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Network Revamping Analysis to Estimate Power Losses

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***Abstract*: A distribution power system comprises of technical and non-technical losses. The technical losses can be reduced by network reconfiguration or network revamping of the power utilities that leads to the ultimate goal of consumer satisfaction. Technical losses in the mix feeder arrangement can be reduced effectively by implementing the network revamping approaches. Thus the proposed paper analyzes the network revamping to provide effective and good performance in the primary as well as secondary distribution system. The proposed network revamping analysis helps in the improvement of voltage profile, decrease in power loss, minimization of annual costs.**

***Keywords*: HT feeder, losses, network, mapsource, revamping, reconfiguration, transformer etc.**

1. Introduction

Feeder segregation refers to the supply of electricity to agricultural and non-agricultural consumers (i.e. domestic and non-domestic) separately through dedicated feeders. This type of feeder arrangement allows the distribution company an easy rationing of power supply to agricultural consumers as and when needed for effective demand-side management (DSM) along with the reduction in losses [7-8]. The core objective of feeder segregation is to provide regulated supply to agricultural consumers and continuous supply to non-agricultural consumers in rural areas.

The distribution network comprises of distribution network lines i.e. primary distribution network in the range of 11KV, in corporation with the secondary distribution lines (415 volts line voltage). An elementary connection fundamentally takes care of the high tension (HT) consumers and transformers (DT). Distribution transformers or in short DT's takes care of the distribution networks at low voltage levels which are basically termed as secondary distribution lines. The LV network termed as the low voltage network is the final connection which feeds the end user consumers. The distribution system includes transformers, poles, cables and wires in the close by circuits. Distribution substation screens and modifies the circuits within the system that helps within the best possible power supply to any or all top purchasers. Substations are yards with fencing that contains switches, transformers and other electrical gear. The voltage level is being brought down or attenuated at the substation that is then fed to different types of loads and end users through the distribution framework. Conducting elements are termed as a feeder which goes about as a bearer of power from the substation to consumers. Foundational aim of this paper is to explore and address the issues that consumers faced in the domestic as well as industrial regions because of the current situation with the power distribution, likewise suggests ways for the improvement of the present distribution system by means of feeder segregation / network revamping. The paper provides the data collection and methodology for 11 KV HT feeders in Section-2. Section-3 gives the loss estimation in 11 KV feeder. Section- 4 gives the results obtained & Conclusions are put forth in Section-5.

2. Data Collection and Methodology for 11 KV HT Feeders Revamping

For analyzing the losses before and after 11 KV feeder revamping, one can need the complete data of a mixed 11 KV feeder along with the data of 33/11 KV substation that feeds this particular feeder. An 11 KV feeder is called mixed feeder when it is having both domestic load and industrial load. The detailed data of 33/11KV Kundli substation which comes under UHBVN is collected for this purpose along with the details of all other 11KV feeders originating from this Sub-station. The 11 KV feeders originating from 33/11 KV Kundli substation is Friends colony, Rasoi Industrial area, Kundli Industrial II, Border feeder. This substation also includes independent 11 KV feeders which are as follows, JB Fashion, Harsh Indp., Punjab Steel, Jash Plastic, Yogsidhi, MDH.

1) Present arrangement & Data of 11 KV Kundli -1Industrial Feeder (Mixed Feeder)

The current arrangement of 11 KV Kundli feeder, given in below figure, with the help of Mapsource software which is based on the geographical coordinates or location points as well as the recording device. Here on this specified Kundli feeder includes both type of load i.e. industrial load as well as domestic loads and thus the chosen feeder is known as the mixed feeder. In the figure given below 33KV substation is shown by the red flag from where the network is originated, and the distribution transformers are shown by the red diamond shape which has

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household connection from it. From the figure 2.1 one can easily understand the SLD of 11 KV Friends colony feeder. By the use of Mapsource software and data from the table 2.1 the other parameters i.e. feeder length and the capacity of the feeder can be easily found out. The complete data of mixed feeder Kundli is collected from the field survey which is shown in given below table 2.1. In this field survey data the complete details of each distribution transformer, loading on each transformer and other parameters like LT line length from each transformer is required to evaluate the losses on this feeder.

