

# Best Practices in Technical Loss Reduction –Case Studies

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- High Voltage Distribution System
- Network Re-Configuration
- Network Re-conducturing
- Optimal Location of DTRs
- Integrated Optimal Strategy



## Existing LT Distribution Network

Present LT Distribution system consists of 3 phase distribution transformer with a capacity of 100 KVA in rural areas which feeds supply to all the consumers through 3 phase 4 wire LT network.

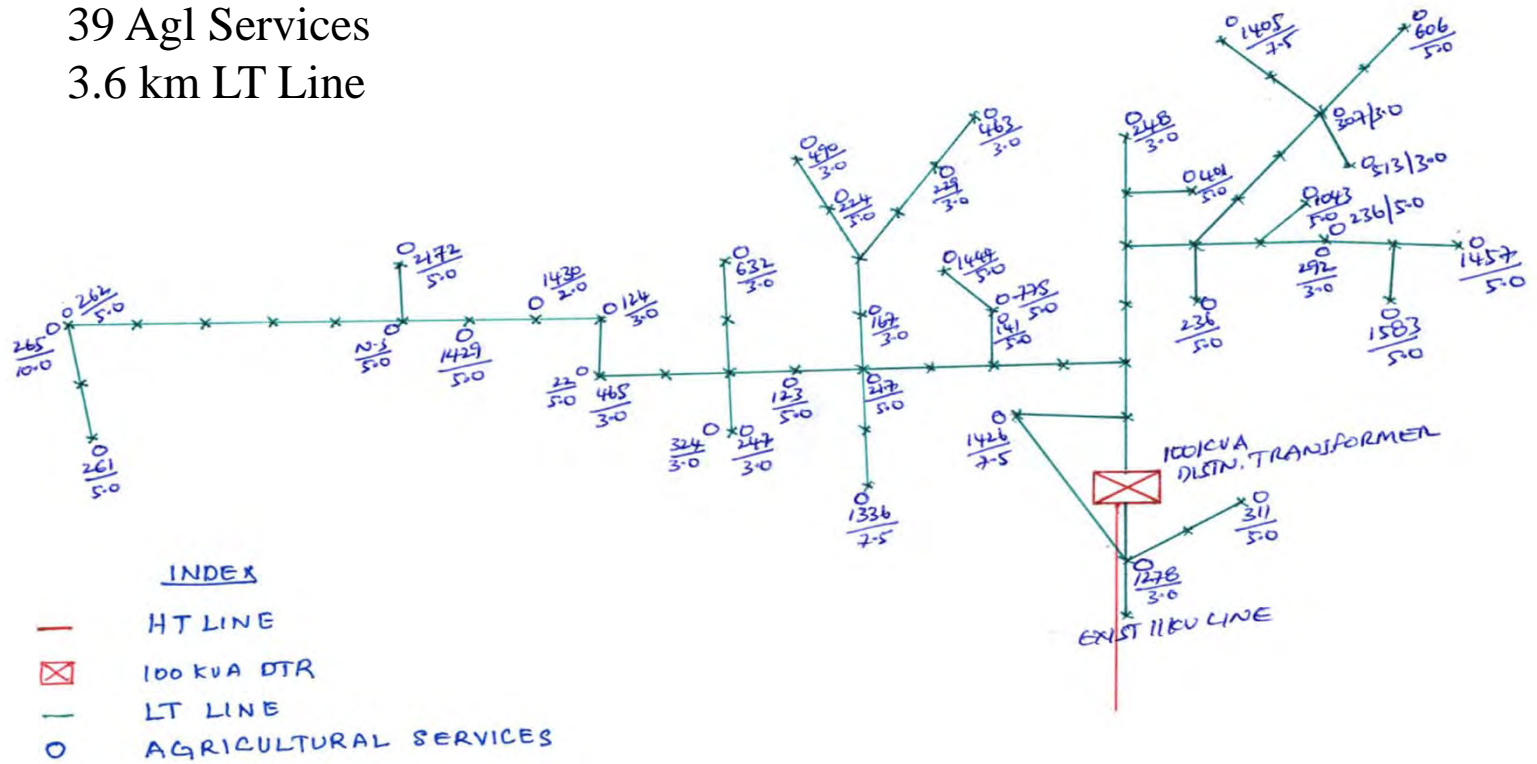
### DISADVANTAGES OF EXISTING SYSTEM

- Lengthy LT Lines.
- Voltage drop at the consumer end.
- High  $I^2R$  losses .
- Frequent motor burn-outs due to low voltage and consequent expenditure on repairs.
- Transformer failures-expenditure towards repairs and inconvenience to the consumers.

Continue...

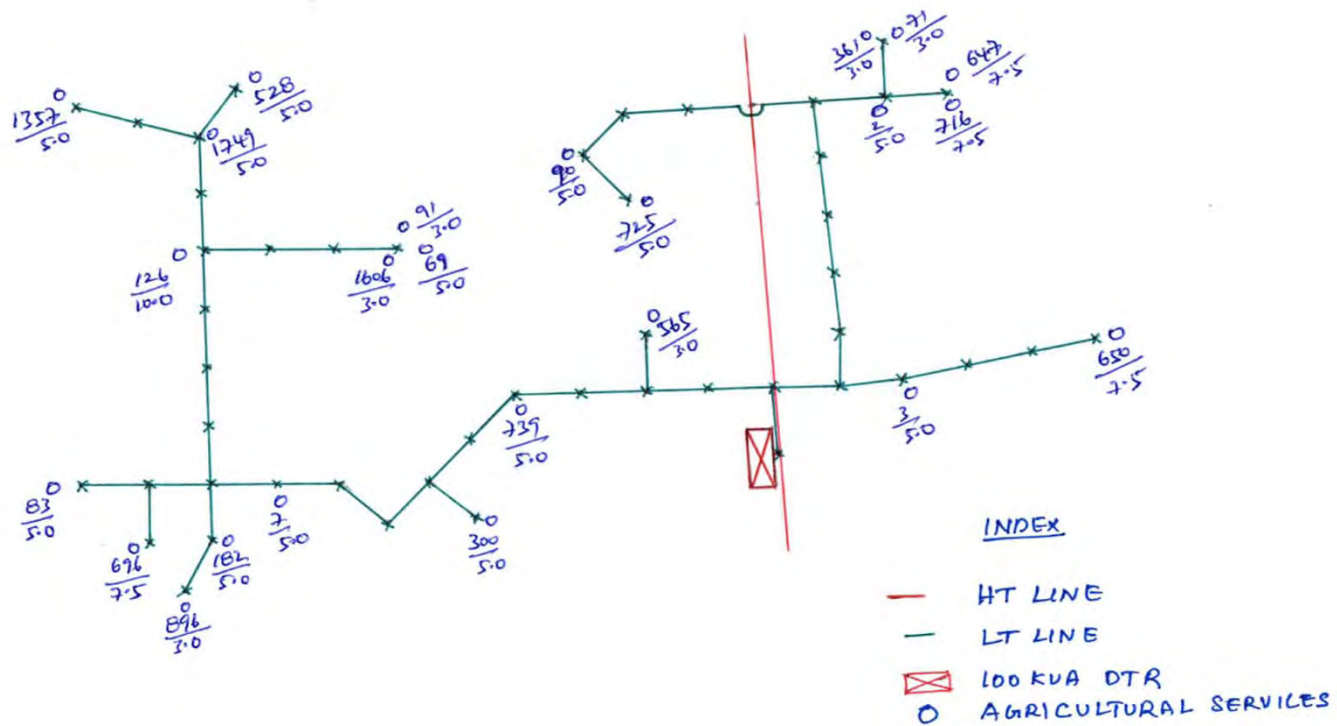
- Damage to standing crops, due to delay in replacement of failed distribution transformers.
- Fluctuations in voltages due to more number of consumers connected under this transformer (say 25 to 30 consumers).
- Nobody owns the transformer since everybody thinks that others will take care of the transformer.

