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Challenges in Preparation of Detailed Project Report for High Voltage Distribution System (HVDS) Scheme – A Case Study

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High Voltage Distribution System (HVDS) is being implemented in many utilities across our Nation. In rural areas, loads particularly agricultural consumers are widely dispersed and low tension lines of 433 V run for long distances to feed a small load. Two or three low tension spans are to be laid to fetch a load of one pump set and such 30 to 40 pump sets are connected on each distribution transformer of 63 kVA or 100 kVA. These transformers are generally overloaded due to long LT lines and more number of consumers connected. This paper describes about the various aspects in preparing HVDS scheme on an overloaded 100 kVA transformer and its Cost Benefit Analysis (CBA).

Keywords: *HVDS, LVDS, Distribution transformer (DTR), Low tension (LT)line – 433 V, High tension (HT)line – 11 kV.*

1.0 INTRODUCTION

It is estimated that huge losses are lost in LT 3-phase 433 V distribution System. This is mainly due to the high capacity (63 kVA and above) transformerslocated away from load centre, serving loads of different category through long length of LT lines.

The HVDS scheme aims at reducing losses through conversion of the existing low voltage distribution system to high voltage distribution system. This is done through

- Restructuring of the existing low voltage distribution network to high voltage distribution network and installation of three phase 25kVA, 11/ 0.433 kV transformers to serve the loads.
- Erection of LT ABC in LV lines to serve the loads, there by completely avoiding the pilferage of energy and reduction in commercial losses.

The main advantages [1] in conversion of conventional LVDS to HVDS are

(i) For the distribution of same quantum of power, the comparison of losses and voltage drop will be reduced with HVDS.The consequential benefits are:

   (a) Small size A.C.S.R or aluminum alloy conductor or high conductivity steel wire can be used as HV current is low.

   (b) Better voltage profile.

   (c) Reduced line losses.

   (d) Direct tapping of L.T. lines is avoided.

(ii) Both reliability and security of power supply are improved.

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2.0 METHODOLOGY

CPRI along with utility engineers carried out 'walk-down' survey of selected highly loaded DTR on entire Low Voltage (LV) – 433 V network nearly 2.32 kM and collected available data in the field whose LT network is shown in Figure 1 and load details in Table 1.

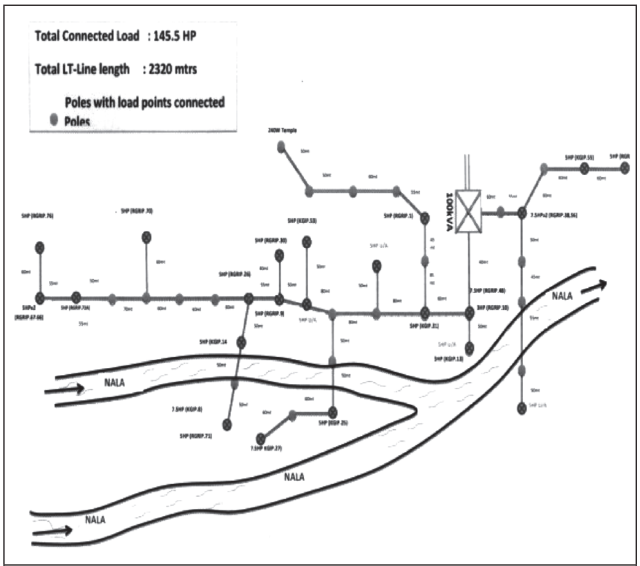

FIG. 1 100 KVA DISTRUBUTION TRANSFORMER FEEDING AGRICULTURAL LOADS

TABLE 1

CONNECTED LOADS ON 100 KVA DTR

Sl. No.	RR No	Capacity
1	KGIP-13	5 HP
2	KGIP-31	5 HP
3	KGIP-8	7.5 HP
4	KGIP-55	5 HP
5	RGRIP-48	7.5 HP
6	RGRIP-10	3 HP
7	RGRIP-01	5 HP
8	RGRIP-56	7.5 HP
9	RGRIP-38	7.5 HP
10	RGRIP-91	5 HP
11	KGIP-53	5 HP
12	RGRIP-26	5 HP
13	RGRIP-30	5 HP
14	RGRIP-09	5 HP
15	RGRIP-71	5 HP
16	RGRIP-76	5 HP
17	RGRIP-70	5 HP
18	RGRIP-72 A	5 HP
19	RGRIP-67	5 HP
20	RGRIP-66	5 HP
21	KGIP-14	5 HP
22	KGIP-25	5 HP
23	KGIP-27	7.5 HP
24	4X5 HP Unauthorised	20 HP (Not registered)

The total connected load is 145.5 HP With the same connected loads, the Figure 1 LVDS is converted to HVDS The task of conversion needs to re-construct [2] the LT network with replacement of 11 kV pin insulators & 11 kV cross arm to provide necessary clearances between phase to ground and phase to phase. The existing poles and conductor remained in place with no change. However, the conductor is straightened wherever sag is more and few poles are inserted at intermediate points to provide sufficient clearance to the ground.The current carrying in the LT lines would be 133 A weasel conductor is used for LVDS and after conversion the same line to HT, the current would be approximately 4 % of the current flown in LVDS. Therefore, change of conductor is not required. The low capacity three phase transformers are erected on the poles, which need not require a plinth or Double Pole (DP) structure. From secondary distribution box, service wires are run to connect 2 - 5 numbers of consumers. An aerial bunched cable (ABC) is used as LT conductor instead of bare conductor, wherever required. Figure 2 shows the network after conversion to HVDS.

