A Comparative Analysis of Advanced Distribution System and Existing Distribution

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Abstract

To improve the quality and economy of the electricity distribution Aggregate Technical and Commercial (AT&C) minimization is the critical component. In the existing Low Voltage Distribution System (LVDS) where the consumer loads are supplied from a single large capacity transformer and the loads are not uniformly distributed from the Starting bus to the Tail End bus. The existing 415 V distribution system with single 315KVA transformer is considered for analysis and comparison of distribution loss reduction techniques. In this, the existing Low Voltage Distribution system of Ashoka Garden Bhopal M.P. Sub-Station Layout has been simulated with the help of ELECTRICAL TRANSIENT ANALYSIS PROGRAM (ETAP) software and the distribution losses and voltage profile of the system have been identified in order to improve efficiency of the distribution system. Further capacitor banks are used at load buses to supply reactive power demand of load to minimise distribution losses and to improve voltage profile of the system. Hence, to minimize the losses HVDS with some modifications is introduced to get the desired results. HVDS is implemented for the same number of consumers as in LVDS and distribution losses and voltage profile of the system is determined.

Keywords - *Low voltage distribution system, High Voltage distribution System, ETAP, Load Flow, Distribution losses.*

I. INTRODUCTION

In order to meet the demand there are two possible ways, one way is increasing the generation capacity and the other way is to conserve the energy [1-3]. As far as generation capacity is concerned, there are several upcoming projects in India, which are on the way to meet the demands by year 2030. While in the field of energy conservation, many activities and techniques are being adopted. Consumers are aware about energy crises and to encourage them for using energy efficient and star rated devices [4].

In this paper, HVDS method has been proposed to reduce the commercial losses [5-13]. In order to check the effectiveness of the method Ashoka Garden Bhopal M.P. feeder has been taken as case system.

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A. Generation statistics

Grand Total Installed Capacity in M.P. is 1,86,990 MW (as on 30.06.2013). Fig. 1 given below shows the percentage of generation from different conventional and non-conventional sources. The generation statistics in India (Source wise) has been given in Fig.2.

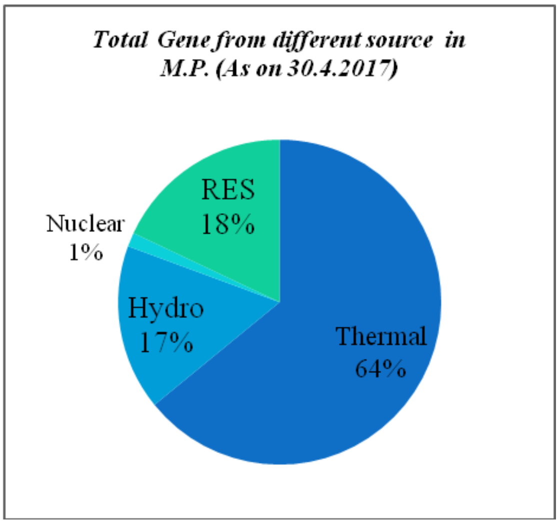

Fig. 1 Total Generation from different source in M.P.

II. ELECTRICITY LOSSES

Electricity losses in India during transmission and distribution are extremely high and vary between 30 to 45%.Electricity is critical to fuel the economic growth of India. In 20011-12, electricity demand outstripped supply by 8-13%. Due to scarcity of electricity, power cuts are frequent throughout India and this has unfavourably affected the country's economic growth. Theft of electricity, common in most parts of urban India, amounts to 1.5% of India's GDP [14-19]. Despite an striving rural electrification program, around 400 million people are facing scarcity of electricity during blackouts. In Madhya Pradesh, the transmission and distribution losses varies from 34 to 48%. Energy efficiency is extremely important and can be promoted by setting appropriate prices and controlling theft of electricity [20-21].

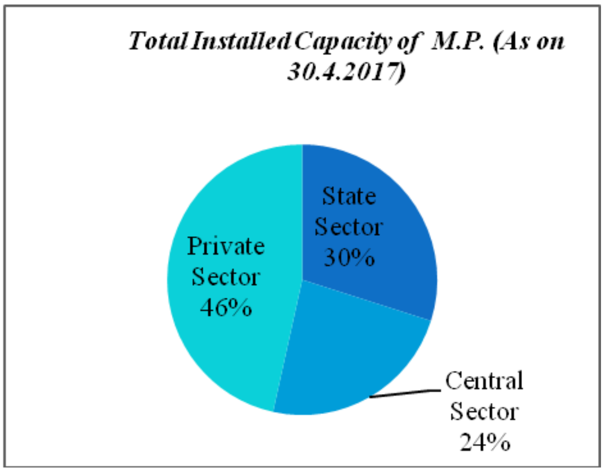

Fig. 2 Generation statistics in M.P.