39 Agl Services  
3.6 km LT Line

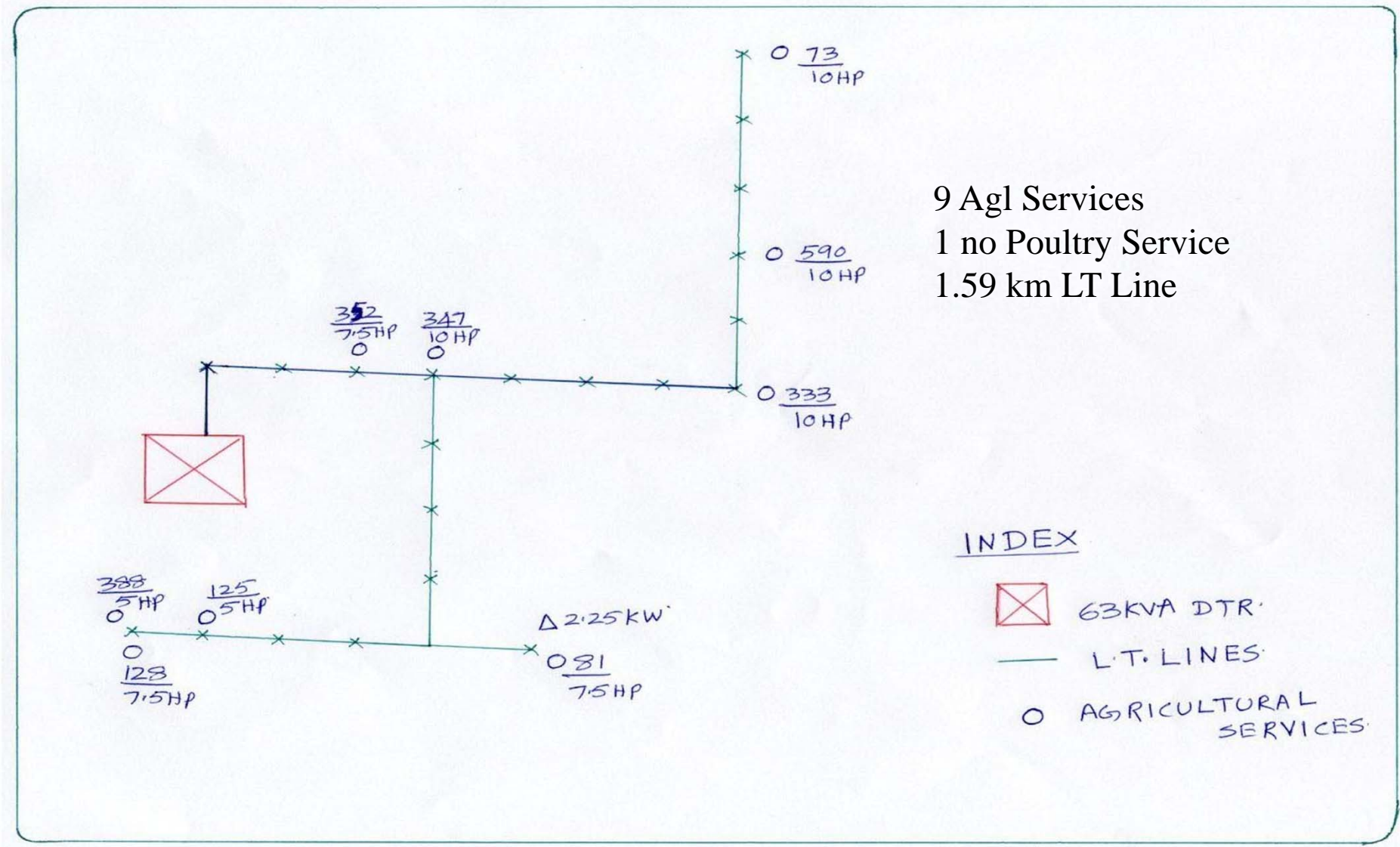


Existing LT Distribution of KOTTUR - SS-I

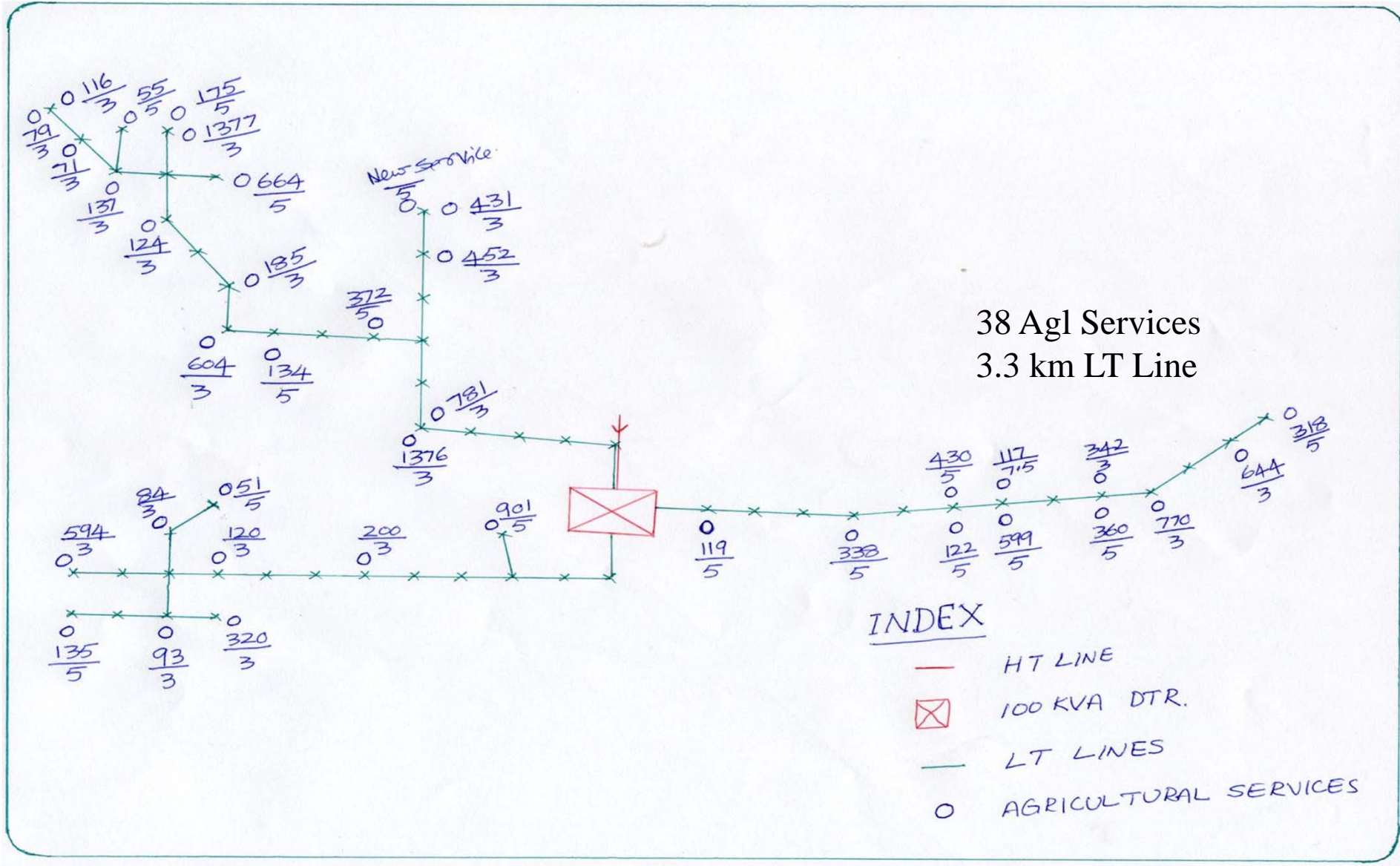
24 Agl Services  
3.0 km LT Line



Existing LT Distribution of Murakambattu - SS-II



Existing LT Distribution of Patnam – SS II




Existing LT Distribution of Bangaru Palem – SS IV

## CALCULATION OF LT LINE LOSSES

- Electronic meters fixed on the LV Side of the distribution transformers
- All Agricultural Services provided with electronic energy meters.
- Energy sent out from the transformer measured.
- During the same period energy consumed by the Agricultural consumers measured .
- Losses worked out.

Continue...

# Original 100 KVA DTR Voltage & Line Loss Comparison

 Vijai Electricals Ltd.

**ORIGINAL 100 KVA DTR VOLTAGE & LINE LOSS COMPARISON**

<u>Sl.No</u>	<u>Particulars</u>	<u>Kottur-ss I</u>	<u>Murakkombattu -ss II</u>
1	Crop pattern	Sugarcane, paddy	Coconut , mango garden, paddy and part of the land cultivated by sugarcane.
2	Length of LT lines	3.6Km	3.0 Km
3	No. of Pump sets	39	24
4	Connected Loads	179.5 HP	130 HP
5	No. of days	13 days	14 days
6	Input	4290 units	3059 units
7	Output	3490.4 units	2638 units
8	Loss of units	799.6 units	421 units
9	% of line loss	18.63%	13.76%

### ORIGINAL 100 KVA DTR VOLTAGE & LINE LOSS COMPARISON

<u>Sl.No</u>	<u>Particulars</u>	<u>Patnam-ss</u>	<u>Bangarupalem –ss</u>
1	Crop pattern	Sugarcane -90% paddy &G.nut	Sugar cane,Paddy,Coconut,Mango Garden
2	Length of LT lines	1.59Km	3.3 Km
3	No. of Pump sets	9	38
4	Connected Loads	72.5 HP+2.25 KW	130 HP
5	No. of days	40 days	19 days
6	Input	17672 units	6152 units
7	Output	14700 units	5149 units
8	Loss of units	2972 units	1003 units
9	% of line loss	16.82%	16.30%

As seen from the previous table results the LT line losses are more in LT distribution network.

To overcome this, HVD 3Ph system is introduced to maintain better voltages and reliability of supply.

## HVD SYSTEM

Existing LT Lines converted into HV Lines by replacing

- L T 3-Phase crossarm by 11KV . V crossarm
- Replacement of 3 number L T pininsulators with 3 number 11KV pin insulators.
- Replacement of 3 number LT shackles with 3 number 11KV strain insulators .
- Erection of additional supports where ever clearances are inadequate.
- Erection of smaller capacity 3 phase distribution transformer of 15 KVA capacity for every 2 to 3 pumpsets.
- Connection of existing pumpsets from the newly erected 15KVA distribution transformers with airbunched cable .

## Approach followed in taking up HVDS in the State...

- Following four feeders were selected to convert LT System to HVDS
  - Kottur - SS1
  - Murakambattu - SS2
  - Patnam –SS2
  - Bangarupalem-SS4
- The LT & HT lines as existing in the field were meticulously plotted and Line/conductor parameters noted
- Computation of HT line requirement to optimize losses and improve voltages were made
- Metering equipment was arranged to measure losses prior to the conversion to assess the benefits of conversion
- The whole activity was systematically planned and benefits computed and were demonstrated to the customers

## Conversion of existing LT 3ph 4w Line into HT Line



Existing LT 3Phase 4 wire line  
on support



Same support with HVD System

## HVD SYSTEM



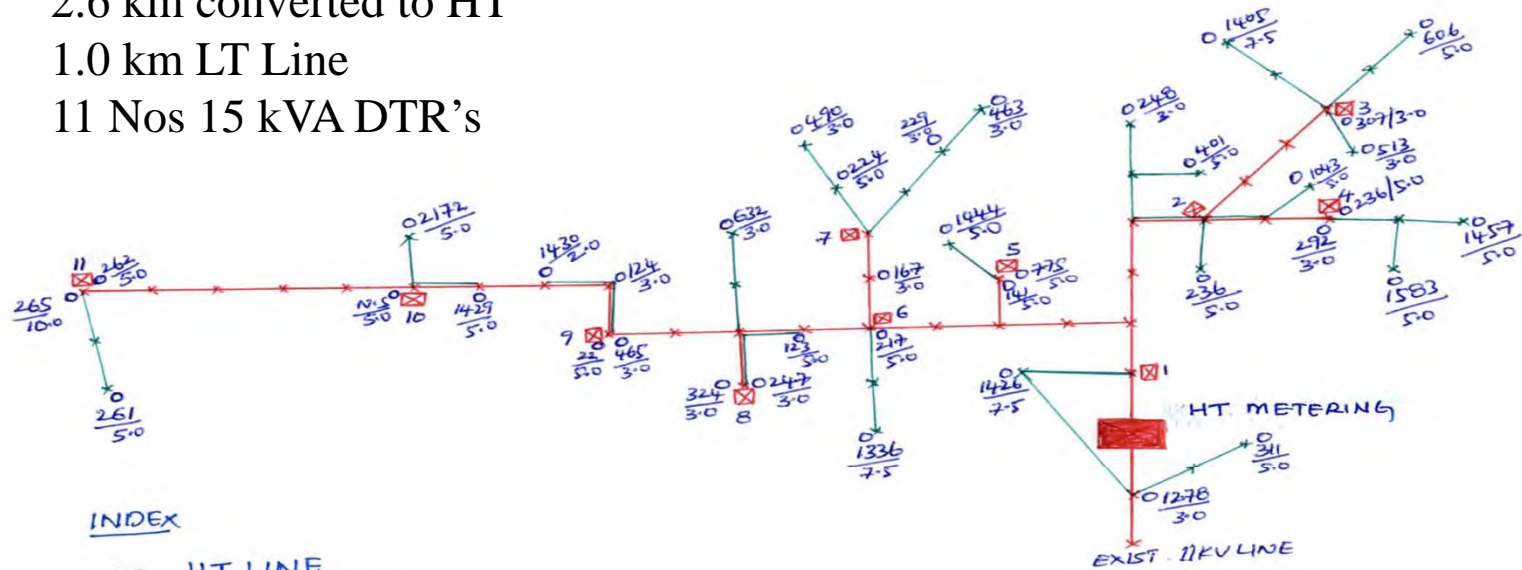
Original 3ph 100KVA Dist. Transformer replaced with 11KV. CTPT set



3ph 15KVA Dist. Transformer erected under HVDS to cater 2 to 3 services

## H.T. and L.T Layout of HVD System.KOTURU-SS-I

- 39 Agl Services
- 3.6 km LT Line
- 2.6 km converted to HT
- 1.0 km LT Line
- 11 Nos 15 kVA DTR's