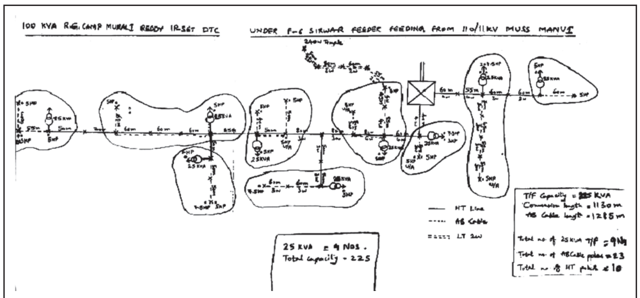

FIG. 2 100 KVA NETWORK AFTER CONVERSION TO HVDS

2.1 The salient features of the scheme are as given below:

- Distribution transformer of 100 kVA is taken up in a rural section whose LT line length is 2.32 kM and over loaded by 50% approximately. Based on available field data, DTR with lengthy LV line and highly loaded is DTR is selected for implementation of HVDS. No meter is installed near this DTR and any of the consumers (Agricultural loads).

- Perform load flow analysis for LV network of selected 100 kVA DTR and compute LVline voltage drop, peak power loss and energy losses.
- Determine the number of 25 kVA transformers required for conversion to HVDS for the selected high capacity transformer.
- Small capacity DTR of 25 kVA is located in such a way that
  - o LV AB cable/LV line incident on the DTR is not more than 3 - 4 spans.
  - o The load of pump sets incident on each DTR is around 80 % of the DTR capacity. This is because the existing 3/5/7.5 HP pump sets which are mostly nonstandard and rewound which draw higher currents than the rated currents. Ex. 25 kVA DTR, 3 x 5 HP or2 x 7.5 HP are proposed. In case of combination of 3, 5 and 7.5 HP, the total load of pump sets is limited to around 80% of the DTR capacity as stated above. However, near 4 nos. of DTRs, the loading is around 90%. Out of four DTRs, 3 DTRs includes unauthorized pump set of one number each.
- Accordingly conversion of LV line to 11 kV is proposed from the starting point of LV network of high capacity DTR to cover the small capacity DTRs located as mentioned.
- Small capacity 3 Phase distribution transformers of 25 kVA will be erected as many as and wherever required.
- The existing LV– 3 Phase (433 V), 4 wire line will be converted to 11 kV line by changing the insulators, cross arms and necessary hardware.
- Insertion of 8 mts. PSC poles where the span length is more than 60 meters.
- The DTR, HV& LV Horn Gap (HG) fuses, Lightning Arresters (LAs) will be mounted on 9.0 Mt pole erected for the purpose.
- LV AB cable of the cross sectional area 3x16+25 mm^2 is run to connect Agriculture services. These loads were being fed earlier from LV lines before conversion.
- Providing 11 kV AB switches to control group of 25 kVA Transformers.
- Dismantlement of 100 kVA DTR, LV cross arms, LV insulators etc.

3.0 LOAD FLOW ANALYSIS:

Load flow analysis [3] is performed on selected transformer considering the same loads before and after conversion to high voltage distribution system. Voltage drop - Balanced method is adopted during analysis. The selected DTR is highly loaded and therefore 82.29 kW load is considered (load used) for running a load flow out of 108.28 kW (load read). If the entire load is considered during computation of load flows, the system would become unstable and few loads would convert to constant impedances for convergence. This is one of the main reasons for converting LVDS to HVDS i.e. the distribution system would be more stable with high voltage lines, that cater to all loads connected to the system. However, computation of load flows for HVDS, 100% loads are considered for each DTR. The load flow results for LVDS and HVDS are shown in Tables 2 and 3.

TABLE 2

LOAD FLOW SUMMARY OF LVDS

Total Summary	kW	kVAR	kVA	PF (%)
Load read (Non-adjusted)	108.78	127.18	167.35	65
Load used (Adjusted)	82.292	96.21	126.604	65
Total Loads	82.292	96.21	126.604	65
Line Losses	19.733	4.371	20.211	97.63
Cable Losses	0	0	0	0
Transformer Losses	2.791	10.123	10.5	26.58
Total Losses	22.524	14.493	26.784	84.09

TABLE 3				
LOAD FLOW SUMMARY OF HVDS				
Total Summary	**kW**	**kVAR**	**kVA**	**PF(%)**
Load read (Non-adjusted)	111.44	132.91	173.45	64.25
Load used (Adjusted)	108.78	127.18	167.35	65
Total Loads	108.78	127.17	167.34	65
Line Losses	108.78	127.17	167.34	65
Cable Losses	0.051	0.014	0.052	96.61
Transformer Losses	0.161	0.038	0.166	97.37
Total Losses	2.457	6.229	6.696	36.69

3.1 Current and voltage is measured nearfew loads during survey and based on this value, power factor is assumed to be near 0.65. Load factor is assumed to be 0.4.