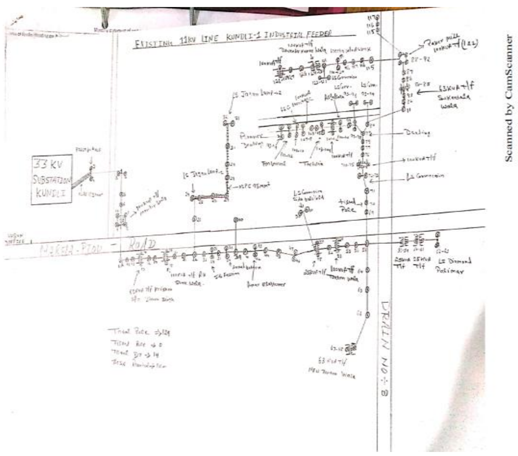

Fig. 1. SLD of existing 11KV feeder

Total system losses may be disaggregated into transmission and distribution losses as follows[4,7]:

Total Losses = $T_{LT}+T_{LNT}+D_{LT}+D_{LNT}$

Where T_{LT} and TL_{NT} are the technical and nontechnical transmission losses, respectively, And D_{LT} and D_{LNT} are technical and non-technical distribution losses, respectively. Above equation assumes that generation injections are net- rather than gross-quantities. Otherwise, that equation can be modified in the obvious manner. The details of 11 KV feeder

Table 2.1
Essential data of substation

Feeder from ss	Peak load (amp)	Length of 11 kv line	Number of dt
Kundli	180 a	6 km	36
Border	200 a	6 km	73
Friends colony	220 a	12 km	63
Rasoi	280 a	4 km	21

from 33 KV substation situated at Kundli which are required for the case study.

2) Network revamping approaches

On the basis of the methodology, network revamping is classified in two ways broadly, Type A network revamping

3) Type a Revamping

In this type of network revamping, development of a new network from the same substation for domestic loads and the old feeder is used for industrial supply. In this case, the supply to domestic loads is provided through new feeder which is more reliable than earlier mixed type network. This procedure saves the money to be invested as only domestic loads network needs to be developed. For loss reduction in the new developed network the rabbit conductors is used in place of weasel conductors. Also, the number of transformers is increased because in the earlier network all the transformers are operated under the overloading condition all the time. Due to this overloading operating conditions, the three star rated transformers operates as two star rated transformers. On implementing the adequate number of transformers helps in reducing the technical losses in the network.

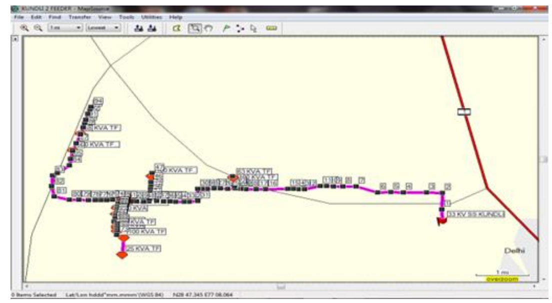

Fig. 2.2. Arrangement of11 KV Kundli feeder (Mixed Load) (By Mapsource)and Type B network revamping.

Network design for domestic loads by this technique: The newly developed network is essential from the earlier mixed type configuration to supply domestic loads only. The network is developed by the use of global positioning system data of feeder in accordance to the loads connected to it. By using the MAPSOURCE software [7-8] one can efficiently develop the separate network for domestic loads. Network for industrial loads: For feeding the industrial loads the same network is used after separating domestic loads from it. It is very economical for addition of the separate industrial feeder.

4) Type B Revamping

In context to this technique of network revamping, new substation is installed after estimating the old feeder positions. This technique helps in reducing the overall length of 11 KV feeders. The assumption of new station should be in accordance to the adjoining sub stations. This technique is considered as more economical than type A technique. This technique requires more financial support but in turns there is reduction in the overall length of the network and this finally leads to reduction in technical losses of the distribution network. In this technique old conductors are also replaced with the new adequate size conductors.

Network design for domestic loads: Here in this technique, the newly developed network is available for supplying the power to domestic loads. Various factors like distance among various substations, geographical location, land availability etc. In the proposed case separate network is developed from existing friends colony feeder as this will helps in reducing the length of the newly developed network. Design for industrial loads: Here in this technique for industrial loads of friends colony feeder the technical losses are quantified as in the old network configuration and supply it from newly proposed substation. For augmentation of existing mix feeder type, neglect the longer section.

3. Loss Estimation in 11 KV Feeder

This section firstly gives the brief description of the distribution losses in the primary distribution network. A general approach for computing technical losses in the 11 KV mixed feeder network is discussed in this section. Finally, the technical losses are reduced by segregating/ revamping the mixed feeder into individual domestic and industrial feeders.

1) Distribution losses

The amount of electricity supplied to the dispersion framework doesn't incorporate with need of the clients, this leads to higher power loss in dispersion framework. This mismatching of electricity should be minimized by reducing the losses. The losses here in dispersion framework defined as situation in which the quantity of energy transferred by framework which in turns unpaid by user or end clients. The difference between the energy injected and the units billed to users is defined as the percentage of units injected in framework [2,9].