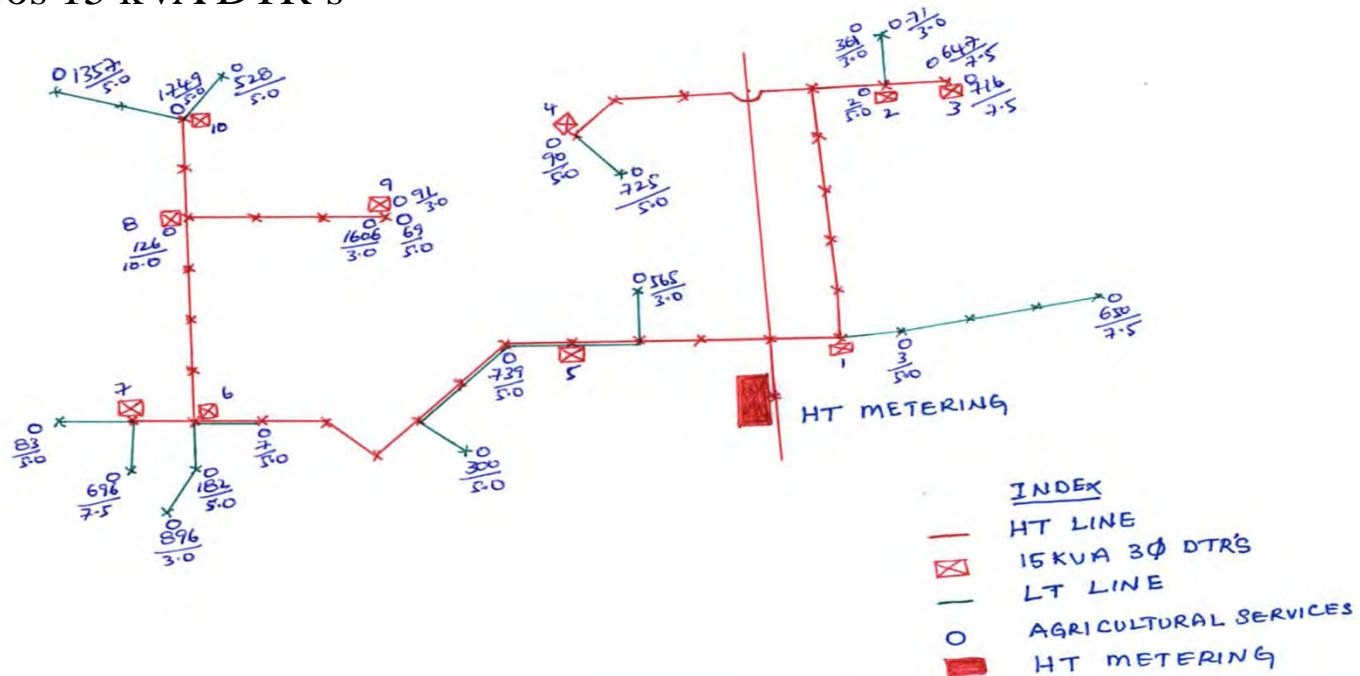


INDEX

- HT LINE
- ☒ 15KVA 3Φ DTR'S
- LT LINE
- AGRICULTURAL SERVICES
- HT METERING

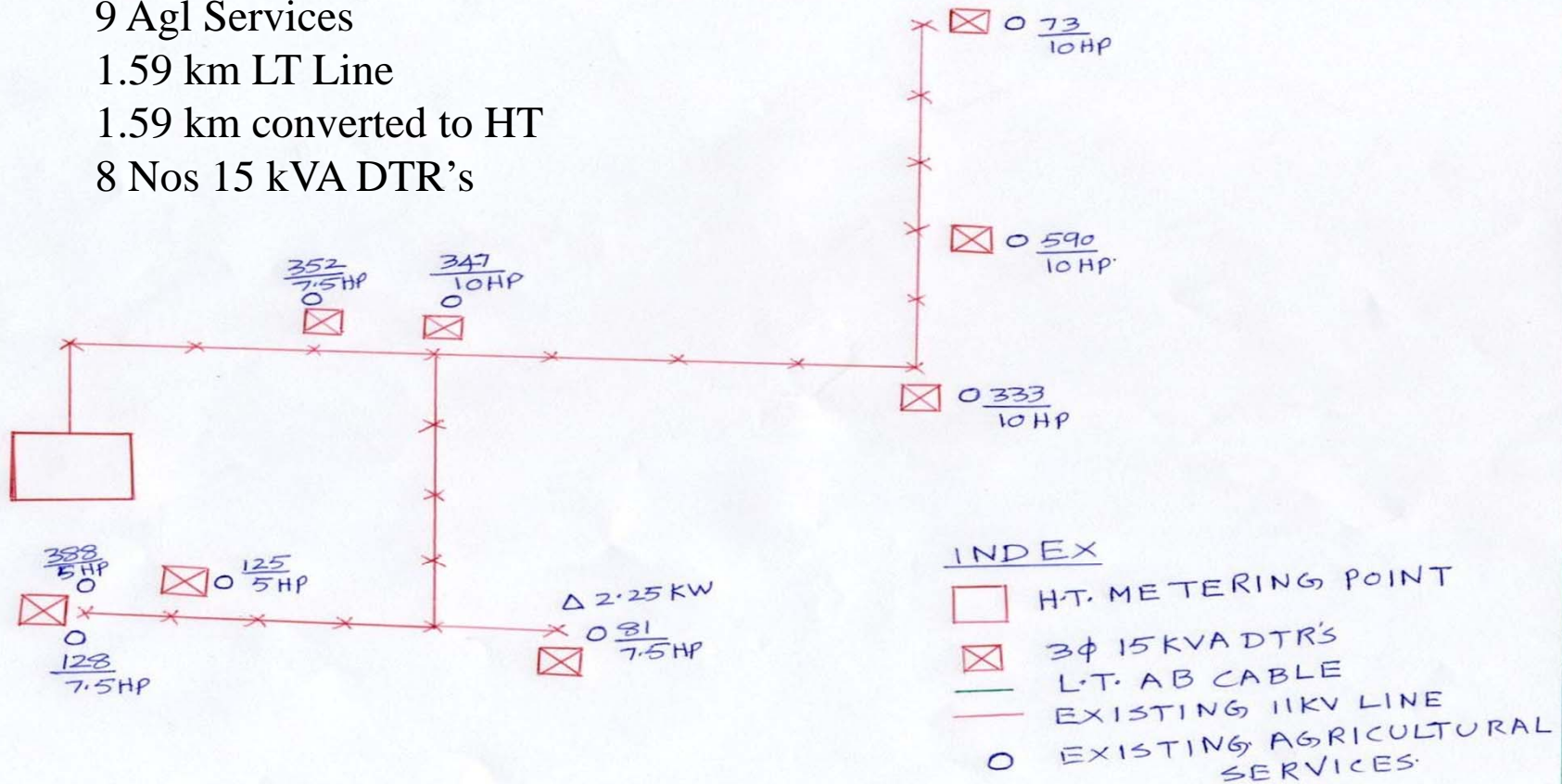
## H.T and L.T layout of HVD System Murakambattu SS II

24 Agl Services  
3.0 km LT Line  
2.04 km converted to HT  
0.96 km LT Line  
10 Nos 15 kVA DTR's



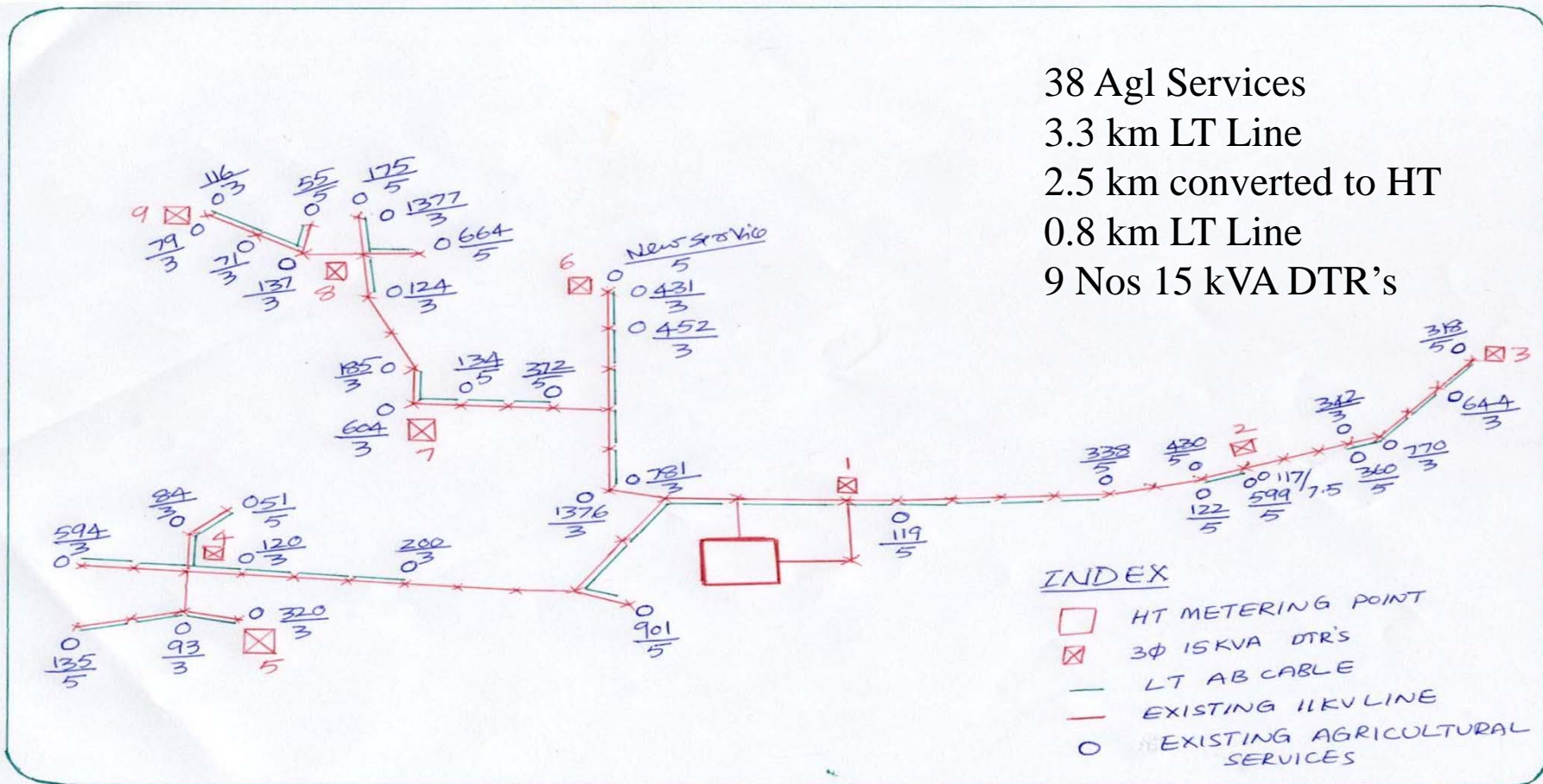
## H.T. and L.T. Layout of HVD System. Patnam SS-II

9 Agl Services  
 1.59 km LT Line  
 1.59 km converted to HT  
 8 Nos 15 kVA DTR's



**H.T and L.T layout of HVD System Bangaru Palem SS IV**

- 38 Agl Services
- 3.3 km LT Line
- 2.5 km converted to HT
- 0.8 km LT Line
- 9 Nos 15 kVA DTR's



## **Calculation Of HT Line Losses in HVD System**

- **11 KV CT PT set erected in place of existing 100 KVA Distribution Transformer**
- **Readings taken simultaneously at CT PT set and at all pump sets.**
- **Losses worked out.**

**Continue...**

<u>Sl.No</u>	<u>Particulars</u>	<u>Kotturu SS-I</u>	<u>Murakkambattu ss-II</u>
1)	No 15KVA distribution transformer erected	11 nos	10 nos
2)	No of days	15 days	13 days
3)	INPUT	5310 units	3926 units
4)	OUTPUT	5019.2 units	3712.2 units
5)	Losses	290.8 units	213.8 units

Continue...

<u>Sl.N</u> <u>o</u>	<u>Particulars</u>	<u>Kotturu ss-I</u>	<u>Murakambatt</u> <u>u ss-II</u>
6)	% of line losses on HVDS	5.47%	5.44%
7)	% of line loss on earlier LT Distribution System	18.63%	13.76%
8)	% Net reduction in line losses	13.16%	8.32%

<u>Sl.No</u>	<u>Particulars</u>	<u>Patnam SS- II</u>	<u>Bangarupalem ss- II</u>
1)	No 15KVA distribution transformer erected	8 Nos	9 Nos
2)	INPUT	1299 units	334 units
3)	OUTPUT	1229 units	321.4 units
4)	Loss of units	69.7 units	12.6 units

Continue...