3.2 Peak power loss and energy loss computed is shown in Table 4 for LVDS network and its corresponding HVDS networks.

TABLE 4				
LV AND HV NETWORK ANALYSIS OF PEAK POWER LOSS AND ENERGY LOSS				
Network	**No. of DTR**	**Total (kVA)**	**Peak Power Loss (kW)**	**Energy Loss (Units) for 1 year**
LVDS	1	100	22.524	41040
HVDS	9	225	2.669	4863
Reduction in power and energy loss values			19.855	36177

4.0 EVALUATION OF BENEFITS

The valuation of peak power loss and energy loss plays a critical role in formulation of HVDS scheme for power loss and energy loss reduction.

4.1 Power loss value

The Peak power loss [4] is valued at the annual cost of deferral of investment in Transmission & Distribution (T&D) system. The reduction in power demand could be achieved through reduction in system technical & commercial losses (one such method is HVDS) and this will be equal to set up of equal capacity of generation capacity. The prevailing cost for installation of one MW of generating capacity is Rs.5 crores (approx.). Therefore, the investment requirement for addition of generation capacity may be reduced by Rs.5 crores with implementation of HVDS. However, in respect of these studies the cost is taken as Rs 2.5 crores/MW is i.e. 50% of the cost. The annual cost of investment is 21% comprising 12% interest, 6% depreciation and 3 % O&M. The investment is kept low to get a conservative estimate.

The annual benefit due to reduction of one kW of peak power loss is 2.5 *0.21 = Rs. 0.525 crores/MW or Rs. 5250/kW

4.2 Energy loss value

The energy loss value is taken as Rs. 4.36 units as per the Average Realization Rate (ARR) of utility for 2011-12.

4.3 Financial Benefits

a. Power loss = 19.855 kW x Rs. 5250
= Rs.1,04,239.00

b. Energy loss = 36177 units x Rs. 4.36
= Rs.1,57,732.00

c. Benefit due to avoidance of theft:

Unauthorized connections are found to be 15%, i.e. 4 Nos. of 5 HP pump sets Likely consumption per service = 5 HP x 0.746 x 5 Hrs x 200 days/year = 3730 Units

Benefit for one 5 HP service = 3730 x 4.36 = Rs. 16263.00

Since 4 Nos. of 5 HP unauthorized connections are found, the total Benefit due to avoidance of theft is Rs. 16263 x 4 Nos. = Rs. 65052.00

4.4 Total Benefits

i. Due to power loss reduction
= Rs.1,04,239.00

ii. Due to energy loss reduction
= Rs. 1,57,732.00

iii. Due to avoidance of theft
= Rs.65,052.00

Totals = Rs. 3, 27,023.00

4.5 Financial Analysis

The details of item wise cost is shown in Table 5

a. Total cost of the project (Gross)
= Rs.10,38,780.00

b. Total cost of the project (Net)
= Rs.10,13,820.00

c. Total Profits
= Rs. 3,27,023.00

d. Payback period on net cost
= 3.1 Years

e. Payback period on gross cost
= 3.18 Years.

TABLE 5

COST ESTIMATE AS PER SCHEDULE RATES (SR) OF UTILITY FOR 2011-12

Sl. No	Item	Qty	Rate (Rs)	Amount (Rs)
1	3-ph 25 kVA DTRs	9 Nos	95530	859770
2	Conversion of LV line to HV line	1.13 kM	69982	79080
3	Erection of LT AB Cable (3x16+25 sq.mm)	1.285 kM	77767	99930
	Total			1038780
	CREDITS :			
1	100 kVA DTRs	1 No	22880	22880
2	LT 3-phase X arms, clamps etc.	80 kgs	26	2080
	Total :			24960
	Net Cost:			1013820
	ABSTRACT			
1	Gross Cost (Rs) :			1038780
2	Less Credits (Rs)			24960
3	Net Cost (Rs) :			1013820

5.0 CONCLUSIONS

After studying the network details, total connected load is 108.323 kW which is being catered by 100 kVA transformer. As per power factor (0.65) the total kVA load demand will be approximately 166 kVA. Also by adding the technical losses and reactive power required by the lines the actual demand on DTR will be even higher than 166 kVA which is much higher than the DTR rating. With total loads on LVDS, the software was not converging. Hence, simulation software is performing analysis & converge the calculations without violating voltage & loading limits and respecting the calculation tolerance.

Further, using the LF results, the HVDS scheme is concluded as

i. Payback period on gross and net cost is around three years for both net and gross project cost.

ii. The selected DTR of 100 kVA is technically and financially viable for conversion to HVDS.

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