Table 3.2
Transformers classification according to their capacity in mix feeder (Friends colony

Total Transformer In Mix Feeder			Standard Losses In Each Unit Of 2 Star Rated Transformer (Watts)	
Capacity (Kva)	Quantity (Nos.)	No. Of T/F With Lt	Iron Losses	Copper Losses
100	44	44	210	1910
63	19	19	150	1335

Let power injected is given by PI and power delivered to users given by PD; then power loss P_{loss}will be given by :P_{loss}= $P_I - P_D$

The power loss is calculated or estimated for every month or can be estimated annually So, the

$$\text{Distribution losses (\%)} = \frac{(\text{Energy injected} - \text{Energy delivered}) \times 100}{\text{Energy injected}}$$

For ideal conditions dispersion losses are incorporated in the range of 3% to the 6%.

2) Component of Distribution Losses

Distribution losses generally comprises of two elements that are (i) Technical Loss (ii) Commercial Loss

Technical Loss: The losses immanent to dispersion framework falls under this category. These kinds of losses takes place basically in the equipment incorporated with the distribution framework. In the dispersion framework technical losses are because of High tension (HT) i.e., (11000 volts /6.35 kV) network connections, Low tension (LT) (0.415/0.23 kV) network lines, Transformers i.e. Distribution Transformer (DT) Service drops etc.

- Various grounds for Technical Losses [3, 5]
- Differing load dispersion amid LT framework's three phases thereby imposing higher neutral currents.
- Dripping real power
- Over burden of connecting framework.
- Deviating operational conditions in context to transformers operations.
- High amount of current is being drawn by inductive loads at client's end results in lowering down of the voltage level of framework..
- Degraded apparatus applications in agricultural pump sets, Air conditioner, heavy industrial loads.

3) Calculation of Technical losses in Friends colony feeder

This section computes the technical losses of the mixed feeder at Friends colony that contains both domestic and industrial consumers. Table 5.2 gives the annual electricity consumption of various feeders from 33 KV grid substation, Kundli.

Table 3.1
Consumption of 11 KV feeders

Feeders From Substation	Peak Load (Amp)	Kwh Consumption (Annually)	Length Of Line (Km)
Friends Colony	220	1,21,81,926	12
Rasoi	280	46,66,789	4
Border	225	1,44,37,547	5
Kundli	180	42,41,887	6

4) Friends Colony Feeder Essential Data

Total length of feeder = 12 Km
Total Connected Load on Feeder = 5518.7 KVA
Average Load = 168.3 A
Peak Load = 220 A
Total energy supplied annually = 1, 21,81,926 kWh (converting to the scale of 24 hrs)
Resistance = 0.745 Ω/Km (Weasel)
Total Transformer In Mix Feeder Standard Losses In Each Unit Of 2 Star Rated Transformer (Watts)
Capacity (Kva) Quantity (Nos.) No. Of T/F With Lt Iron Losses Copper Losses
100 4444210 1910
631919150 1335

Calculation Total Technical Losses in Mixed Feeder Annually (i.e. feeder serving both Domestic and Industrial load).

Peak load = $\sqrt{3} \times V_1 \times I_1$ (KVA)
Where V_1 is line voltage & I_1 is line current
Peak load = = $\sqrt{3} \times 11 \times 220$ = 4191.56 KVA
Diversity factor (DF) = Total connected load (KVA) / Peak load (KVA)
DF = 5518.7 KVA / 4191.56 KVA = 1.31
Load factor (LF) = Average load (A) / Peak load(A)
LF = 168.3 A / 220 A = 0.76
K = 0.28
Loss load factor (LLF)= (LF^2X 0.72 + LF X 0.28)
LLF = 0.76 X 0.76 X 0.72 + 0.76 X 0.28 = 0.62
Iron Losses in Transformer (Annually)

$$\text{Iron losses} = \frac{\text{Iron loss in each unit} \times \text{number of such unit} \times 8760}{1000}\ \text{KWh}$$

Iron loss in 100 KVA transformers = (210 X 44 X 8760) / 1000 = 80942.4 kWh
Iron loss in 63 KVA transformers = (150 X 19 X 8760) / 1000 = 24966 kWh
Total iron losses in all transformers annually = 1,05,908.4 kWh ……………………..(A)

Copper Losses In Transformer (Annually)

$$\text{Copper losses} = \frac{\text{Copper loss in each unit} \times \text{number of such unit} \times LF^2 \times 8760}{1000} \text{ KWh}$$

Copper loss in 100 KVA transformers = (1910 X 44 X 0.81^2 X 8760) / 1000 = 4,83,014.52 kWh