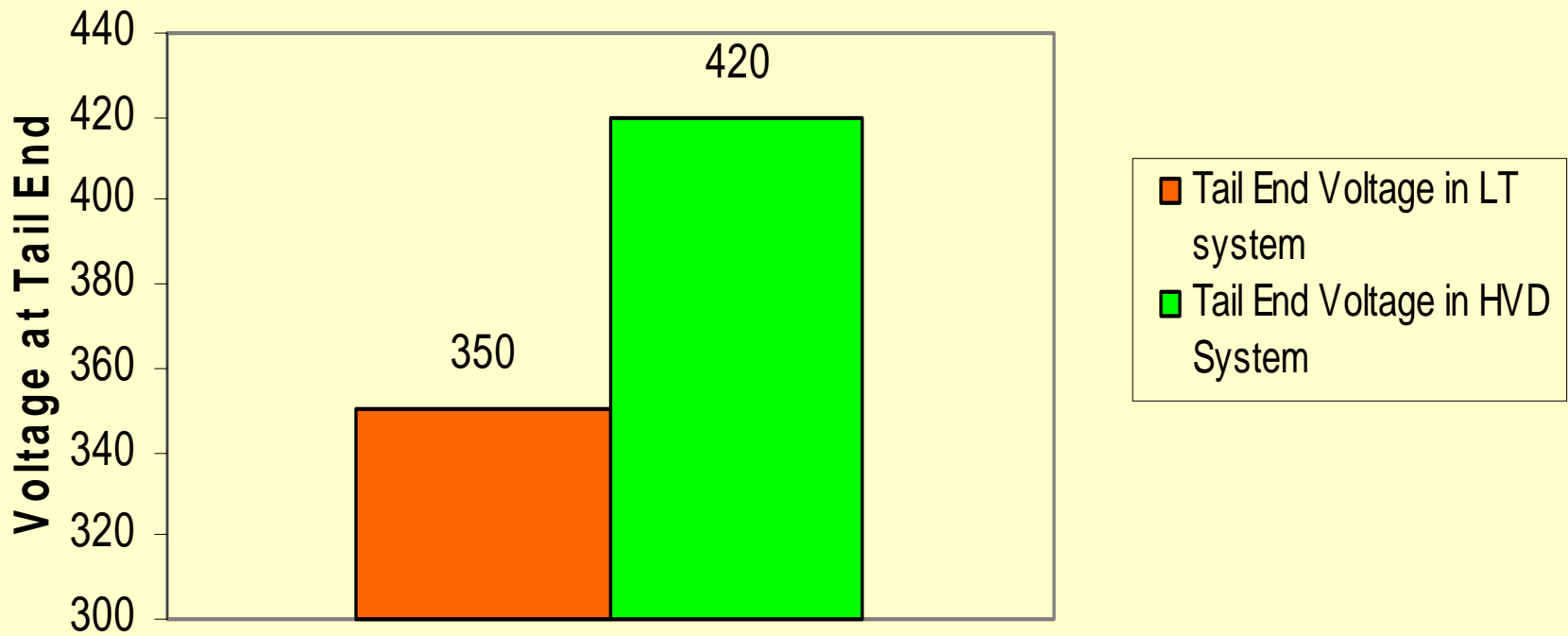
<b><u>Sl.N</u></b> <b><u>o</u></b>	<b><u>Particulars</u></b>	<b><u>Patnam ss-</u></b> <b><u>II</u></b>	<b><u>Bangarupale</u></b> <b><u>m ss-II</u></b>
5)	% of line losses on HVDS	5.30%	3.77%
6)	% of line loss on earlier LT Distribution System	16.82%	16.30%
7)	% Net reduction in line losses	11.52%	12.53%

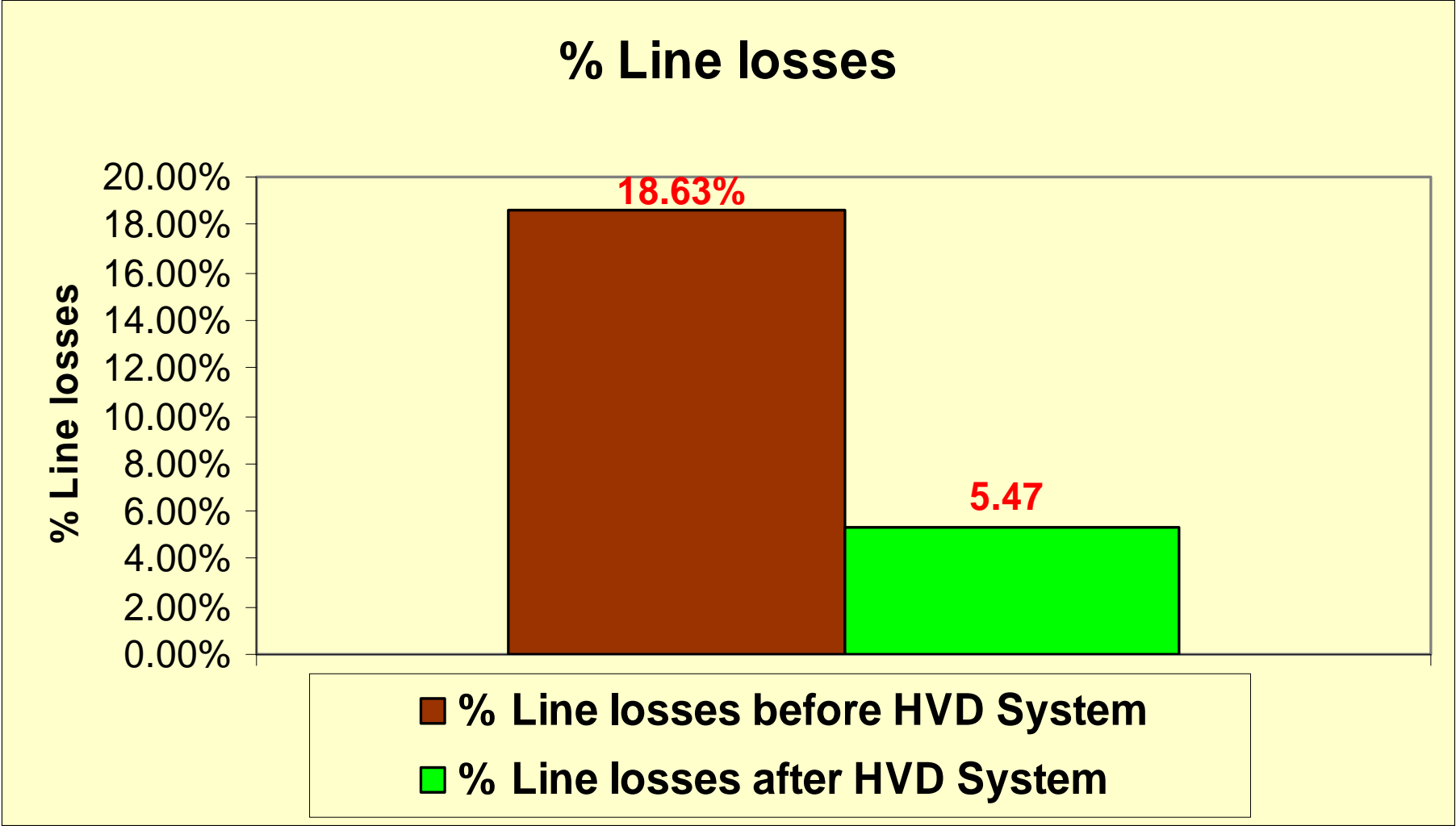
## Comparison between LT System with HVD System

### KOTTURU SS-I

<u>Particulars</u>	<u>LT</u>	<u>HVDS</u>
Length of HT lines	-	2.6Km
Length of LT lines	3.6 Km	1 Km
No of Distribution transformers	100 KVA –1 no/..	15KVA- 11 no/..
Voltage at tail end	350 volts	420 volts
% line losses	18.63%	5.47%

### Voltage at Tail End

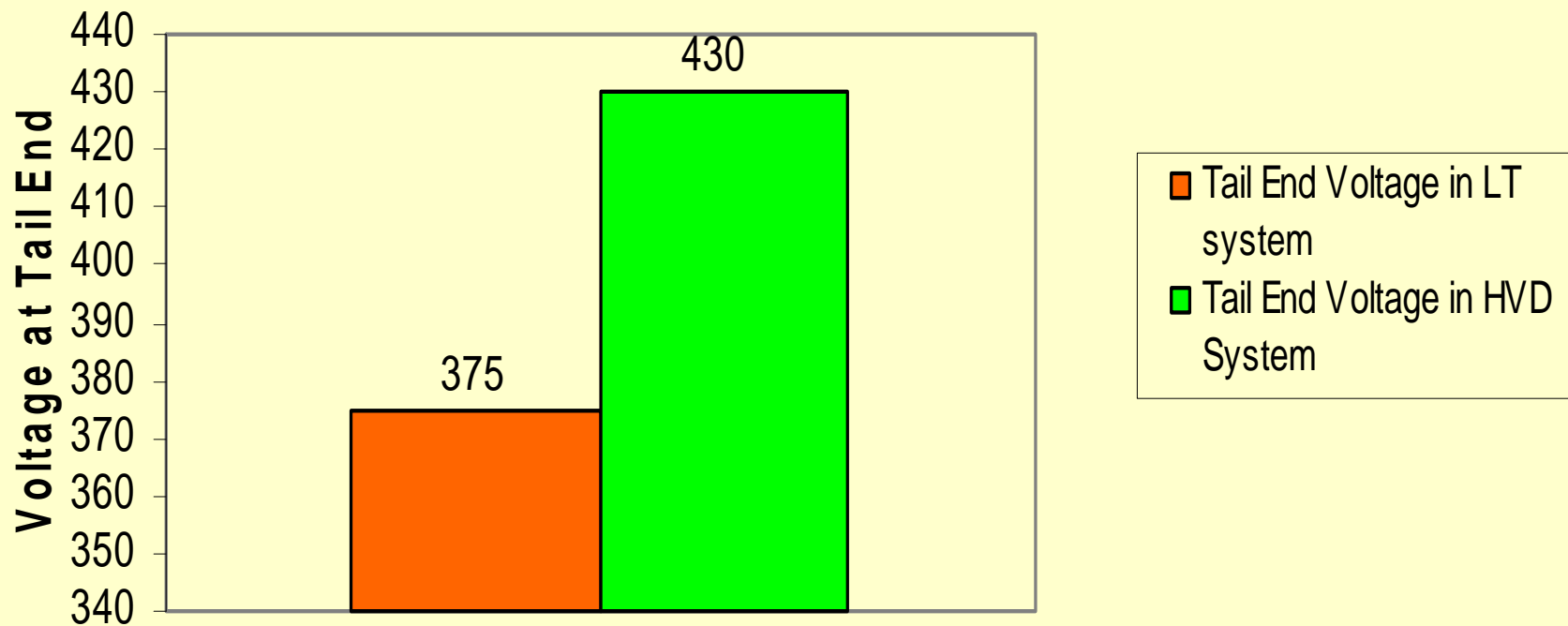




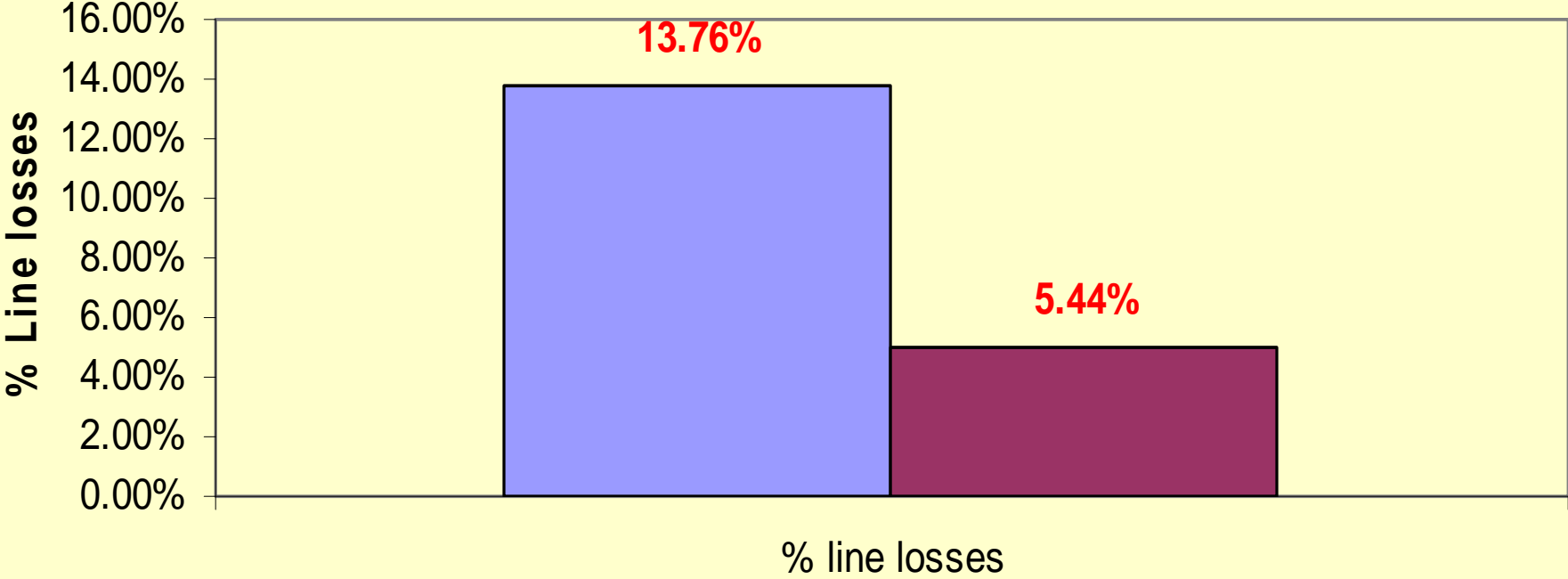
## MURAKAMBATTU SS-II 100 KVA

<u>Particulars</u>	<u>LT</u>	<u>HVDS</u>
Length of HT lines	-	2.04Km
Length of LT lines	3.6 Km	0.96 Km
No of Distribution transformers	100 KVA –1 no/..	15KVA- 10 no/..
Voltage at tail end	385 volts	430 volts
% line losses	13.76%	5.44%