A. Transmission and distribution losses

The T&D losses have been consistently on higher side, and reached to the level of 32.86% in the year 2006-07.The reduction of these losses was essential to bring economic viability to the State Utilities.

As the T&D loss was not able to capture all the losses in the net work, concept of Aggregate Technical and Commercial (AT&C) loss was introduced. AT&C loss captures technical as well as commercial losses in the network and is a true indicator of total losses in the system. In AT&C Losses, the major part consists of T & D losses. State wise T&D losses (%) in India shown in table1.1

$$AT\ \&C\ loss = \frac{\text{Energy input} - \text{Energy realised}}{\text{Energy input}}\ X\ 100$$

Energy require = Energy billed×Collection efficiency

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

B. Various Techniques For Minimizing The Technical Losses:

Various techniques for minimizing the technical losses are presented as follows:

a) Network reconfiguration
b) Network re-conductoring
c) Preventing leakages at insulators
d) Employing AVB (Automatic Voltage Booster
e) Better management of distribution transformers
f) Load balancing and load management
g) Capacitor installation (Shunt or Series
h) Improving joints and connections
i) Use of automated instruments
j) Use of polymer insulators
k) Effective winding system

III. LOW VOLTAGE DISTRIBUTION NETWORK

The present LT system consists of LT distribution system with lengthy LT lines serving the disbursed consumer loads contributing more losses in the system.

The simulink diagram of the LVDS network with load flow results is shown in Fig 3. The power flow in different branches of the distribution network in kW and kVAr is shown in the diagram. The voltages at all the consumer end is also depicted in the diagram. It is clear from the load flow results that far end consumer will suffer from low voltage problem.

I. Technical losses

The simulation results of LVDS network have been categorized in two ways. i.e. technical and commercial losses, which are given as below: Technical losses calculated of existing LVDS network are given in Table 1 at various branches. Table 1 also represents power flow in the branches. The total technical losses for given network in the case of low voltage distribution system is 21.7 kW.

As shown in Fig. 3 all the consumer buses are having voltage below the 95% of the rated voltage. Some of the consumer buses are having voltage below 90% of the rate voltage which is not permissible. As the voltage of the system is reduces losses in the system will increase.

Electrical power system structure consists of Generation, Transmission and Distribution. Generation of electrical energy takes place at 11kv and after that energy is stepped up to 33kv, 66kv and 132kv for transmitting the power. Then energy is again stepped down to 11kv to make avail for the consumer ends. Distribution Structure can be classified in following ways.

1. Based on number of feeders-

a) One end feeder network- In this type, the network is fed from one end.
b) Two end feeder network- In this type, the network is fed from both ends.
c) Ring main system- In this type, the network is connected in a ring form and the supply is fed from more than one end.

2. Based on voltage level-

a) Low voltage distribution system- in this type, 11kv and 230 volts both share a considerable distance.
b) High voltage distribution system- in this type only 11kv plays the major role, 230 volts comes in picture at extreme i.e. at consumer end only.

Existing distribution networks inherited by various companies and subsequently expanded to widen the scope of supply was in line with European practices characterized by long low tension (LT) network fed from an 11/0.4 kV transformer. Even for supplying to widely dispersed load blocks of various consumers, similar LT network arrangement was adopted resulting in an unsatisfactory situation stemming from factors like:

a) Rampant pilferage from accessible low voltage lines causing revenue losses.
b) High technical losses attributable to high LT current on the network.
c) High peak power loss of network due to unauthorized load.
d) Unsatisfactory voltage profile at consumer installations.
e) Unreliable supply consequent upon overloading of LT lines.

Reduction of these losses through conversion of the existing LVDS to HVDS which is done through restructuring of the existing LVDS network to HVDS network and installation of 16 KVA, 25 KVA 1 phase / 3 phase transformers to serve the loads in 11kVfeeder. The load flow simulink diagram of the high voltage distribution system is shown in Fig. 4. Power is distributed at 11 kV voltage and step down by 25/16 kVA transformers at consumer end. The voltage profile of the system is shown in Fig. 4. It is clear from the figure that voltage profile of the system better then the LVDS configuration. The simulation results of the proposed HVDS network have been categorized in two ways. i.e. technical and commercial losses. Fig. 4 shows the % voltage drop on different consumer busses. It is clear from the figure that voltage at all the consumer busses are above 99% of the rated voltage.

A. Activities involved

Following activities have been involved in replacing the existing LVDS network with the HVDS system.

Replace LT conductor with 11 KV conductors on the existing poles.