Copper loss in 63KVA transformers = (1335 X 19 X 0.81^2 X 8760) / 1000 = 1,45,783.71 kWh

Total copper losses in all transformers annually = 6,28,798.23 kWh …………………..(B)

Losses in HT Line (Annually)

$$\text{Losses HT line} = \frac{10.5 \times (\text{Peak load} \times 2) \times \text{Length} \times \text{Resitsnce} \times LLF}{DF^3 \times 2} \text{ KWh}$$

$$\text{Losses in HT line} = \frac{10.5 \text{ X } (4191.56 \text{ X } 2) \text{ X } 12 \text{ X } 0.745 \text{ X } 0.62}{1.31^3 \text{ X } 2}$$

= 1,42,242.72 kWh……(C)

Losses in LT line (Annually)

Average LT loss for 100 KVA transformer = 3310W

Average LT loss for 63 KVA transformer = 1130W

$$\text{PEAK POWER LOSS (PLL)} = \frac{3 \times (\text{LT LOSS in each TF} \times \text{No.of TF})}{DF^2 \times 1000}$$

$$\text{PLL} = \frac{3 \text{ X } (3310 \text{ X } 44 + 1130 \text{ X } 19)}{1.31^2 \text{ X } 1000} = 292.13$$

Losses in LT line = PLL X LLF X 8760 kWh

LT line loss = 292.13 X 0.62 X 8760 = 15,86,616.45 kWh …………………(D)

Total Technical Losses In Mix Feeder (Annually) = L1 = A + B + C + D = 24,63,565.80 kWh

$$\% \text{ TECHNICAL LOSS} = \frac{\text{Total Technical Losses in Feeder Annually (kWh)} \text{ X } 100}{\text{Total energy supplied annually (kWh)}}$$

= (2463565.80 / 12181926) X 100

= 20.22 %

5) Estimation of losses after segregation/ revamping of mixed feeder

Friends Colony Feeder Data (Domestic Load)

Total length of feeder = 12 Km

Total Connected Load on Feeder = 906.88 KVA

Average Load = 16.08 A

Peak Load = 25 A

Resistance = 0.552Ω/Km (RABBIT)

6) Calculation Total Technical Losses in Feeder (domestic load only).

Peak load = √3 x V_1 x I_1 (KVA)

Where V_1 is line voltage & I_1 is line current

Peak load = = √3 x 11 x 25 = 475.75 KVA

Diversity factor (DF) = Total connected load (KVA) / Peak load (KVA)

DF = 906.88 KVA / 475.75 KVA = 1.90

Load factor (LF) = Average load (A) / Peak load(A)

LF = 16.08 A / 25 A = 0.64

K = 0.28

Loss load factor (LLF)= (LF^2 X 0.71 + LF X 0.29)

LLF = 0.64 X 0.64 X 0.71 + 0.64 X 0.29 = 0.47

Table 3.3
Domestic Loads in the Network

Account no.	Sanc. Load in KW
SP 437 K	9.8
SP 488	18.4
SP 419	12
SP 470	9
SP 448	19.1
SP 407	9.9
SP 431	14.5
SP 446	19.3
SP 492 K	5.9
SP 498	13.7
SP 416	2.5
SP 460	9.7
SP 235	9.6
SP 310	9.2
SP 359	19.7
SP 485	19.8
SP 398	19.4
SP 334	19.6
SP 363	19.9
SP 257	19.9
SP 325	18.6
SP 450	19.8
SP 380	20
SP 420	19.8
SP 258	19.9
SP 316	9.6
SP 230	10.6
SP 454	5.6
SP 435	9.8
SP 388	9.7
SP 337	19.6
SP 238	19.4
SP 375	15.2
SP 298	19.3
SP 303	12.6
SP 326	13.9
SP 368	19.3
SP 323	20
SP 323	12.8
SP 418	19.9
SP 477 K	15
SP 453	5
SP 190	10.4
SP 220	10.6
SP 301	12.3
SP 371	14.9
SP 294	11.4
SP 3-410	14.6
SP 2-275	15.0
SP 2- 199	11.4
SP 2- 311	9.9
SP 3- 422	10.9
SP 3- 228	19.9
SP 497 K	19.9
SP 3 – 210	19.6
SP 3- 221	19.7
SP 2- 333	11.8
SP 3- 416	11.2
SP 479	19.1
SP 461	15.5
SP 2- 112	12.8

Iron losses in transformer (Annually)

$$\text{Iron losses} = \frac{\text{Iron loss in each unit} \times \text{number of such unit} \times 8760}{1000} \text{ KWh}$$