## Murakambattu SS II 100 KVA



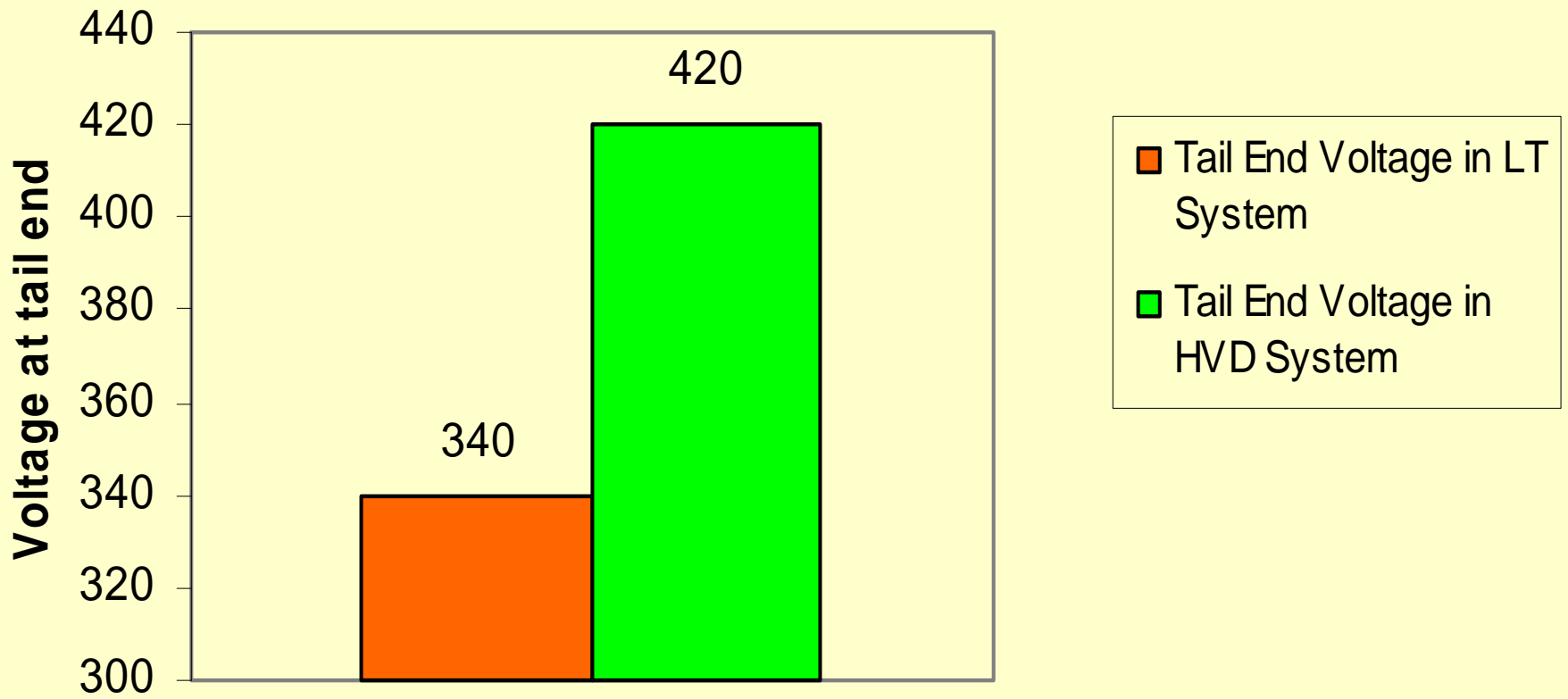
### Murakambattu SS II 100 KVA



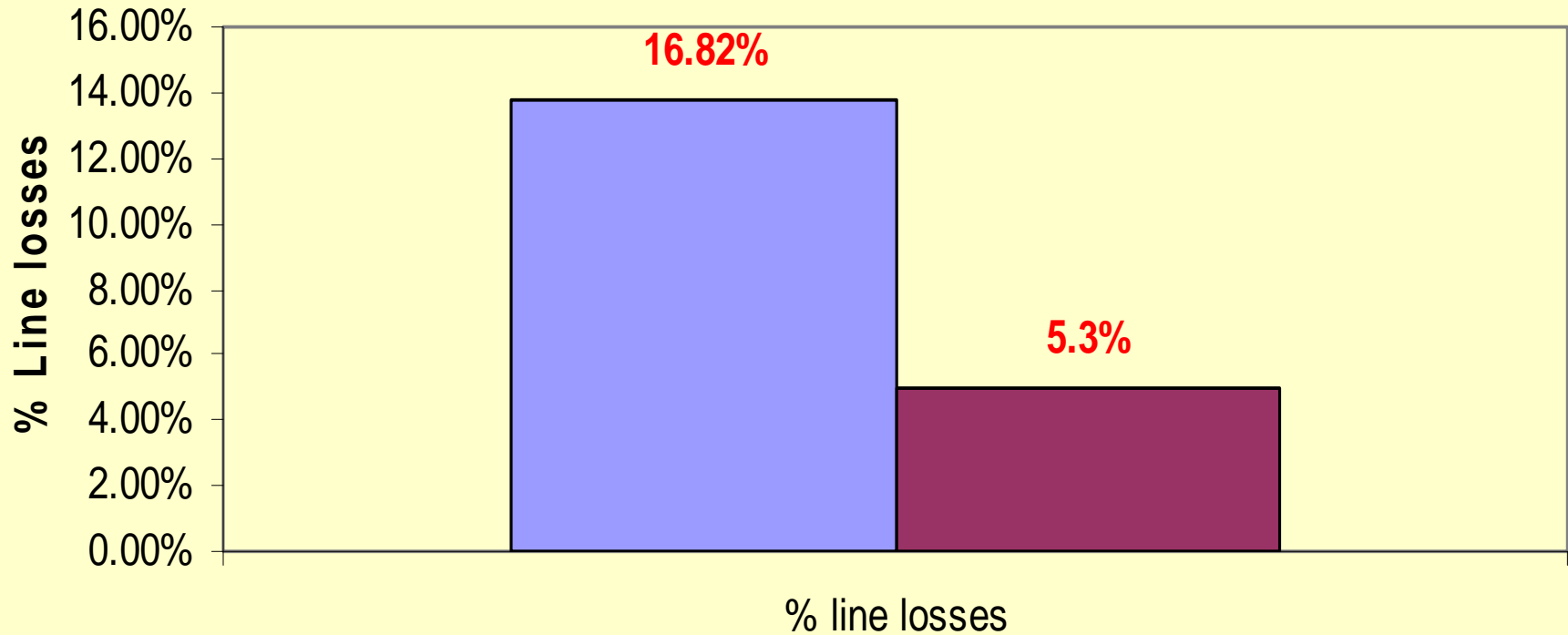
## PATNAM SS-II 63 KVA

<u>Particulars</u>	<u>LT</u>	<u>HVDS</u>
Length of HT lines	-	1.59 Km
Length of LT lines	1.59 Km	-
No of Distribution transformers	63 KVA –1 no/..	15KVA- 8 no/..
Voltage at tail end	340 volts	420 volts
% line losses	16.82 %	5.30%

### Patnam SS II 63 kVA



## Patnam SS II 63 KVA



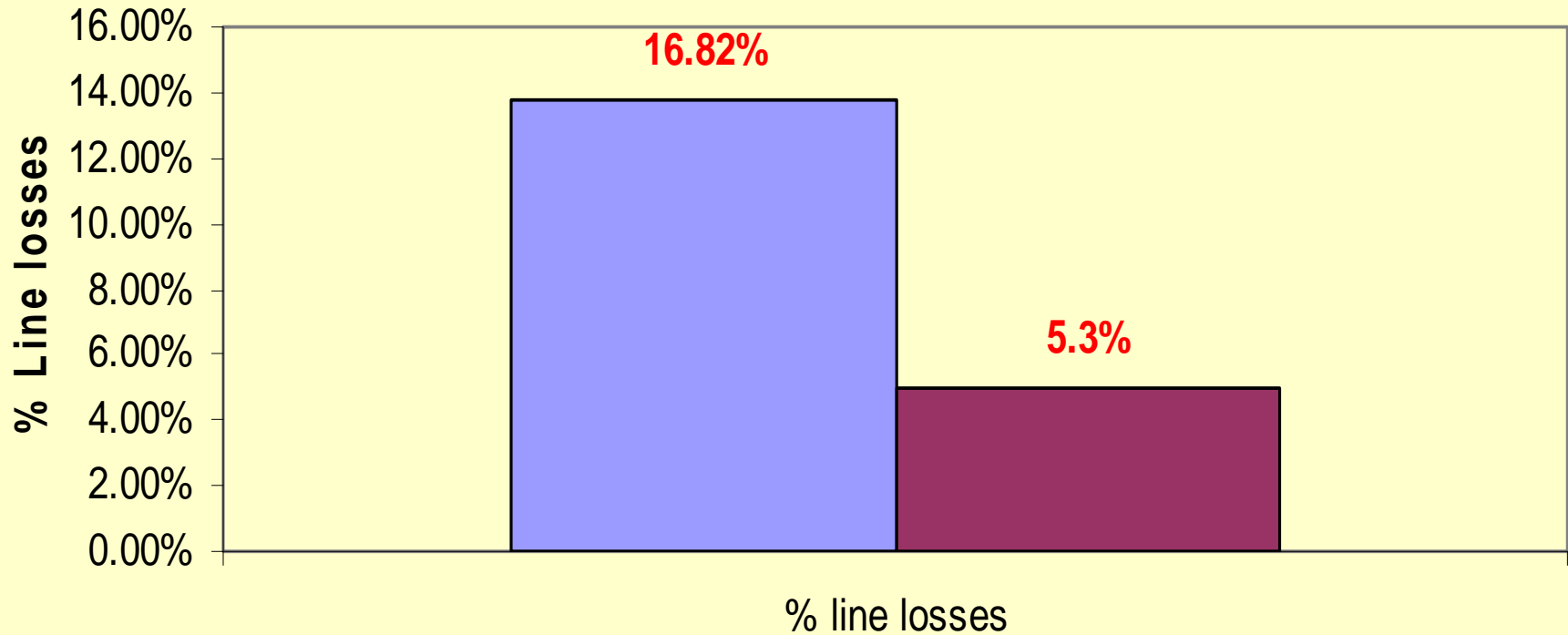
## **NEW VERSION OF HVDS SYSTEM**

### **Bangaru Palem SS-IV 100 KVA**

**The New version of HVDS system is an extension of HVDS work executed at previous locations. The H.T line losses in previous systems is 5.3%. An effort has been done to further reduce the H.T line losses by adopting following methods.**

- 1.Reinforcement of existing LT net work of 7/2.59 ACSR conductor with 55 sqmm conductor.**
- 2.Providing of required rated capacitors at each agricultural services.**

## Patnam SS II 63 KVA



## NEW VERSION OF HVDS SYSTEM

### Bangaru Palem SS-IV 100 KVA

The New version of HVDS system is an extension of HVDS work executed at previous locations. The H.T line losses in previous systems is 5.3%. An effort has been done to further reduce the H.T line losses by adopting following methods.

