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An Approach for Measurement of Non-Technical losses of 11KV feeder and its Minimization

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Abstract
Distribution losses comprise Technical & Non-Technical losses. In this paper technical losses calculation of 11KV Kochar Urban Gohlwar, TarnTaran feeder by load power flow analysis using technical data with utility has been presented. Non technical losses of this feeder have been arrived at by subtracting technical losses from total distribution losses. As non technical losses are on higher side, new proposals for minimization of non technical losses have been suggested which include checking of technically rejected temporary tubewell connections during paddy season and seasonal factories such as rice shellers and ice factories to avoid accumulation of consumption units.

Keywords- Bus Bar, current Transformer, Distribution Transformer, Energy Meter, Power Plant, Shunt Capacitor, Transmission Line.

I. Introduction-

In power system, all the power generated at power plant is unable to reach the consumer end. A very high percentage of power is wasted as T&D losses.80% of the total losses are distribution losses. In Punjab distribution losses amounts to Rs.3667.46 crores (6234MU) as per the latest data of PSERC [1]. So a lot of scope is still there to solve this problem of undesirable loss to Power sector. These losses very much affect the economy of the country which cannot be tolerated. To cover up these losses the power plant has to generate more energy. The energy required for covering up the transmission and distribution losses will also be transmitted through the transmission and distribution system which will also add energy losses to the system concerned. These losses affect the determinations of tariff which will be on higher side to recover the amount due to excess distribution losses. So it is utmost necessary for the utility to reduce the losses wherever practical. Transmission and Distribution system acts as a link between generation of power supply at power plant and its consumption at the consumer side. Transmission system is expended after the technical study of all required transmission data and transmission line routes with planed manner but expansion of distribution system is done as and when required, on the emergent demand basis. So no planning is involved in the expansion of distribution system. Due to these reason there is increase in T&D losses and reliability of power supply is minimum. End users are dissatisfied and are burdened with high tariff due to high distribution losses. So focus has rightly been shifted to improvement in distribution system to reduce distribution losses.

Minimization of distribution losses is not a new topic for dissertation. A lot of work has already been done in this regard by different authors/agencies. New techniques are being developed in a effort that maximum part of generated energy should reach to the consumer end. Some of the techniques such as replacing disc type energy meter with electronics meters, use of aerial bunched cables, power factor improvement by installing capacitor units at substation [2], 11KV feeder and the motor terminals, HVDS system for agriculture connections, load balancing on each phase, checking of connections by flying squads of utilities and levying heavy penalty, high tariff/penalty for peak load hours, placing transformer at load centre etc are being adopted by utilities. In spite of the best effort done by utilities we are not close to the developed countries of the world such as, USA, Japan & South Korea on this issue [3]. From practical experience of electrical field, more efforts can be done in this regard. New suggestions have been made in this paper, along with Comprehensive analysis of already prevailing techniques for minimization of non technical losses in distribution system.

For calculating non-technical losses, a case study of 11KV Gohlwar, TarnTaran feeder has been undertaken. The first step is to calculate distribution losses from the feeder data of billed energy units & incoming energy units of the feeder. Technical losses have been calculated by load flow analysis by Newton Raphson method using MiPower Software.

Non technical losses are calculated by subtracting technical losses from total distribution losses. In the end, some new techniques have been suggested for minimization of losses. In India T&D losses are officially declared as 24% [4], but different agencies including TERI (The Energy Research Institute) has estimated the T&D losses as high as 50% from their sample study carried out. This paper presents a case study of calculation of distribution losses of 11KV Kochar Urban feeder emanating from 66KV substation Gohlwar, TarnTararn Punjab.

II. A Case Study

In this Paper, a case study of 11KV Kochar Urban feeder emanating from 66KV substation, Gohlwar is under taken..