Iron loss in 63 KVA transformers = (150 X 2 X 8760) / 1000 =

2628 kWh

Iron loss in 25 KVA transformers = (77 X 32 X 8760) / 1000 = 21,584.64 kWh

Total iron losses in all transformers annually = 24,212.64 kWh ……………………..(E)

Copper Losses In Transformer (Annually)

$$\text{Copper losses} = \frac{\text{Copper loss in each unit} \times \text{number of such unit} \times LF^2 \times 8760}{1000}\ \text{KWh}$$

Copper loss in 63 KVA transformers = (1250 X 2 X 0.56^2 X 8760) / 1000 = 6867.84 kWh

Copper loss in 25 KVA transformers = (695 X 32 X 0.56^2 X 8760) / 1000 =61,096.30 kWh

Total copper losses in all transformers annually = 67,964.14 kWh …………………..(F)

Losses in HT line (Annually)

$$\text{Losses HT line} = \frac{10.5 \times (\text{Peak load} \times 2) \times \text{Length} \times \text{Resitsnce} \times LLF}{DF^3 \times 2}\ \text{KWh}$$

$$\text{Losses in HT line} = \frac{10.5 \times (475.75 \times 2) \times 12 \times 0.552 \times 0.47}{1.90^3 \times 2}$$

= 2267.38kWh………..(G)

Losses In Lt Line (Annually)

Average LT loss for 100 KVA transformer = 1900W

Average LT loss for 63 KVA transformer = 720W

Average LT loss for 25 KVA transformer = 60W

$$\text{PEAK POWER LOSS (PLL)} = \frac{3 \times (\text{LT LOSS in each TF} \times \text{No.of TF})}{DF^2 \times 1000}$$

$$PLL = \frac{3 \times (720 \times 2 + 60 \times 32)}{1.90^2 \times 1000} = 2.79$$

Losses in LT line = PLL X LLF X 8760 kWh

LT line loss = 2.79 X 0.43 X 8760 = 10,509.37kWh ………………… (H)

Total Technical Losses in Feeder (Domestic Load Only) =

L2 = E + F + G + H = 1, 04,953.53kWh

Friends Colony Feeder Data (Industrial Load)

Total length of feeder = 12 Km

Total Connected Load on Feeder = 4496 KVA

Average Load = 150 A

Peak Load = 220 A

Resistance = 0.552Ω/Km (RABBIT)

Table 3.4

Transformers in Domestic network

Total transformer in feeder			Standard losses in each unit Of 3 star rated transformer (watts)	
Capacity (kva)	Quantity (nos.)	No. Of t/f with lt	Iron losses	Copper losses
100	11	11	185	1800
63	45	45	150	1250
25	23	23	77	695

7) Calculation Total Technical Losses in Feeder (Industrial Load Only). (24 Hours Operation)

Peak load = $\sqrt{3}$ x V_1 x I_1 (KVA)

Where V_1 is line voltage & I_1 is line current

Peak load = = $\sqrt{3}$ x 11 x 220 = 4186.6 KVA

$$\text{Copper losses} = \frac{\text{Copper loss in each unit} \times \text{number of such unit} \times LF^2 \times 8760}{1000}\ \text{KWh}$$

$$\text{Losses HT line} = \frac{10.5 \times (\text{Peak load} \times 2) \times \text{Length} \times \text{Resitsnce} \times LLF}{DF^3 \times 2}\ \text{KWh}$$

Diversity factor (DF) = Total connected load (KVA) / Peak load (KVA)

DF = 4496 KVA / 4186.6 KVA = 1.07

Load factor (LF) = Average load (A) / Peak load(A)

LF = 150 A / 220 A = 0.68

K = 0.31

Loss load factor (LLF)= (LF^2 X 0.69 + LF X 0.31)

LLF = 0.68 X 0.68 X 0.69 + 0.68 X 0.31 = 0.52

Table 3.5

Industrial loads connected to network

Account no.	Address	Sanc. Load in KW
LS 499	M/s anand met fast	249.9
LS 598	Saboli cold store	220
LS 449	M/s balaji agro product	149
LS 650 K	M/s garg brothers	100
LS 337 K	M/s aman enterprise	498
LS 177	M/s sapu international	74.53
LS 370 K	M/s durga shakti cold store	159.9
LS 354	M/s mahabir singh	474.5
LS 38 K	M/s surya rubber	95.8
LS 456	M/s rekha singh	425
LS 158	Kay dee industries	425
LS 439	Santosh agro food p.ltd.	196.52
LS 441	M/s v.k. enterprises	149.4
LS 110	M/s trinetra builders	580.74
LS 216	Priya plastic products	149.9
LS 549	M/s nova oxide	300
LS 170-	M/s m.s. processor	119.7
LS 181	S.r. enterprises	108.19

