Reengineering of Distribution lines for Power Loss Reduction-Bhiwandi Case Study

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Abstract: - The Indian Power sector is currently undergoing sea change. Increased efficiency in the sector can help in the task of achieving the national perspective of power to everyone by the year 2012. The transmission and distribution losses world wide when compared shows that in the developing nations these are very high as compared to developing nations. Therefore this is definitely the matter of concern to the developing nations. The distribution system performance is normally controlled by either voltage regulation at the farthest end of the distribution line or thermal limitation of the current carrying conductor of such distribution line. The case study presented here is carried out in the Bhiwandi city which is textile hub of the state of Maharashtra in India. The Bhiwandi city is near Mumbai and has large concentrated load of industry mainly related to Textile business. The reengineering of the distribution system carried out has yielded the results and the distribution system losses have reduced from highest in the state to below state average.

Keywords: - Distribution lines, Overload, ASCR Conductor, Power Losses, Reliability, Controlling carbon emission.

1. Introduction to Power loss and area of experiment:

The Transmission and Distribution losses in the developing countries are between 16% to 32%.In the developed countries these are ranging from 7% to 12%.[Please refer table 1]Therefore reduction in T and D losses in power sector is one of the major challenge for power sector professionals. These losses in Bhiwandi distribution circle of Maharashtra State Electricity Distribution Company Limited (MSEDCL-INDIA) were the matter of concern to all stake holders of the company. The experiment for reduction in losses carried out in this area is detailed in this paper. The power to this city is fed from 5 different Extra High Voltage substations with the primary voltage of 100 kV and 220 kV and secondary voltage of 22 kV. Before the start of this experiment last year i.e. in January 2007 there were 46 High Voltage 22 kV distribution lines. All these distribution lines emanating from either of the above referred EHV lines. Out of these about 17 number of distribution lines were observed critically loaded. [Please see table 2]

These 22 kV distribution lines are mainly overhead and having 0.1 (DOG) or 0.2 (PANTHER) ACSR conductor. These were loaded from1.2. To 2.1 times the conductor's thermal capacity causing overload tripping of the distribution lines. Almost all industrial units are of textile industry which requires high reliability. This loss of reliability was a matter of concern to both consumer and utility.

We have done system reengineering and applied the study result to sort out issue of reduced system reliability. While doing this we achieved the reduction in power loss in this distribution area. The following lines would discuss about the study carried out and the results including payback period.

2. Problem of Loss of Reliability and Increased Losses:

2.1 Existing System Loading

The Transmission substations having input on 100 kV and 220 kV level had installed capacity of 650 MVA .The entire industrial city area has load demand for 850 MVA. This had forced to restrict the load of the distribution lines with rotational load shedding causing availability of power only for 17 hours per day .Therefore all the load would simultaneously be 'ON' for these 17 hours for these distribution lines.. However due to the limiting current transformers on distribution lines and power transformers there was frequent tripping due to overload of distribution lines. Secondly due to this system components installed of the distribution lines including jumps connected would burn out leading to non availability of power and decrease in reliability.

2.2 Existing Distribution Line Losses

The losses in the distribution line are due to two factors.

1. Current flowing through the conductor
2. The resistance of the line

For any loss reduction activity it is important to control these parameters. It would be apt here to check for the rule book again.

$P_{LS}= 3 I^2 * R$ -------- Equation (1)

Where,

P_{LS} is power loss in the distribution line

I is the total current flowing through the line. The lines are 3 phase 3 wire.

R is resistance of the line

Further

$R= \rho * L/A$ -------- Equation (2)

Where,

ρ is the resistivity of the conductor

L is the length of the line

A is the cross sectional area of the conductor

From the equation (1), it can therefore be drawn out that Power Loss is directly proportional to the current flowing through the line.

Also the impact of R, the resistance, is less in the case of overloaded distribution lines.

We therefore calculated the power loss of these distribution lines. We used following practical assumption to factor for loading discounting for various load curve pattern and period. We worked out annual losses on each distribution line.

The equation therefore is

$P_{LS}=3 I^2 * R*L*0.8*0.9*5304$

------------------- Equation (3)

Where,

I –current flowing through the line

R-Resistance per km in ohms

L-Length of distribution line in kilometres

0.8-discounting factor

0.9-load factor

5304= 17*314(Hours of working per day * no of working days in a year)

The power loss is plotted for various currents for same length takes the pattern as in figure (1), appended herewith.

It can be seen that this curve pattern can be defined as

$Y=aX^n$ where n>1

----------------------Equation (4)

From the above it can be seen that the power loss in the distribution line increase exponentially with the increase in current.