- 1.Reinforcement of existing LT net work of 7/2.59 ACSR conductor with 55 sqmm conductor.
- 2.Providing of required rated capacitors at each agricultural services.

Bangaru Palem SS-IV 100 KVA with reinforcement of conductor and installing rated capacitors.

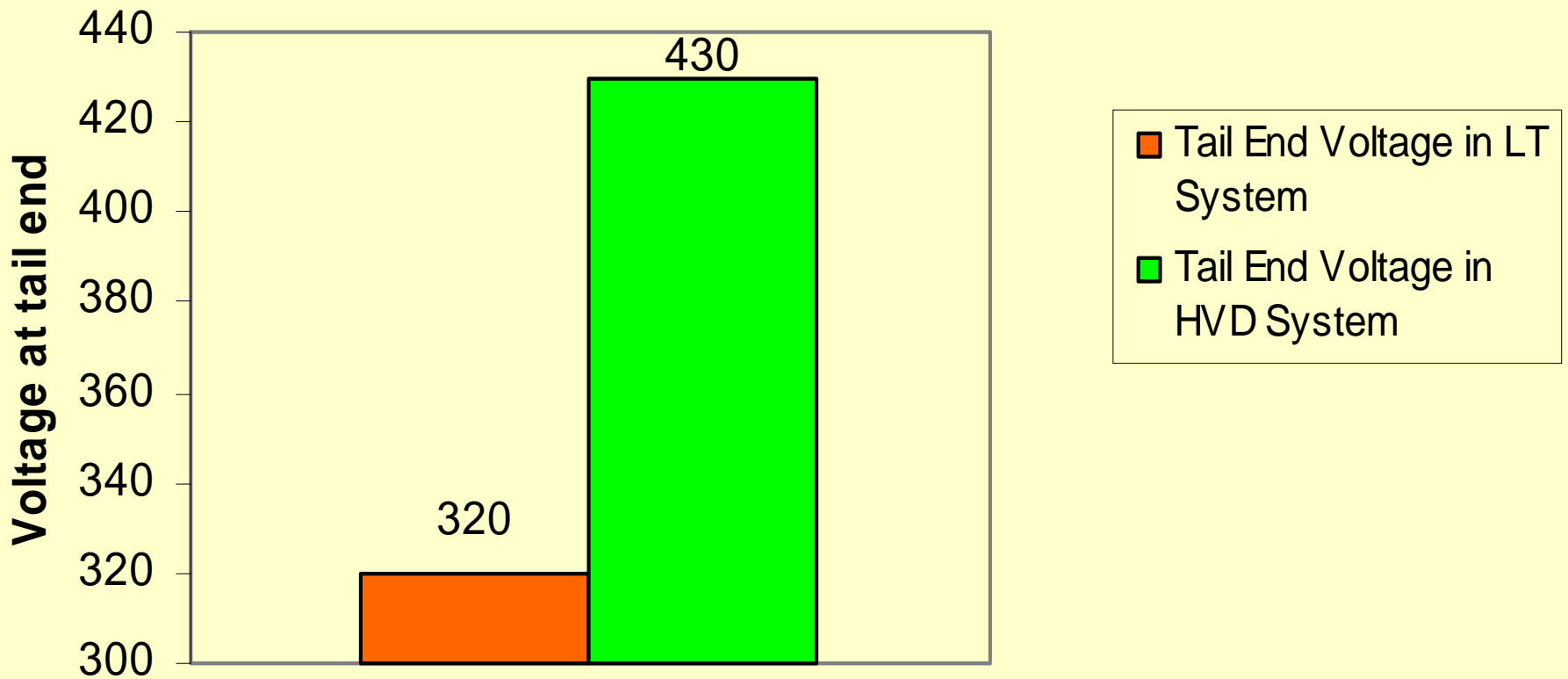
<u>Particulars</u>	<u>LT</u>	<u>HVDS</u>
Length of HT lines	-	2.5 Km
Length of LT lines	3.3 Km	0.8 Km
No of Distribution transformers	100 KVA –1 no/..	15KVA- 9 no/..
Voltage at tail end	320 volts	430 volts
% line losses	16.30 %	3.77%

Bangaru Palem SS-IV 100 KVA.

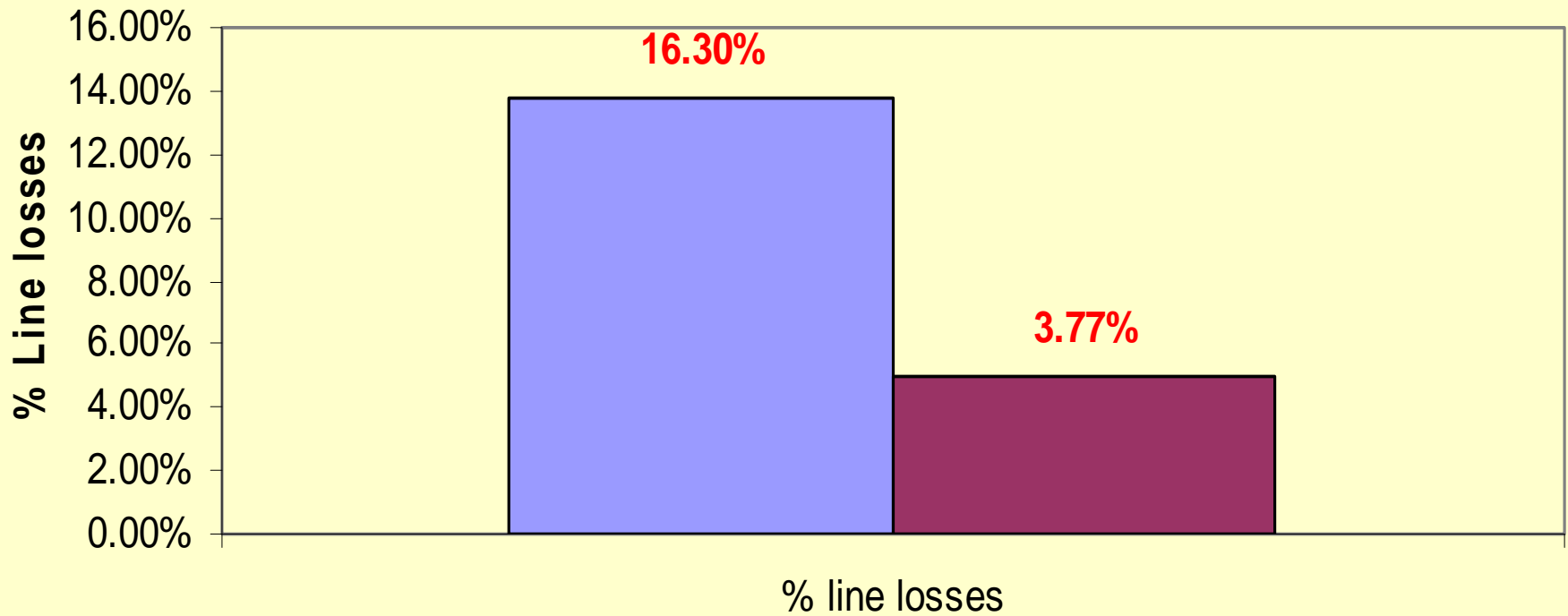
Comparison between HVDS with existing conductor and HVDS with reinforcement of conductor and installing rated capacitors

<b>Particulars</b>	<b>HVDS with existing conductor</b>	<b>HVDS with Reinforcement of conductor and rated capacitors</b>
<b>Voltage at tail end</b>	<b>420 volts</b>	<b>430 volts</b>
<b>% line losses</b>	<b>5.31 %</b>	<b>3.77%</b>

### Bangaru Palem SS IV 100 kVA



## Bangaru Palem SS IV 100 KVA



## ADVANTAGES OF HVD SYSTEM

- ❖ The registered customers will feel ownership and take responsibility and not allow others to meddle with the L.T. Network.
- ❖ Prevention of unauthorized loads by the consumers themselves since the distribution transformer may fail if loaded beyond its capacity.
- ❖ Failure will be minimal because of no over loading and no meddling of L.T Lines.
- ❖ In the event of equipment failure only 2 or 3 customers will get affected instead of 25 to 30 customers in original system.
- ❖ High quality of supply since there is practically no voltage drop.
- ❖ Less burnouts of motors because of good voltage and less fluctuations.

Continue...

- ❖ Considerable reduction in line losses and consequent savings in power purchase cost
- ❖ Since Losses are reduced considerably ,Power can be supplied to additional loads without any further investment on infrastructure.
- ❖ No additional generation capacity needed for giving new loads due to reduction in power drawals.
- ❖ Accidents due to touching of snapped conductors reduced due to the fact that the breaker trips at substation since the line is at 11 KV potential.

<b>HVDS Scheme – Pay Back Period</b>							
S.No	Item	Unit	Rate (Rs.)	Kottur SS-I		Bangarupalem SS	
				Qty	Amount (Rs.Lakhs)	Qty	Amount (Rs.Lakhs)
1	3 Ph 15 kVA DTRs	Nos.	30470	11	3.35	9	2.74
2	Conversion LT 3 Phase 4 Wire Line to 11Kv Line	Kms	12800	2.6	0.33	2.5	0.32
	Total:				3.68		3.06
	Credits:						
1	100 Kva DTRs	Nos	55000	1	0.55	1	0.55
2	LT 3 Ph Line (4 <sup>th</sup> Wire)	Kms	14600	2.6	0.38	2.5	0.37
	Total Credits				0.93		0.92
	Net Cost				2.75		2.15

<b>FINANCIAL BENEFITS</b>			
<b><u>S.No</u></b>	<b><u>Item</u></b>	<b><u>Kottur SS-I</u></b>	<b><u>Bangarupalem SS</u></b>
1	% Line Losses before conversion	18.63%	16.30%
2	% Line Losses after conversion	5.45%	3.70%
3	Connected Load in HP	179.5	130
4	No. of input units fed in to the LT network per annum (approximately 900 units per HP)	161550	117000
5	Line Losses per annum for LT system in units)	30097	19071
6	Lines Losses per annum for HVDS System (in units)	8804	4329
7	Saving in Line Losses (in units)	21292	14742
8	Financial Benefits @ Rs. 2.26 per unit (in Rs. Lakhs)	0.481	0.333
9	Power Loss reduction due to saving in Line Losses (kW)	7.596	5.259
10	Financial benefits due to power loss @Rs. 4320/- per kW (in Rs. Lakhs)	0.328	0.227
11	DTR Failure Rate	15%	15%
12	New Failure Rate	2%	2%
13	Probability of Failure	13%	13%
14	Cost of repair saved (@Rs.15,000/- failure)	0.020	0.020
15	Total Financial Benefits (8+10+14) in Rs. Lakhs	0.829	0.580
16	Pay Back Period	3.32	3.70

## PALAMANER HVDS RESULTS

After getting excellent results in the pilot 4 DTR Locations, the entire Network from Palamaner 33/11 Sub-Station was brought under HVDS in 2003.