Iron Losses in Transformer (Annually)

$$\text{Iron losses} = \frac{\text{Iron loss in each unit} \times \text{number of such unit} \times 8760}{1000}\ \text{KWh}$$

$$\text{PEAK POWER LOSS (PLL)} = \frac{3 \times (\text{LT LOSS in each TF} \times \text{No.of TF})}{DF^2 \times 1000}$$

Iron loss in 100 KVA transformers = (185 X 11 X 8760) / 1000 = 17,826.6 kWh

Iron loss in 63 KVA transformers = (150 X 45 X 8760) / 1000

Table 3.6

Transformers connected in the network

Total Transformer In Feeder			Standard Losses In Each Unit Of 3 Star Rated Transformer (Watts)	
Capacity (Kva)	Quantity (Nos.)	No. Of T/F With Lt	Iron Losses	Copper Losses
100	11	11	185	1800
63	45	45	150	1250
25	23	23	77	695

= 59,130 kWh

Iron loss in 25 KVA transformers = (77 X 23 X 8760) / 1000 = 15,513.96 kWh

Total iron losses in all transformers annually = 92,470.56 kWh …………………….. (I)

Copper losses in transformer (Annually)

Copper loss in 100 KVA transformers = (1800 X 11 X 0.68^2 X 8760) / 1000 = 80,202.35 kWh
Copper loss in 63 KVA transformers = (1250 X 45 X 0.68^2 X 8760) / 1000 = 2,27,847.6 kWh
Copper loss in 25 KVA transformers = (695 X 23 X 0.68^2 X 8760) / 1000 = 64,749.22 kWh
Total copper losses in all transformers annually = 3,72,799.17 kWh …………………..(J)
Losses in ht line (Annually)

$$\text{Losses in HT line} = \frac{10.5 \text{ X } (4186.6 \text{ X } 2) \text{ X } 12 \text{ X } 0.552 \text{ X } 0.52}{1.07^3 \text{ X } 2}$$

= 1,23,157.81 kWh……...(K)

Losses in LT line (Annually)

Average LT loss for 100 KVA transformer = 1900W

Table 3.7
Transformers Mix feeder

Total Transformer In Mix Feeder			Standard Losses In Each Unit Of 3 Star Rated Transformer (Watts)	
Capacity (Kva)	Quantity (Nos.)	No. Of T/F With Lt	Iron Losses	Copper Losses
63	2	2	150	1250
25	32	32	77	695

Average LT loss for 63 KVA transformer = 720W

Average LT loss for 25 KVA transformer = 60W

PLL = { 3 X (1900 X 11 + 720 X 45 + 60 X 23) } / 1.07^2 X 1000 = 143.27

Losses in LT line = PLL X LLF X 8760 kWh

LT line loss = 143.27 X 0.52 X 8760 = 6,52,663.99 kWh …………………(L)

Total Technical Losses In Feeder (Industrial Load Only) = L3 = I + J + K + L = 12,41,091.53 kWh

After Type a Revamping Total Technical Losses Of Revamped Feeder (Domrestic & Industrial Load)

L4 = (L2 + L3) = 1,04,953.5 + 12,41,091.53 =13,46,045.06

$$\%\ \text{TECHNICAL LOSS} = \frac{\text{Total Technical Losses in Feeder Annually (KWh) X 100}}{\text{Total energy supplied annually (KWh)}}$$

= (13,46,045.06/1,21,81,926) X 100

= 11.04%

$$\text{Iron losses} = \frac{\text{Iron loss in each unit} \times \text{number of such unit} \times 8760}{1000}\ \text{KWh}$$

Total Saving W.R.T. Mixed Feeder i.e., (L1-L4) = 24,63,565.50-13,46,045.06= 11,17,520.44

$$\text{Copper losses} = \frac{\text{Copper loss in each unit} \times \text{number of such unit} \times LF^2 \times 8760}{1000}\ \text{KWh}$$

3.5 Estimation of Losses After Type B Revamping

Friends Colony Feeder Essential Data (Domestic Load)

Total length of feeder = 3.2 Km

Total Connected Load On Feeder = 906.88 KVA

Average Load = 16.08 A

Peak Load = 25 A

Resistance

$$\text{Losses HT line} = \frac{10.5 \times (\text{Peak load} \times 2) \times \text{Length} \times \text{Resitsnce} \times \text{LLF}}{DF^3 \times 2}\ \text{KWh}$$

ce = 0.552Ω/Km (RABBIT)

$$\text{PEAK POWER LOSS (PLL)} = \frac{3 \times (\text{LT LOSS in each TF} \times \text{No.of TF})}{DF^2 \times 1000}$$