We have seen in the problem definition that there was loss of reliability due to increase in current. Therefore it was essential to reduce overload of these feeders to increase reliability and also for reduction of distribution losses.

3. Providing Additional Circuit is the solution for problem:

From the above discussion it was evident that reduction in loading is foremost requirement for solutions to the defined problems. It can be seen from the graph that as the distribution line load increase beyond 250 Amperes the power loss rises exponentially. We were having feeder loading between 400 to 550 Amperes.

Therefore it was concluded for bifurcation of the existing distribution line load into two to three lines. This would be done by laying additional cable length to mid load point of the feeder [Please refer fig 2]. For this it was necessary to have breaker arrangement .Since in the substation it was not possible due to space constraints and it was neither in the immediate programme of Transmission Company, we decided to have a switch with two breaker kind of arrangement for bifurcating the distribution line after the breaker of Transmission company on each distribution line.[Fig.3 and 4]

The work is completed for all the distribution lines which were critically loaded. The results are encouraging. The tripping on the feeders has stopped while due to reduction of current the units consumed by utility have come down by 12 to 15 %.The typical 6 distribution lines data about length, power loss in million units and cost benefit analysis is appended as Annexure A. It can be seen that the pay back period is very low as 1.5 years.

This has further given way for additional feeder bifurcation programme. The simple solution operated in least time has reduced losses and increased reliability.

This has also reduced requirement of additional generation of electricity which in turn has helped in controlling carbon emission. This has also improved the reliability indices i.e. SAIDI (System Average Interruption Duration Index) and SAIFI (System Average Interruption Frequency index).

It is interesting to see the loss reduction level in Bhiwandi after one year. At the start of experiment i.e. in January 2007 the sliding six monthly average T and D loss declared by MSEDCL was 41% and the same at January 2008 is 24%.The state average is at 27%.The month wise loss reduction is shown graphically [Please refer figure 4]

4. Conclusion

The urge to reduce losses is essential. The menace of losses in power distribution system is not only limited to utility or franchisee from business point of view but also it is the matter of worry for sustainable development. The development at the cost of increased carbon emission would never be of help to humanity. The application of science and reengineering for the disturbed areas would be the key to success. Also simple solutions which can be implemented quickly and easily are necessary. The solution discussed here has relieved the system from the verge of being collapsed, however it would be required to be monitored continuously.

The saving of one unit of electricity is generation of the electricity of same amount. Therefore reduction in losses in distribution system by using local solutions would be necessary to control carbon emission and effective functioning of the system.

References:

[1] Gonen Turan, Electric Power Distribution System Engineering, McGraw-Hill Book Company, Singapore, 1986.

[2] Central Electricity Authority (India), Web data

[3] Maharashtra State Electricity Distribution Company Limited Web Data

Table [1]:

Country-wise Comparison of T&D Losses

Sr. No	Name of the country	T&D losses (%age)
1.	India	31.05
2.	China	7
3.	Myanmar	20
4.	Bangladesh	18
5.	Sri Lanka	18
6.	Nepal	21
7.	Pakistan	26
8.	Japan	4
9.	Australia	7
10.	United Kingdom	8
11.	United States	6
12.	Nigeria	38
13.	Albania	51
14.	Brazil	17
15.	Kenya	21
16.	Tanzania	25
17.	Zimbabwe	21

Table [2]- Identified Distribution Lines Loading

Sr	Feeder Name	Loading in Amps	% Loading
1	Anjurphata- II	850	**213%**
2	Anjurphata- I	800	**200%**
3	Ajanta	780	**195%**
4	Kalyan Rd.	760	**190%**
5	Chavindra	680	**170%**
6	Gayatri Nagar	670	**168%**
7	Nagaon	670	**168%**
8	Shanti Nagar	659	**165%**
9	Varaldevi	630	**158%**
10	Karnivali	628	**157%**
11	Kharbhav	607	**152%**
12	Dargah Road	600	**150%**
13	New Kaneri	600	**150%**
14	Kasheli	586	**147%**
15	D. Naka	580	**145%**
16	Pipeline	560	**140%**
17	Khoni-I	534	**134%**

Figure [1]