Install transformer (10, 16, 25 KVA 1 phase / 3 phases) on poles.

Energize 4 to 10 consumers from each transformer through MCCB distribution board and LT aerial bunched cable.

a) 11 kV CT/PT erected by replacing DTR on the transformer structure.
b) Erection of appropriate number of 16 KVA , 25 KVA 1- phase and 3-phase DTR's under HVDS to cater 2-3 services.
c) LT 3Phase cross arms replaced by V Cross arms.
d) LT Insulators replaced by 11 kV insulator.
e) Connecting of existing load from newly erected 16 KVA 1-phase and 3-phase KVA DTR with aerial bunched cable.

The HVD System has been constructed by refurbishing and retrofitting LT line using the same pole and conductor and erecting new insulator and hardware support. Once conversion of LT to HT line is completed, the transformer either on a single or double pole structure, depending on angularity of the lines. Extended hardware support clamped on to poles is provided on single pole structure.

Table 2 represents comparison of different power distribution configurations in terms of losses

IV. TABLE I-LOSSES IN KW & KVAR (LVDS)

	LVDS without Capacitor			HVDS		
ID	kW	kVAr	% Drop in Vmag	kW	kVAr	% Drop in Vmag
TF1	6.9	10.4	3.60	4.4	6.6	
Line-1	0.1	0.0	0.41	0.0001	-0.016	0.00
Line-2	0.0	0.0	0.27	0.0000	-0.016	0.00
Line-3	0.0	0.0	0.04	0.0000	-0.016	0.00
Line-4	2.0	0.6	1.69	0.0008	-0.015	0.00
Line-5	0.0	0.0	0.16	0.0000	-0.016	0.00
Line-6	3.3	1.1	2.17	0.0020	-0.015	0.00
Line-7	0.0	0.0	0.07	0.0000	-0.016	0.00
Line-8	0.0	0.0	0.00	0.0000	-0.016	0.00
Line-9	1.2	0.4	1.30	0.0003	-0.016	0.00
Line-10	3.3	1.1	2.18	0.0142	-0.011	0.01
Line-11	1.6	0.5	1.50	0.0030	-0.015	0.00
Line-12	0.7	0.2	1.01	0.0007	-0.015	0.00
Line-13	0.6	0.2	0.94	0.0006	-0.015	0.00
Line-14	0.0	0.0	0.14	0.0000	-0.016	0.00
Line-15	0.0	0.0	0.14	0.0000	-0.016	0.00
Line-16	0.4	0.1	0.72	0.0000	-0.016	0.00
Line-17	0.4	0.1	0.72	0.0000	-0.016	0.00
Line-18	0.2	0.1	0.53	0.0000	-0.016	0.00
Line-19	0.0	0.0	0.01	0.0001	-0.016	0.00
Line-20	0.1	0.0	0.38	0.0005	-0.016	0.00
Line-21	0.0	0.0	0.23	0.0000	-0.016	0.00
Line-22	0.1	0.0	0.34	0.0001	-0.016	0.00
Line-23	0.0	0.0	0.23	0.0000	-0.016	0.00
Line-24	0.0	0.0	0.01	0.0000	-0.000	0.01
Line-25	0.3	0.1	3.54	0.0002	-0.016	0.00
Line-26	0.4	0.1	0.74	0.0003	-0.016	0.00
Line-27	0.7	0.2	1.00	0.0001	-0.016	0.00
Line-28	0.3	0.1	0.65	0.0003	-0.016	0.00
Line-29	0.2	0.1	0.54	0.0003	-0.016	0.00
Line-30	0.1	0.0	0.38	0.0001	-0.016	0.00
Line-31	0.0	0.0	0.21	0.0000	-0.016	0.00
Total	22.8	15.5		4.4	6.1	

B. Pay Back Period Calculation

To implement the modified HVDS network in place of existing LVDS network, 1 no. 315 KVA transformer and 0.841 km LT line have been replaced with 2 no. 25 KVA transformers, 25 no. 16 kVA transformers and 0.839 km 11 kV line. The total cost of the replacement is 1027841 Rupees. With new network, additional revenue is generating. i.e. 16560/- per month. Hence the cost of replacement can get adjusted within 62 months. Which is quite clear with the data presented below.

C. Cost of the new items

KVA transformer 3 no.= 45000x3=135000
16 KVA transformer 22 no.= 25000x22=550000
839 mtr 11 KV line= 839x25=43628.