3.5.1 Calculation Total Technical Losses in Feeder (Domestic Load Only).

Peak load = √3 x V_1 x I_1 (KVA)

Where V_1 is line voltage & I_1 is line current

Peak load = = √3 x 11 x 25 = 475.75 KVA

Diversity factor (DF) = Total connected load (KVA) / Peak load (KVA)

DF = 906.88 KVA / 475.75 KVA = 1.90

Load factor (LF) = Average load (A) / Peak load(A)

LF = 16.08 A / 25 A = 0.64

Table 3.8
Transformers connected in mix feeder network

Total Transformer In Mix Feeder			**Standard Losses In Each Unit Of 3 Star Rated Transformer (Watts)**	
Capacity (Kva)	Quantity (Nos.)	No. Of T/F With Lt	Iron Losses	Copper Losses
100	11	11	185	1800
63	45	45	150	1250
25	23	23	77	695

K = 0.28

Loss load factor (LLF)= (LF^2 X 0.71 + LF X 0.29)
LLF = 0.64 X 0.64 X 0.71 + 0.64 X 0.29 = 0.47
Iron Losses In Transformer (Annually)
Iron loss in 63 KVA transformers = (150 X 2 X 8760) / 1000 = 2628 kWh
Iron loss in 25 KVA transformers = (77 X 32 X 8760) / 1000 = 21,584.64 kWh
Total iron losses in all transformers annually = 24,212.64 kWh……………………..(M)
Copper Losses In Transformer (Annually)
Copper loss in 63 KVA transformers = (1250 X 2 X 0.56^2 X 8760) / 1000 = 6867.84 kWh
Copper loss in 25 KVA transformers = (695 X 32 X 0.56^2 X 8760) / 1000 =61,096.30 kWh
Total copper losses in all transformers annually = 67,964.14 kWh …………………..(N)
Losses in HT line (Annually)
Losses in HT line = 10.5 X (475.75 X 2) X 3.2 X 0.552 X 0.47 =
1.90^3 X 2
604.98 kWh…………..(O)
Losses in LT line (Annually)
Average LT loss for 63 KVA transformer = 720W
Average LT loss for 25 KVA transformer = 60W

$$\text{PLL} = \frac{3 \text{ X } (720 \text{ X } 2 + 60 \text{ X } 32)}{1.90^2 \text{ X } 1000} = 2.79$$

Losses in LT line = PLL X LLF X 8760 kWh
LT line loss = 2.79 X 0.43 X 8760 = 3769.59 kWh

…………………(P)

Total Technical Losses In Feeder (Domestic Load Only) = L5 = M + N + O + P = 96,551.35 kWh

$$\text{Iron losses} = \frac{\text{Iron loss in each unit} \times \text{number of such unit} \times 8760}{1000}\ \text{KWh}$$

Friends Colony Feeder Essential Data (Industrial Load)
Total length of feeder = 6.9 Km
Total Connected Load on Feeder = 4496 KVA
Average Load = 150 A
Peak Load = 220 A
Resistance = 0.552Ω/Km (

$$\text{Copper losses} = \frac{\text{Copper loss in each unit} \times \text{number of such unit} \times LF^2 \times 8760}{1000}\ \text{KWh}$$

RABBIT)

Table 5.9 Transformer in the network (industrial loads)

$$\text{Losses HT line} = \frac{10.5 \times (\text{Peak load} \times 2) \times \text{Length} \times \text{Resitsnce} \times LLF}{DF^3 \times 2}\ \text{KWh}$$

3.5.2 Calculation Total Technical Losses in Feeder (Industrial Load Only). (24 HOURS OPERATION)
Peak load = √3 x V_1 x I_1 (KVA)
Where V_1 is line voltage & I_1 is line current
Peak load = = √3 x 11 x 220 = 4186.6 KVA
Diversity factor (DF) = Total connected load (KVA) / Peak load (KVA)
DF = 4496 KVA / 4186.6 KVA = 1.07
Load factor (LF) = Average load (A) / Peak load(A)
LF = 150 A / 220 A = 0.68
K = 0.31
Loss load factor (LLF)= (LF^2 X 0.69 + LF X 0.31)
LLF = 0.68 X 0.68 X 0.69 + 0.68 X 0.31 = 0.52