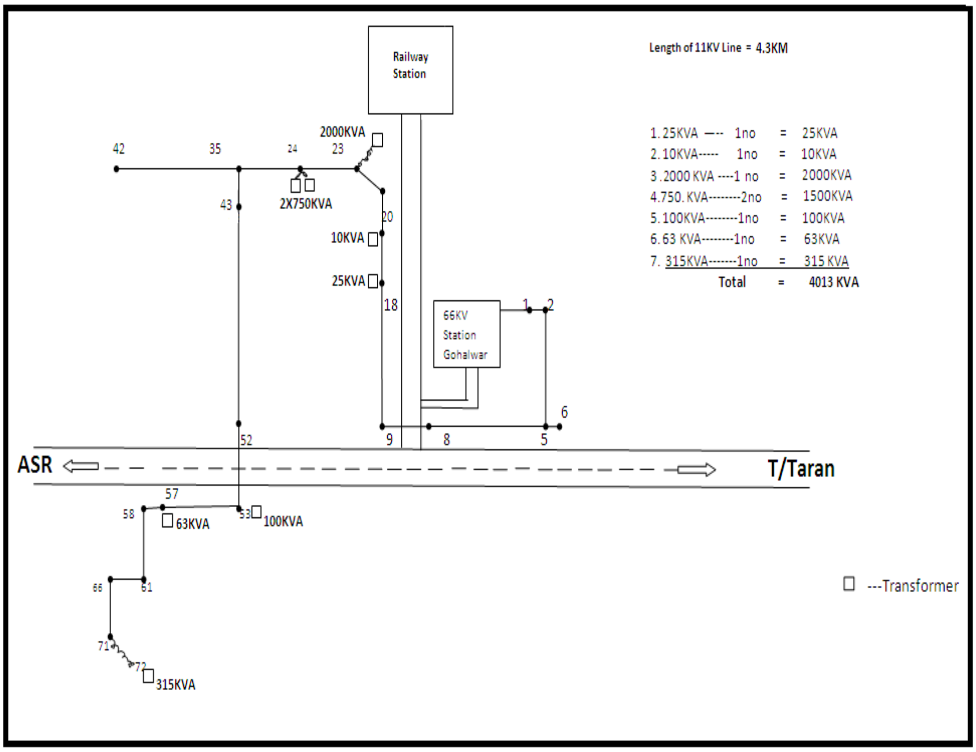

Fig.1 Sketch of 11KV Kochar Urban Feeder

Gohlwar village is located at a distance of about 12 KMs from TarnTaran district headquarters. This substation has two nos. 66/11KV step down power transformer. The key diagram of 11KV Kochar Urban feeder is shown as per figure 1.

This feeder has 32 number mixed categories of consumers, namely large supply (LS), small power (SP), non-residential supply (NRS) and domestic supply (DS). The major power consumption is of large supply & small power connections.

2.1 Methodology

The distribution losses of 11KV Kochar urban feeder have been calculated by subtracting energy units billed in the area of this feeder from the units supplied to this feeder from substation as recorded by energy meter installed at the start of the feeder. The Punjab State Power Com Limited has all the records of energy incoming and outgoing from the substation duly recorded in log sheet Performa. The methodology adapted [5] for the loss calculation has been shown as per figure 2.