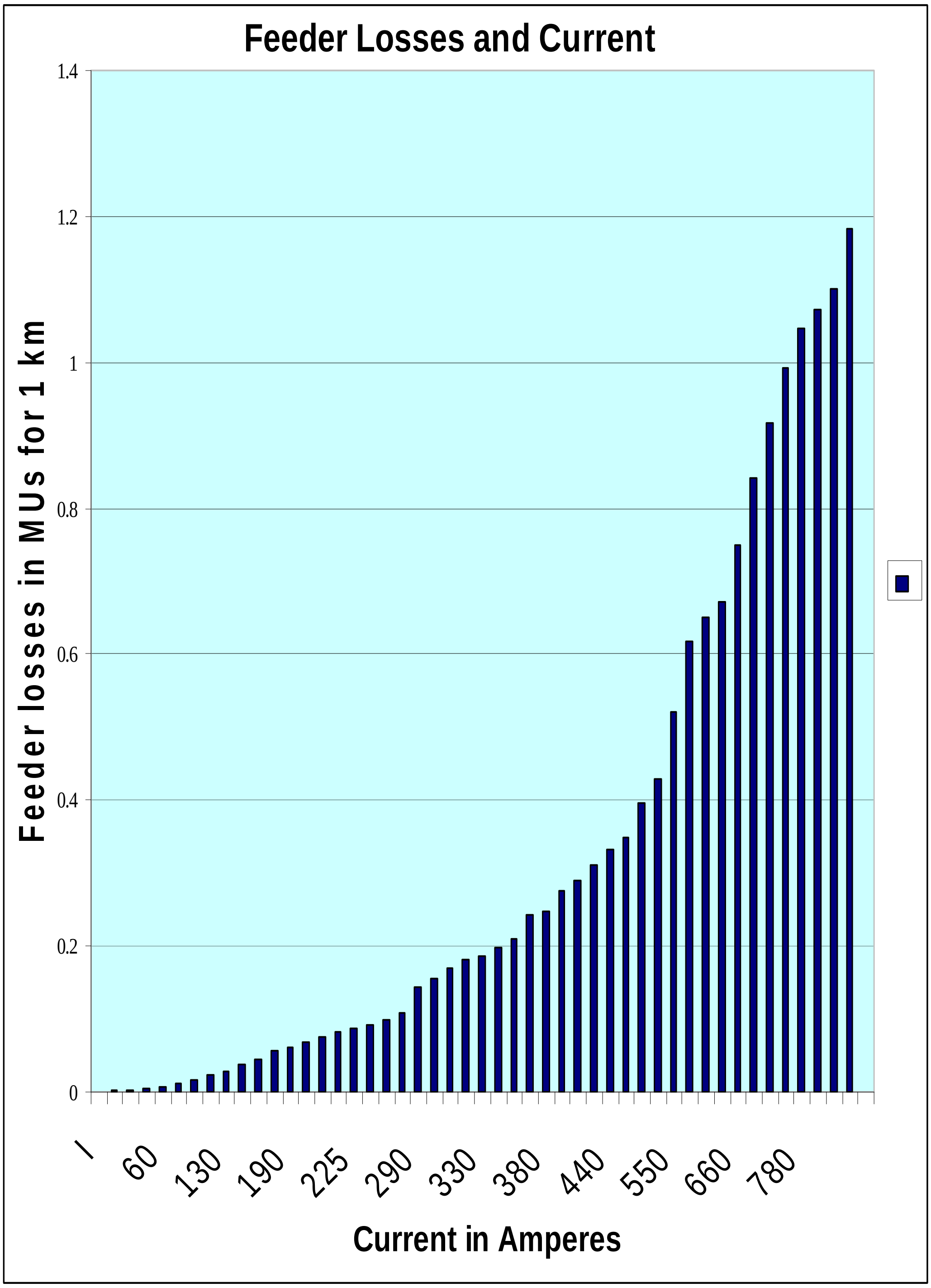

Feeder Losses and Current
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Feeder losses in MUs for 1 km
I
60
130
190
225
290
330
380
440
550
660
780
Current in Amperes