Period	No. of DTRs Existing	No. of DTRs Failed	% DTRs Failed
2002 – 03	311	60	19.09%
2003 April – Aug	364	51	14.01%
2003 Aug – Dec	2602	25	-

# Best Practices in Technical Loss Reduction –Case Studies

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**-Network Re-Configuration**

# NETWORK RECONFIGURATION CASE STUDY

Load flow analysis of existing network

Name of feeder	No. of Busses	Length in KM	Power Loss KW	Voltage Drop %
F1	47	52.70	536	27.98
F2	29	31.70	72	6.53
F3	30	29.80	67	7.66

# NETWORK RECONFIGURATION

## CASE STUDY

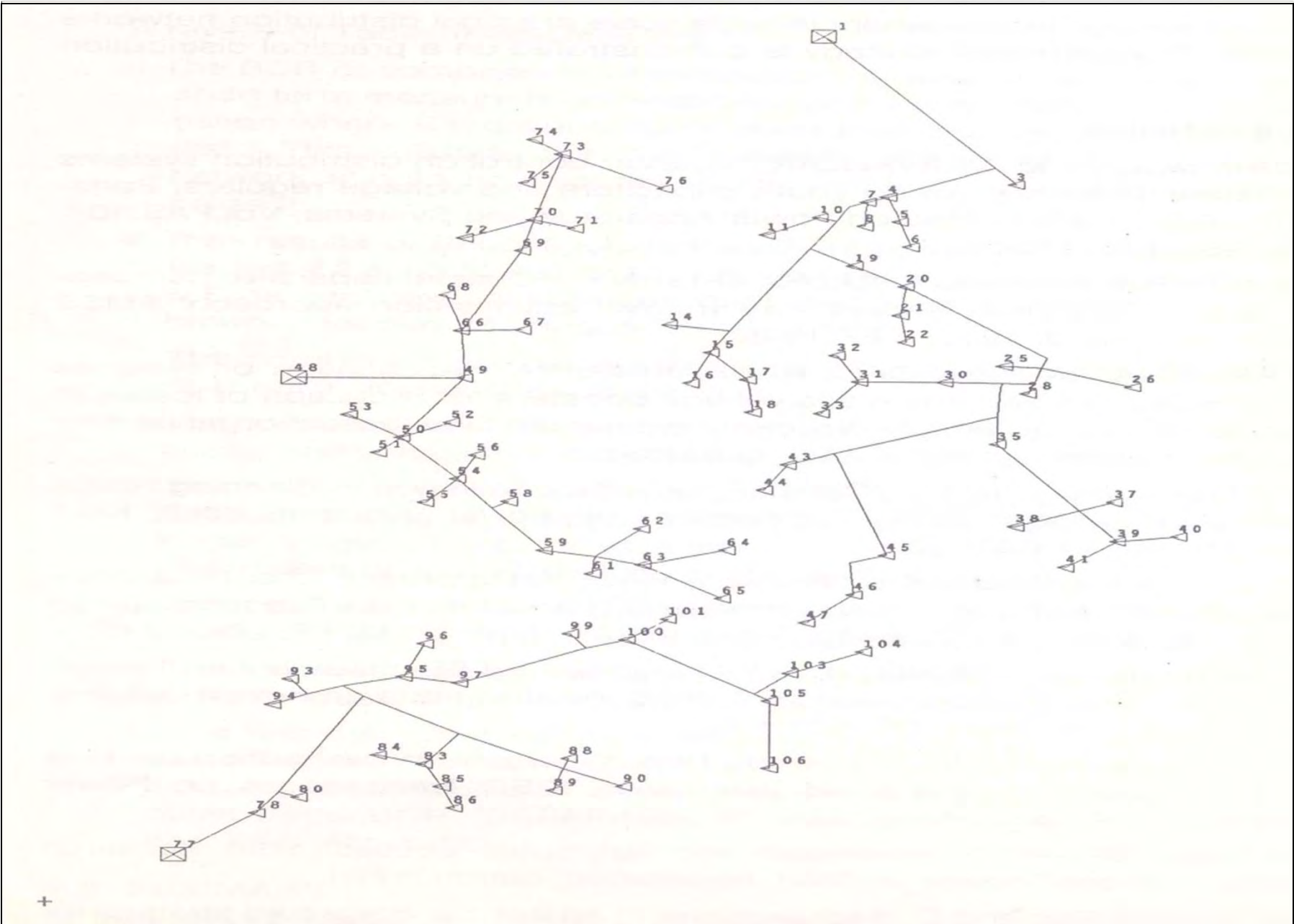
### Results of Reconfiguration

Feeder segment added		Feeder segment Opened	
Bus Nos	Length in KM	Bus Nos.	Length in KM
44-62	2.17	29-34	1.00
47-104	1.20	42-45	3.50
47-65	1.46	63-64	0.50
33-18	1.53	31-30	1.00
32-17	1.05	31-33	1.00

# NETWORK RECONFIGURATION CASE STUDY

Load flow analysis of reconfiguration network

Name of feeder	No. of Busses	Length in KM	Power Loss KW	Voltage Drop %
F1	30	42.24	172	13.10
F2	31	38.51	158	10.53
F3	25	33.40	104	10.68



# BENEFIT-COST ANALYSIS FOR NETWORK RECONFIGURATION CASE STUDY

- Power loss before reconfiguration...675 KW
- Power Loss After Reconfiguration.....434 KW
- Reduction in Power Loss . . . . 241 KW
- % Reduction In Power Loss . . . . 35.7

- Reduction in Energy Loss assuming a load factor of 0.4 . . . . . 4.39
- Value of power Saving Assuming is Rs. 4320/KW & Rs. 2/- per unit..... Rs. 19.18 lakhs
- Length of new feeder Segments required for Reconfiguration (11 KV Network) ..... 7.5 KW

**Capital Investment :Rs. 11.25 lakhs**

**Annual Cost of Capital @21%**

**.....Rs.2.36 lakhs**

**(15%int+3%Depreciatio+3% O&M)**

**Benefit – Cost Ratio ..... 8 (App)**

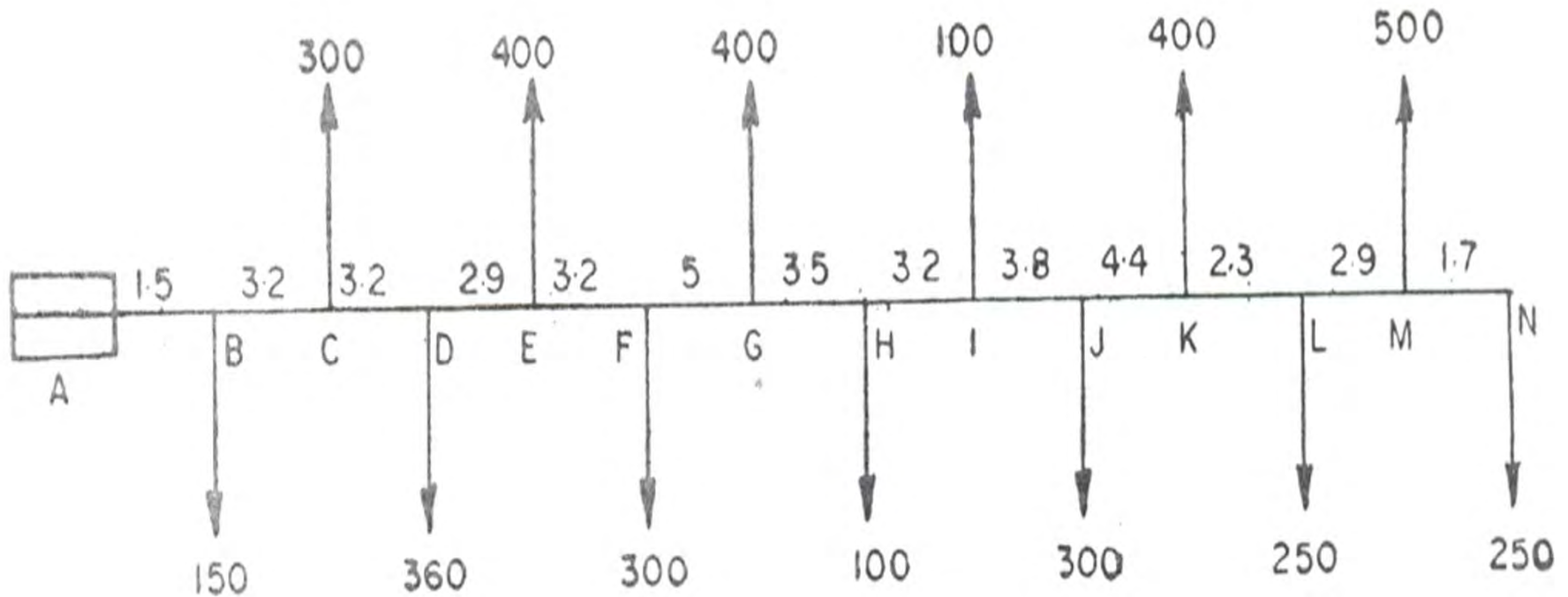
**Pay Back Period ..... 7 Months**

# Best Practices in Technical Loss Reduction –Case Studies

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**-Network Reconducturing**

# Network Reconducturing



# 11 kV Feeder

A simple example—losses of 11 kV feeder with installation of capacitor to minimize losses is given below: (1) Data

- Name of the feeder : 11 kV
- Connected kVA : 4851 kVA
- Peak load on the feeder : 150 amps.
- Energy sent out from the feeder : 47,01,210 kWhrs
- Min. load recorded : 20 amps
- Power factor (of the feeder) : 0.75

# 11 kV Feeder

- Size of the conductor :Rabbit ACSR upto  
kms from KUSS and  
balance 2 ACSR
- Annual load factor : (LF) :47,01,210  
----- = 0.251  
3x11x150x0.758760
- Annual load factor (LLF) : 0.3 LF+0.7 LF<sup>2</sup>  
(based on the curve in  
different seasons) 0.3x0.251+0.7x0.251<sup>2</sup>  
= 0.119
- Resistance of Rabbit : 0.51/km
- Resistance of 2 ACSR :0.9155/km

## II. Assumptions

- (I) Current distribution in each section has been assumed to be proportional to the connected kVA.
- (ii) Loads have been lumped suitably to minimize the sections,
- (lit) Single line diagram of the feeder with lumped loads.

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	300	400	400	1 00	400	500
1 50	300	300	1 00	300	230	250

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(i) Distances indicated are in kms.

(ii) Loads indicated are in IV A.

(iii) Size of the condition from A to F: Rabbit

(iv) Size of the condition from F to N: 2 SCOPE

# Proposal for Reconductoring

Replace the existing conductor from Point P to N by Rabbit ACSR.

Losses in the 11 kV line after reconductoring  
=  $3 \times 176.6972 \times 0.119 \times 8760$   
= 5,52,588.68 kWhrs/lyear

% Losses            5, 52,588.68    11.75%  
                          47,01,210

Savings in losses due to reconductoring  
=  $7,12,739.36 - 5,52,588.68$   
= 1,60,150.68 kWhrs/year.

@Rs. 0.25 per unit, Savings =Rs. 40.038 per year

Approximate cost of the work work  
= Rs. 1,36,329

The investment would be returned within 3 years and 5 months

R/C  $\frac{40,038}{1,36,329 \times 0.109} = 2.69$  which is more than 1 hence  
scheme is feasible. Air

# Best Practices in Technical Loss Reduction –Case Studies

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## Optimal Location of DTRs

# OPTIMAL LOCATION OF DTRs- Case Study

PARTICULARS	DF 1.5	DF 2.0
✘ Total power losses in 20 dtrs at inappropriate locations(kw)	215.3	121.2
✘ Total power losses in 20 dtrs At their optimal locations(kw)	98.5	64.8
✘ Saving in power loss ((kw)	116.8	56.4
✘ % saving in power loss (kw)	55.2	55.2

# OPTIMAL LOCATION OF DTRs DTRs- Case Study

PARTICULARS	DF 1.5	DF 2.0
✘ Total Energy losses in 20 dtrs at inappropriate location(kwh)	53744	30231
✘ Total Energy losses in 20 dtrs at their optimal location(kwh)	24083	13546
✘ Saving in Energy loss (kwh)	29662	16685
✘ % saving in power loss (kw)	55.2	55.2

# OPTIMAL LOCATION OF DTRs DTRs- Case Study

PARTICULARS	DF 1.5	DF 2.0
• Return on investment	37.47 %	36.16%
• % Improvement In Voltage	5.62 %	to 19.1%

# Best Practices in Technical Loss Reduction –Case Studies

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## Integrated Optimal Strategy

# Rule Based Optimal Integrated Strategy

**Rule 1:** Check the loading on the feeders in the network. If the feeders are unequally loaded viz., some feeders are heavily loaded compared to others, then reconfigure the network for minimal losses. Otherwise, go to Rule-2. The above measure automatically equalises the loading on the feeders. Then check for losses and voltage drop. If the target values for any feeder are not achieved, go to Rule-2.