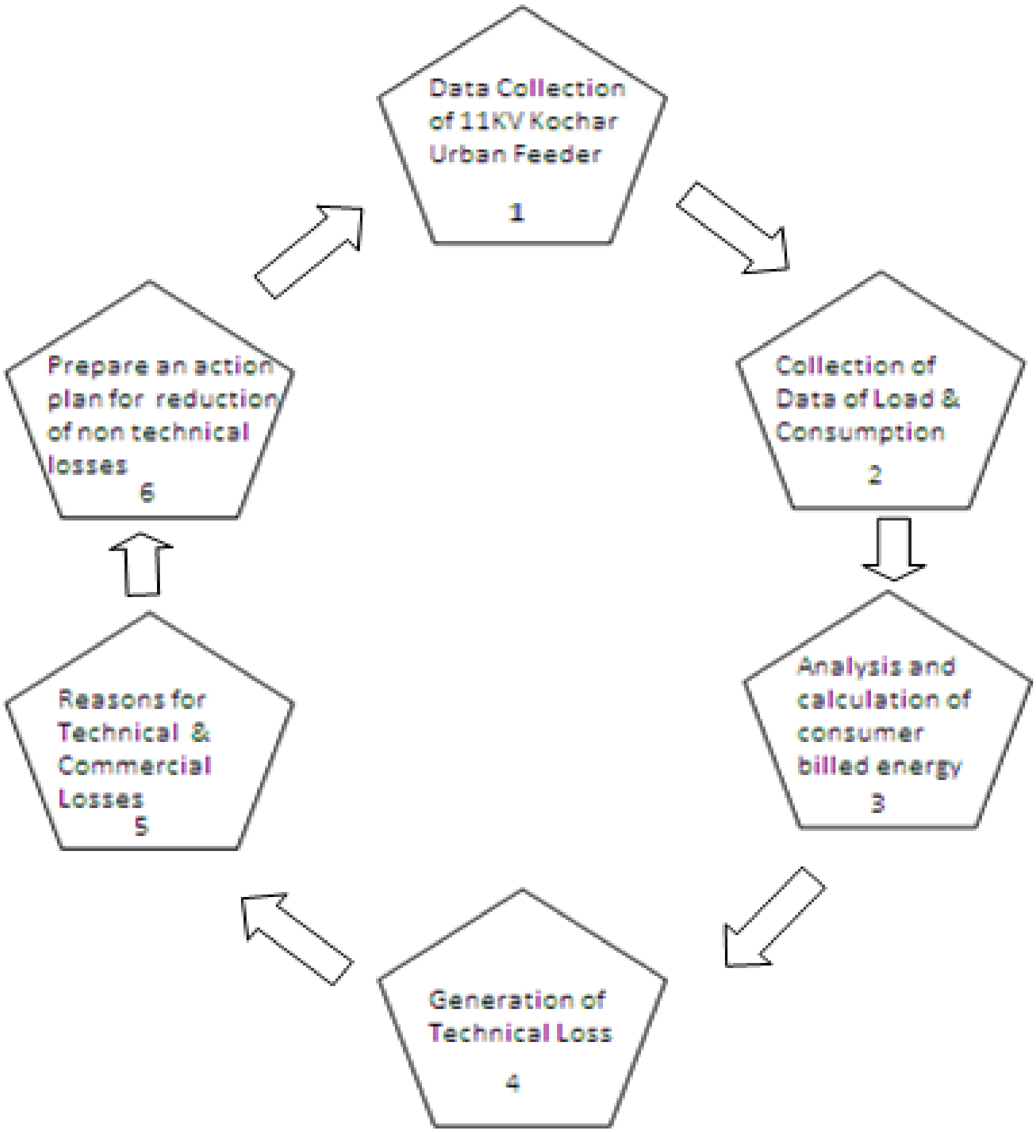

Fig.2 Flow Chart of Methodology

At first the data related to the consumption/ billed units of all consumers of this 11KV feeder is taken from the consumer ledger is taken to calculate the consumption of units & total load. The consumption data as collected has been shown as per table no.1

Table no.1 Consumption Data of 11KV Kochar Urban feeder for the month of October, 2014

S.No.	Name of transformer	Connection A/C no.	Type of Connection	Consumption in KWH	Load (KW)
1	25KVA Mohinder Singh	GW33/1312	DS	1058	1.42
2	25KVA Mohinder Singh	GW33/1313	DS	1500	1.42
3	25KVA Mohinder Singh	GW33/1314	DS	638	1.42
4	25KVA Mohinder Singh	GW33/1315	DS	0	1.42
5	25KVA Mohinder Singh	GW33/1316	DS	686	1.42
6	25KVA Mohinder Singh	GW33/1317	DS	0	1.42
7	25KVA Mohinder Singh	GW33/1318	DS	1021	1.42
8	25KVA Mohinder Singh	GW33/1319	DS	963	1.42
9	25KVA Mohinder Singh	GW33/1320	DS	675	1.42
10	25KVA Mohinder Singh	GW33/1338	DS	1017	5
11	10KVA Single Phase Transformer	VP14/1812	NRS	236	1.46
12	10KVA Single Phase Transformer	VP14/1872	DS	362	1.7
13	750KVA-2nos. Karam Singh & Raghbir Singh	LS01/006	LS	304436	1300.439
14	2000KVA LT food Pvt. Ltd.	LS01/007	LS	271294	1678.822
15	100KVA Sandeep Singh Bala Chack	SP55/145	SP	411	17.65
16	100KVA Sandeep Singh Bala Chack	SP55/156	SP	679	4.99
17	100KVA Sandeep Singh Bala Chack	SP55/181	SP	517	14.94
18	100KVA Sandeep Singh Bala Chack	SP55/196	SP	1318	14.93
19	63KVA Vijay Kumar	SP55/15	SP	121	3.95
20	63KVA Vijay Kumar	SP55/146	SP	216	12.76
21	63KVA Vijay Kumar	BC37/483	DS	179	2.13
22	63KVA Vijay Kumar	BC37/708	DS	183	2.83
23	63KVA Vijay Kumar	BC37/1144	DS	224	1.53
24	63KVA Vijay Kumar	BC37/1248	DS	364	0.46
25	63KVA Vijay Kumar	BC37/1252	DS	255	1.92
26	63KVA Vijay Kumar	BC37/1263	NRS	93	0.94
27	63KVA Vijay Kumar	BC37/1282	DS	180	1.34
28	63KVA Vijay Kumar	BC37/1283	DS	223	2.55
29	63KVA Vijay Kumar	BC37/1292	NRS	121	0.8
30	63KVA Vijay Kumar	BC37/1299	DS	11	0.96
31	63KVA Vijay Kumar	BC37/1344	DS	224	1.78
32	315KVA KK Agro food	LS01/0010	LS	6860	193.994
				596065	**3280.655**

2.2 Distribution Losses Calculations (Technical Losses & Non technical Losses)

For distribution losses calculation the readings of energy meter installed at substation have been recorded for one month which are given as per table 2.