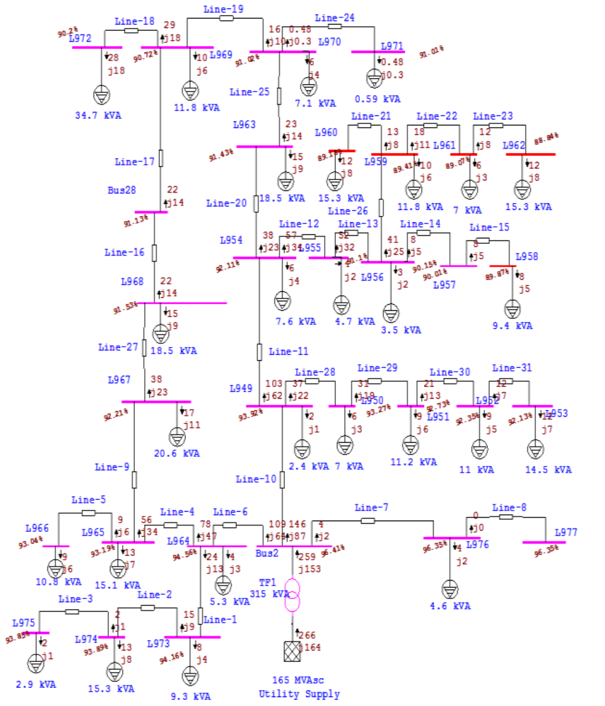

Fig.3 ETAP Simulink Diagram of LVDS network

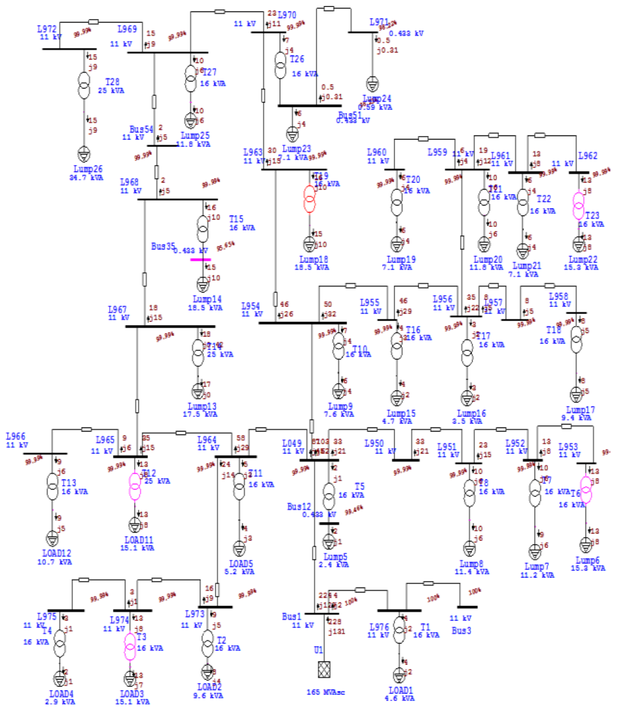

Fig.4 ETAP Simulink Diagram of HVDS network

V. TABLE I

COMPARISON OF DIFFERENT POWER DISTRIBUTION CONFIGURATIONS

Labor cost = 5,97,316 Rupees.
Total cost= 1325944 Rupees.
Cost of the materials to be returned
315 KVA transformer 1 no.= 296000
0.841 km LT line= 0.841x2500=2103
Total cost = 298103 Rupees.
Total estimate cost= 1325944-298103
= 1027841 Rupees
Distribution Line Losses
Distribution Line Losses (kWh) = Loss Factor x Line Losses x period
Loss Factor = 0.33LF+0.67LF2

$$\textbf{Load Factor (LF)} = \frac{\textbf{Average Load}}{\textbf{Peak Load}}$$

Gross investment = 1027841 Rupees
Daily hours of supply = 10 hours
Total KW loss reduction in one month = 552 kW
Reduction in loss per month = 5520 KWH
Power purchase price per unit = 3 Rupees
Monthly saving = 16560 Rupees
Total Investment for loss reduction = 1027841 Rupees
Payback period = 62 months

VI. CONCLUSION

In this work the proposed HVDS system has been used for the case system i.e. 11 kV feeders emanating from 33/ 11 kV substation. The results are simulated for the existing LVDS system and the proposed method using ETAP software. The details of the results obtained for both methods are summarized and analyzed in subsequent sections. Further, comparative analysis has been done based on reconfiguration involves of various transformer used, details of overhead lines, calculation of losses, comparison of line losses and voltage of tail end. Comparison of LVDS and HVDS network is shown in Table 2. In this work modified HVDS method has been successfully implemented to reduce the losses and increase the revenue for the distribution authorities as well. To see the effectiveness of the proposed method ashoka garden feeder, pragati nagar, Bhopal, Madhya Pradesh, has been taken as case system. For the simulation ETAP software has been used.

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