# Rule Based Optimal Integrated Strategy (Contd..)

**Rule 2:** Check the power factor of the feeders. If it is below 0.95, determine the optimal number, location and capacity of the shunt capacitor banks to be placed on the network. Otherwise go to Rule-3. Check losses and voltage drop and if violated go to Rule-3.

# Rule Based Optimal Integrated Strategy (Contd..)

**Rule 3:** Check violation of which target is comparatively severe. If voltage drop violation is severe and losses are violated marginally, then install AVB on the feeders to improve voltage profile and maximise reduction of losses. If loss violation is severe and violation of voltage drop is marginal or severe, proceed for implementation of optimal reconductoring of the network.

# CASE STUDY

A typical practical distribution network is shown in Fig.1. It covers an area of 100 Sq..Km and is fed by three 11 KV feeders from three substations located in the area. The total length of 11KV lines is 115.2 Km. There are 86 distribution transformers catering 1259 agricultural pumpsets and 51 small industries and other services. The total distribution transformer capacity is 7500 KVA and maximum demand is 4500 KW.

## CASE STUDY (Contd..)

The power factor of loads is low (70%) and load factor is 20%. The target norms for losses and voltage drop are taken as 3% and 6% for the study. The power losses and voltage drop of the network is indicated in Table – I.

# CASE STUDY (Contd..)

**Table – I**  
**Voltage Drop and losses of existing Network**

S. No.	Name of Feeder	Length Km	Active Load Kw	Reactive KVAR	Power Loss KW	Energy Loss LU	Regulation (%)	Energy Loss (%)
1	F1	52.70	2401.00	1951.00	770.00	4.86	32.27	11.55
2	F2	31.70	1126.00	1087.00	95.00	0.60	7.11	3.05
3	F3	29.80	933.00	894.00	88.00	0.56	8.36	3.41

## CASE STUDY (Contd..)

The benefits are evaluated by pricing the peak power loss reduction at marginal capacity cost and energy savings at marginal energy cost. The values adopted are Rs. 2500/KW and Rs.0.30/KWH. The cost of equipment is taken as follows:

## CASE STUDY (Contd..)

Automatic voltage boosters per line - Rs. 2.0 lakhs

Switched capacitor of 600 KVAR Bank – Rs.1.1 lakhs

Series capacitor - Rs. 5.0 lakhs + Rs. 120 per KVAR

Cost of line - Rs. 22170 + 850\* A

Where

A = Area of cross Section of conductor in sq.mm

Benefit Cost Ratio (BCR) for each LRVI solution is evaluated taking annual cost of capital at 18% of capital investment

## CASE STUDY (Contd..)

All the five short term measures individually are investigated on the network and the results are shown in Table – II. Various combinations of short term measures are investigated for the network and the results are listed in Table - III

## Table – II

### Power Loss and Voltage drop of Network for each short term measure

Details of Short Term Measure	Name of Feeder	Voltage Drop %	Energy Loss %	Power Loss Reduction %	Voltage Improvement %	Benefit Cost Ratio	Works to be Executed
1. Reconfiguration	F1	9.93	4.11	83.63	22.34	10.15	13.3 KM of Line
	F2	13.08	4.81	-140.00	-5.97		
	F3	12.12	4.77	-82.95	-3.76		
2. Shunt Capacitor	F1	19.36	5.81	59.22	12.91	10.38	4 SSCB at Loc 42.28.12 1 SSCB at LOC 49 1 SSCB at LOC 100
	F2	5.42	1.81	43.20	1.69		
	F3	6.40	2.08	42.00	1.96		
3. Reconductoring	F1	11.39	1.93	88.05	20.88	2.911	6.1 KM 7.2 KM 6.8 KM
	F2	4.33	1.42	56.00	2.78		
	F3	5.04	1.45	60.30	3.32		

# TABLE – II (Contd..)

Table – II							
Power Loss and Voltage drop of Network for each short term measure							
Details of Short Term Measure	Name of Feeder	Voltage Drop %	Energy Loss %	Power Loss Reduction %	Voltage Improvement %	Benefit Cost Ratio	Works to be Executed
4. AVB	F1	4.24	8.04	36.49	28.03	4.41	3 AVB at Loc 2.4.12 1 AVB at LOC 49 1 AVB at LOC 81
	F2	0.00	2.65	3.16	7.11		
	F3	2.94	3.08	10.22	5.42		
5. Series Capacitor	F1	14.41	8.57	33.76	17.86	2.52	488 KVAR at Loc 2 166 KVAR at Loc 50 114 KVAR at Loc 78
	F2	0.00	2.62	14.73	7.11		
	F3	1.40	3.00	12.50	6.96		

## Table – III

### Combinations of Short Term measures

Type of Improvement	Feeder No	Voltage Drop %	Energy Loss %	Power Loss Reduction %	Voltage Improvement %	Benefit Cost Ratio	Works to be Executed
1. Shunt Capacitor + Reconductoring	F1	2.52	1.53	90.50	29.75	4.15	4 SSCB + 16.1 KM 2 SSCB 1 SSCB
	F2	5.42	1.81	42.10	1.69		
	F3	6.40	2.08	40.91	1.96		
2. Shunt Capacitor + Reconfiguration	F1	6.59	3.63	84.28	25.68	6.96	4 SSCB + 12.1 KM 2 SSCB 1 SSCB
	F2	10.27	2.66	-25.26	-2.50		
	F3	8.30	2.50	21.59	0.06		
3. Reconductoring + Reconfiguration	F1	7.32	1.19	94.15	24.95	2.58	16.1 KM + 12.1 KM 7.2 KM 6.8 KM
	F2	5.81	1.72	32.63	1.30		
	F3	6.48	1.80	44.32	1.88		

# TABLE – III (Contd..)

**Table – III  
Combinations of Short Term measures**

Type of Improvement	Feeder No	Voltage Drop %	Energy Loss %	Power Loss Reduction %	Voltage Improvement %	Benefit Cost Ratio	Works to be Executed
4. Reconductoring + Shunt Capacitor	F1	4.78	1.01	93.90	27.49	2.72	16.1 KM + 3 SSCB
	F2	3.21	1.05	67.37	3.90		7.2 KM + 2 SSCB
	F3	3.32	0.96	73.86	5.04		6.8 KM + 1 SSCB
5. Reconductoring + AVB	F1	3.47	1.65	89.87	28.88	2.82	16.1 KM + 1 AVB
	F2	4.33	1.42	55.79	2.78		7.2 KM
	F3	5.04	1.45	60.22	3.32		8.8 KM
6. Reconfiguration + Shunt Capacitor	F1	6.91	2.18	91.87	25.36	7.19	13.3 KM + 2 SSCB
	F2	9.34	2.89	-35.79	-2.23		3 SSCB
	F3	8.54	2.52	10.23	-0.18		2 SSCB

# TABLE – III (Contd..)

**Table – III  
Combinations of Short Term measures**

Type of Improvement	Feeder No	Voltage Drop %	Energy Loss %	Power Loss Reduction %	Voltage Improvement %	Benefit Cost Ratio	Works to be Executed
7. Reconfiguration + Reconductoring	F1	5.41	1.50	94.55	26.86	2.91	13.3 KM + 31.8 KM
	F2	7.03	1.44	35.80	0.08		
	F3	6.38	1.60	44.32	2.03		
8. Reconfiguration + AVB	F1	0.00	3.42	12.48	32.27	6.36	13.3 KM + 1 AVB 1 AVB 1 AVB
	F2	2.84	4.07	94.73	4.27		
	F3	4.01	4.11	54.54	4.35		
9. Shunt Capacitor + AVB	F1	0.25	5.50	61.82	30.00	6.11	4 SSCB + 2 AVB 2 SSCB 1 SSCB + 1 AVB
	F2	5.42	1.81	42.11	1.69		
	F3	1.09	1.86	47.73	7.27		

**Table – III**  
**Combinations of Short Term measures**

Type of Improvement	Feeder No	Voltage Drop %	Energy Loss %	Power Loss Reduction %	Voltage Improvement %	Benefit Cost Ratio	Works to be Executed
10. Reconfiguration + Shunt Capacitor + AVB	F1	0.00	2.00	92.59	32.25	5.25	13.3 KM + 2 SSCB + 2 AVB 3 SSCB + 1 AVB 2 SSCB + 1 AVB
	F2	1.40	2.59	21.05	5.71		
	F3	1.83	2.32	17.05	6.53		
11. Shunt Capacitor + Reconductoring + AVB	F1	2.52	1.53	90.50	29.75	3.89	
	F2	5.42	1.81	42.10	1.69		
	F3	1.09	1.86	47.77	7.27		

## Discussion:

On a review of Table – I, it is observed that feeder F1 is heavily loaded and losses and voltage drop are high, whereas Feeders F2 & F3 are approximately equally loaded. Thus the network has a heavy unequal loading, calling for reconfiguration of network.

On a review of Table – II, it is noticed that none of the short term measures when considered alone can bring the network to set target norms of losses and voltage drop. Further, it is observed that

- i) Reconfiguration equalises loading on Feeders and also reduces losses of total network by 45% but neither losses nor voltage drop are within the desired limits.
- ii) With shunt compensation, Feeder F 1 still has high losses and voltage drop, even after it has reduced losses by 60% and improves voltage by 12%

- iii) Reconductoring alone will bring losses of all feeders within the set target norms but the voltage drop of Feeder F 1 is violated
- iv) Installation of AVB has brought voltage profile within the desired limits but losses of all Feeders continue to be high.

- v) Series capacitor will not reduce the losses and voltage drop of Feeder F 1 to set norms and the rate of return is low.

## **A review of Table III indicates that:**

i) The BCR of combination where Reconfiguration is done first and then other short term measure is undertaken later is better than corresponding combination where Reconfiguration is done later and the other measure is done first. This validates the Rule 1 which states that the Reconfiguration of network should be undertaken first, when unequal loading of feeders is present.

- ii) The results of Reconfiguration show that there is a transfer of a load from feeders F2 & F3 to feeder F1 only and the transfer between the feeders F2 & F3 is negligible. It indicates that network Reconfiguration is effective only between feeders of unequal loading

- iii) The combination of Reconfiguration + Shunt Capacitor gives the highest BCR but it violates the voltage limits
- iv) The combination of Reconductoring + AVB alone satisfies both the limits of losses and voltage but BCR is very low and is not recommended.

v) The combination of Shunt Capacitor + Reconductoring has higher BCR than Reconductoring + Shunt Capacitor, as the later involves reconductoring of longer length of line. It validates Rule 3 that Reconductoring should be undertaken only after installation of capacitors required.

- vi) The combination Reconfiguration + Shunt Capacitor + AVB meets the targets set for losses and voltage drop and has highest BCR of 5.25
- vii) The next best combination which meets the targets set is Shunt Capacitor + Reconductoring + AVB but has a lower BCR of 3.85

viii) The fact that combination of Shunt Capacitor + Reconductoring + AVB has a higher BCR compared to combination of Reconductoring + AVB indicates that installation of capacitors is necessary to reduce losses and obtain better BCR. This validates Rule 2 suggesting installation of capacitors after Reconfiguration.

THANK 'U'