4. Iron Losses in Transformer (Annually)

Iron loss in 100 KVA transformers = (185 X 11 X 8760) / 1000 = 17,826.6 kWh
Iron loss in 63 KVA transformers = (150 X 45 X 8760) / 1000 = 59,130 kWh
Iron loss in 25 KVA transformers = (77 X 23 X 8760) / 1000 = 15,513.96 kWh
Total iron losses in all transformers annually = 92,470.56 kWh ……………………..(Q)
Copper losses in transformer (Annually)
Copper loss in 100 KVA transformers = (1800 X 11 X 0.68^2 X 8760) / 1000 = 80,202.35 kWh
Copper loss in 63 KVA transformers = (1250 X 45 X 0.68^2 X 8760) / 1000 = 2,27,847.6 kWh
Copper loss in 25 KVA transformers = (695 X 23 X 0.68^2 X 8760) / 1000 = 64,749.22 kWh
Total copper losses in all transformers annually = 3,72,799.17 kWh…………………..(R)
Losses in HT line (Annually)

Losses in HT line = $\frac{10.5 \text{ X } (4186.6 \text{ X } 2) \text{ X } 6.9 \text{ X } 0.552 \text{ X } 0.52}{1.07^3 \text{ X } 2}$ = 70,815.73 kWh………..(S)

Losses in LT line (Annually)
Average LT loss for 100 KVA transformer = 1900W
Average LT loss for 63 KVA transformer = 720W
Average LT loss for 25 KVA transformer = 60W

PLL = $\frac{3 \text{ X } (1900 \text{ X } 11 + 720 \text{ X } 45 + 60 \text{ X } 23)}{1.07^2 \text{ X } 1000}$ = 143.27

$$\text{PEAK POWER LOSS (PLL)} = \frac{3 \times (\text{LT LOSS in each TF} \times \text{No.of TF})}{DF^2 \times 1000}$$

Losses in LT line = PLL X LLF X 8760 kWh
LT line loss = 143.27 X 0.52 X 8760 = 6,52,663.99 kWh …………………(T)
Total Technical Losses In Feeder (Industrial Load Only)
L6 = Q + R + S + T = 11,88,749.45 kWh
After Type B Revampingtotal Technical Losses Of Revamped Feeder (Domrestic & Industrial Load)
L7 = (L5 + L6) = 96,551.35 + 11,88,749.45 = 12,85,300.80

$$\%\ \text{TECHNICAL LOSS} = \frac{\text{Total Technical Losses in Feeder Annually (KWh) X 100}}{\text{Total energy supplied annually (KWh)}}$$

= (12,85,300.80/1,21,81,926) X 100= 10.55 %
Total Saving W.R.T. Mixed Feeder (L1-L7)
= 24,63,565.50-12,85,300.80 = 11,78,264.40

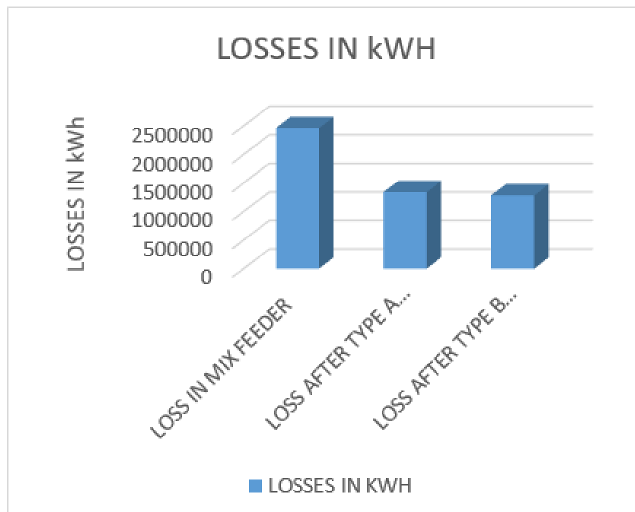

Fig. 3. Graphical representations of technical losses

5. Results

After designing the GPS models of these approaches on MapSource software, we finally estimate the technical losses of mixed network as well as Type A & Type B feeder segregation approach.
Loss In Mixed Feeder Before Revamping = 24,63,565.50kWh
Loss In Feeder After Type A Revamping = 13,46,045.06kWh
Loss In Feeder After Type B Revamping = 12,85,300.80kWh

5. Conclusion

A practical distribution power system has been deemed under measurement and analysis. The revamped network has been modeled. The losses are evaluated on the basis of the practical measurements and data. Technical losses in the mix feeder arrangement can be reduced effectively by implementing the network revamping approaches. Also other measures were implemented in terms of the replacing adequate size of the conductors and reducing the overloading of the transformers by implementing adequate number of transformers in the network. Type A network revamping reduces the losses up to the extent of 1122.21 MWh of units per year. Similarly, while type B network revamping is applied then the losses are reduced to 1178.26 MWh annually while consideration the losses in the mixed feeder type. The numerical result proves that the proposed approach has effectively and good performance to deduce the network issues and problems in the distribution system. By the network revamping the improvement in voltage profile, decrease in power loss, minimization of annual costs of the proposed system has been achieved.

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