corner/load point is as least as not required as per the IEC regulations. This is due to power factor demand of the loads. Simulation studies have shown that by having Express feeders, the voltage profile can improve and losses can be reduced by around 25% & a total benefit of 50% loss reduction can be achieved by HVDS system [6]. The implementation of high voltage distribution systems is not carried out on all rural feeders which can be taken in war footing.

PROTECTION SCHEMES [7] The distribution circuit neutrals and equipment are earthed (i) to stabilize the circuit voltage to earth, (ii) to provide maximum protection by limiting the voltage stress to earth of the insulation of the equipment and (iii) to provide the maximum safety to operators. The neutral of the distribution system is grounded properly. The main protection provided for the distribution system is (i) protection against the lightning using valve type of expulsion type lightning arrestors and (ii) over-current protection using fuses and fused cut-outs, circuit-breakers are used for heavy short-circuit currents and also automatic reclosers. The protective devices are well-coordinated.

The installations of Fast-acting current limiting devices in the electrical distribution system in order to reduce the short-circuit current to acceptable values [8]. The type of electrical distribution system depends on many factors, one of the most important being the amount of power required. Other factors such as the availability of the power supply are equally important but not directly related to the maximum available short-circuit current. In addition to the higher values of short-circuit current, the nominal current will increase.

Current limiters are good solutions to solve the problem of unacceptably high short-circuit currents in industrial sites. Their use has been proven over the years and in addition to clearing severe faults, they also reduce the strain on healthy equipment by limiting the peak currents and thus the mechanical stresses the downstream equipment. Current limiters can be easily integrated into the MCB Set line up and thus be designed and installed like a medium-voltage switchboard.

IV. METHODOLOGY

The following criteria is followed for analyzing HVDS network for its implementation:-

- Data Source is required which can be taken by GIS.
- Sum of Sanctioned Loads (for all zones of distributed feeders)/Maximum demand Index (MDI) for individual connections on individual transformers to be taken with appropriate diversity factors for domestic loads where no. of connections are more than 4 and for non-domestic loads where no. of connections are more than 8.
- Suitable load growth (feeder specific) is applied on individual transformer to estimate loading on transformers after 2-5 years.
- For every transformer, where proposed loading is more than 90% to its rated capacity, proposal in form of load shirt on nearby unloaded transformer, swapping with under-loaded transformer, augmentation of transformer or addition of new transformer can be given.
- Prioritization of proposals based on proposed loading on the transformer and cost implications may be formed.

By meticulously following the above mentioned steps, the Distribution Transformer utilization factor have considerably increased as compared to past features.

V. EFFORTS TO ENCOURAGE ADOPTION

It is shown that the high voltage distribution system scheme had led to the formulation of new strategy of energy conservation and minimisation of transmission and distribution losses by reducing the power theft. So, the efforts for implementation of HVDS scheme are made to its adoption by each and every power utility for better voltage profile and reduction in AT&C losses. The following states of our country had made a serious effort for the implementation of the same:-

- Andhra Pradesh is the leading state for implementation of HVDS scheme
- Greater Noida
- Madhya Pradesh
- Haryana in their Agricultural sector
- Punjab in their Agricultural sector.
- Delhi.

In Delhi, the HVDS scheme was implemented by Tata Power Delhi Distribution Limited (TPDDL). In Delhi distribution system at Pragati Nagar, the total installed capacity of Distribution transformer (DTRs) is 5287MVA, in which distribution type DTR accounts for 2445.91MVA, HVDS DTR accounts for 2386MVA and the HTC consumer accounts for 455.549MVA. The peak demand during the summer of year 2013-14 was 1573MW (1797MVA). So the DTR utilization factor is 34%. So, HVDS presents one of the best least cost options for reducing the distribution losses and for providing reliable and quality supply to the consumers of Delhi. The payback period calculated is about 3.2years.

VI. CONCLUSION

It is found that the substantial amount of generated power is being wasted as transmission and distribution losses. So, loss minimization in power system has assumed greater significance. HVDS scheme has led to the formulation of new technique of energy management and minimization of losses. The adoption of HVDS has been indicated as the necessary factor in efficient energy distribution and developing the proper utilization of electricity. It is concluded that the use of distribution transformer (DTRs) 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. The restricting of LVDS as HVDS in agricultural field presents one of the best technically feasible and financially viable method for reliable and quality power to the consumers. HVDS system is more advantageous as it has improved voltage profile and reduced power losses. Even though there is a drawback of high initial investment, payback period is very less. One more drawback of this system is that it is only concentrated to the agricultural sectors, the same work can be extended to the commercial, large residential and unbalanced distribution systems. The protection of the HVDS scheme is also the major concern for its efficient use, as the chances of failure of supply to the consumers are significantly large.

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