Figure [2]- Typical Single Line Diagram of Distribution Line Bifurcation

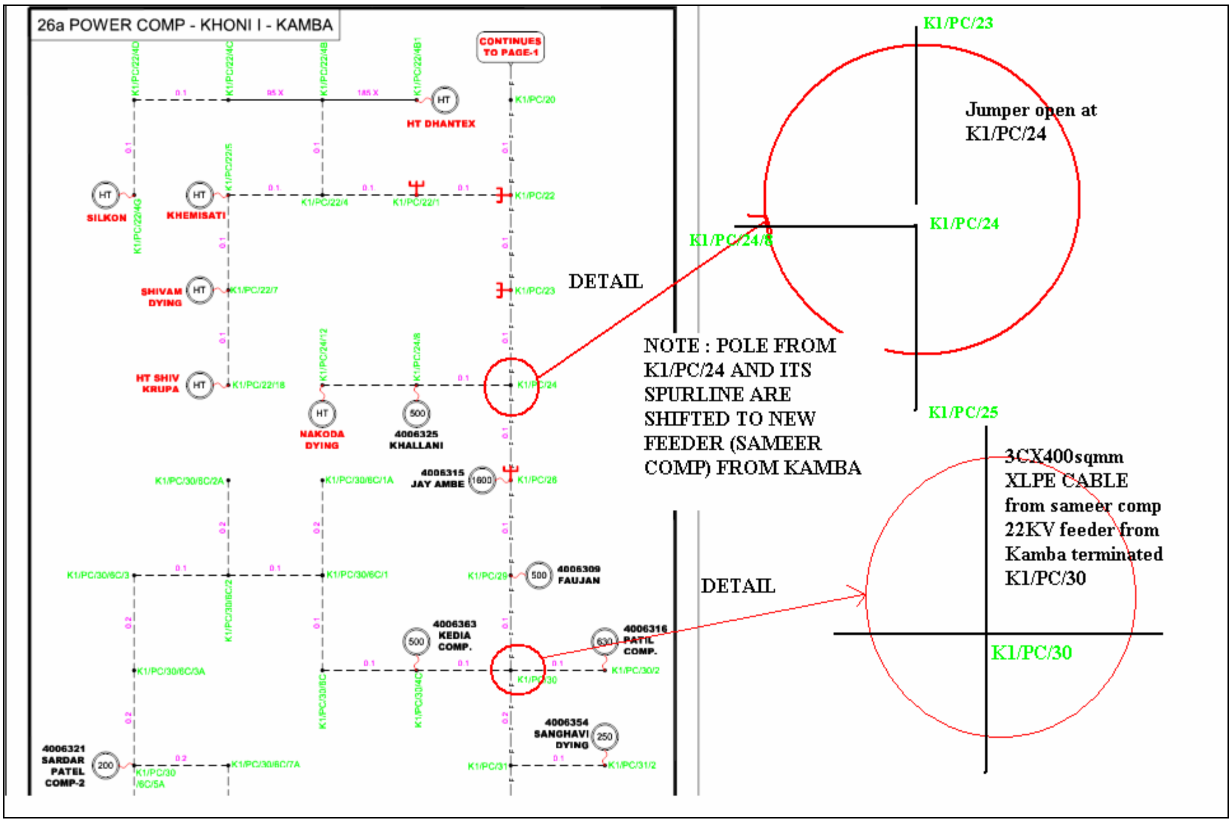
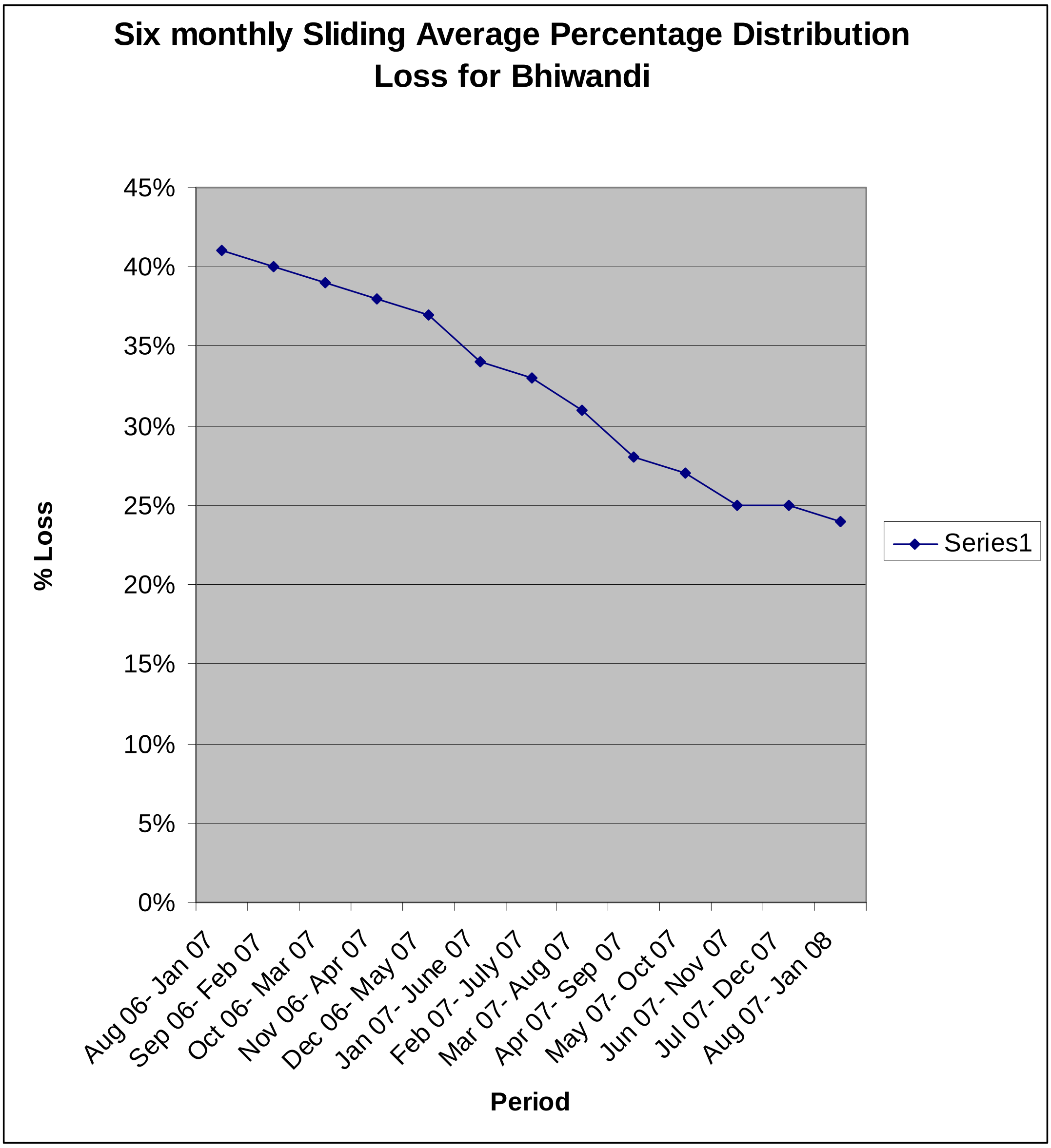


Figure [3]- Ring Main Unit

LOSS CALCULATION- ANNEXURE A

EHV / HV S/S	**Sub Station 1**				**Sub Station 2**	
FEEDER NAME	Feeder 1	Feeder 2	Feeder 3	Feeder 4	Feeder 1	Feeder 2
LOADING IN AMP	600	615	625	600	790(300 +300+190)	830(300 +300+230)
LENGTH IN KM	11	12	5.5	9	11	11
NO OF FEEDERS	2	2	2	2	3	3
LOSS IF SINGLE FEEDER IN MU	6.81	7.8	3.69	5.57	11.80	13.02
LOSS IF WE PROPOSE 2 (OR 3) FEEDERS IN MU	3.40	3.90	1.85	2.78	4.08	4.40
SAVING DUE TO THIS IN MU	3.41	3.90	1.84	2.79	7.72	8.62
SAVING IN RS (@3RS/UNIT)	10230000	11700000	5520000	8370000	23160000	25860000
COST IF CONSIDERING 1or 2 EXTRA FEEDER O/H NETWORK	8800000	9600000	4400000	7200000	17600000	17600000
COST IF CONSIDERING 1or 2 EXTRA FEEDER O/H+U/G NETWORK	16500000	18000000	7900000	13500000	33000000	33000000
PAYBACK PERIOD IN YEARS (O/H)	**0.86**	**0.82**	**0.80**	**0.86**	**0.76**	**0.68**
PAYBACK PERIOD IN YEARS (O/H + U/G)	**1.61**	**1.54**	**1.43**	**1.61**	**1.42**	**1.28**
NET COST(OR SAVING) IF OH	**-1430000**	**-2100000**	**-1120000**	**-1170000**	**-5560000**	**-8260000**
NET COST(OR SAVING) IF OH + U/G	6270000	6300000	2380000	5130000	9840000	7140000

Figure [4]


Six monthly Sliding Average Percentage Distribution Loss for Bhiwandi
% Loss
45%
40%
35%
30%
25%
20%
15%
10%
5%
0%
Aug 06- Jan 07
Sep 06- Feb 07
Oct 06- Mar 07
Nov 06- Apr 07
Dec 06- May 07
Jan 07- June 07
Feb 07- July 07
Mar 07- Aug 07
Apr 07- Sep 07
May 07- Oct 07
Jun 07- Nov 07
Jul 07- Dec 07
Aug 07- Jan 08
Period
Series1