Table 2 Energy Meter reading of 11KV Kochar Urban feeder for the month of Oct.2014

S.No.	Description of feeder	Reading taken on 31/10/14	Reading taken on 30/9/14	Difference of energy meter readings	M.F of energy meter	Total energy sent in KWH
1	11KV Kochar Urban feeder	16763.25	15999.85	763.4	1000	763400

Total incoming units = 763400 KWH

Total consumption/Billed units = 596065 KWH

Distribution Losses = Total Incoming Units - Total Billed Units

= (763400 – 596065) =166925 KWH

= 21.88% (1)

Technical and nontechnical losses are the main two parts of distribution losses. Physical properties of all the components of power system cause technical losses. Power dissipation in transmission line and transformer due to load is the most oblivious example of these losses. Technical losses are naturally occurring losses and cannot be eliminated. These losses occur due to action internal to the power system consisting of transmission lines, substations, transformers, measurement and protection equipments. If we are provided with complete data regarding running load, length and conductor sizes, these losses can be computed and controlled easily. Technical losses in distribution system include copper losses in 11KV lines, LT lines, service drops and energy meters. These losses also include core losses in distribution transformers. These losses are inherent in the power supply distribution system and cannot be avoided.

Theft of energy by consumers / non consumers in one or the other way is the main cause of Non technical losses. These can be calculated by subtracting technical losses from the total distribution losses of the 11KV feeder.

2.3 Calculation of Technical Losses

Technical losses of 11KV feeder can be calculated by analytical method using load factor and load loss factor and by load power flow analysis by different software available. For this, complete data of 11KV feeder along with distribution transformers installed on it is required.

2.3.1 Loading Data of Distribution Transformers

Table no.3 Loading Data of Transformers on 11KV Kochar Urban feeder

S.No	Transformer rating KVA	Qty.	Total KVA	Transformer Load (KW)
1	10	1	10	003.160
2	25	1	25	017.780
3	63	1	63	033.950
4	100	1	100	052.510
5	315	1	315	193.994
6	750	2	1500	1300.439
7	2000	1	2000	1678.822
Total		**8**	**4013 KVA**	**3280.655**

2.3.2 11KV Transmission Line Data

Table 4 ACSR Conductor Details

S no.	Description of Conductor	Length(KM)
1	$50mm^2$ ACSR Conductor	1.6
2	$35mm^2$ ACSR Conductor	1.8
3	$25mm^2$ ACSR Conductor	0.9
	Total	4.3 KM

The Resistance of 11KV line Conductor has been taken for single conductor as per Table 5

$50mm^2$ = 0.640146 Ohm/Km
$35mm^2$ = 0.919246 Ohm/Km
$25mm^2$ = 1.274624 Ohm/Km

Table 5 Sequence Impedance for 11KV Aluminum Conductor

ITEM	Conductor Size		A.C.Resistance Ohm/Cond./KM		Impedance Ohm/Cond./KM			
					Single Circuit		Double Circuit	
	mm^2	Dia of Str.mm/No. of Str.	20^oc	50^oc	X1=X2	Ro+jxo	X1=X2	Ro+jxo
1	25	2.14/7	1.137143	1.274624	0.401496	1.422624+ j1.628310	0.41662	1.570624 + j2.755995
2	35	2.52/7	0.820096	0.919246	0.391226	1.067246+ j1.618040	0.40635	1.215246 + j2.745725
3	50	3.02/7	0.571100	0.640146	0.379854	0.788146 + j1.606667	0.39498	0.936146 + j2.734352
4	70	2.15/19	0.421161	0.472079	0.366401	0.620079 + j1.593214	0.38153	0.766079 + j2.720099
5	95	2.52/19	0.303853	0.340589	0.356424	0.488589 + j1.583237	0.37155	0.636589 + j2.710922
6	120	2.85/19	0.237695	0.266432	0.348692	0.414432 + j1.575505	0.36382	0.562432 + j2.703190
7	185	2.52/37	0.156761	0.175713	0.334439	0.323713 + j1.561251	0.34957	0.471713 + j2.688937

Maximum Current on feeder = 138Amp. (On 18/10/2014 at 1.00hrs)

2.3.3 Technical Losses calculation by power load flow study method.

We are having all the data necessary for calculation of the distribution losses by Newton Raphson method of load flow study. As shown in figure 4 of power flow diagram of 11KV feeder, we have 16nos. of buses including 66KV, 11KV and 0.415KV buses.

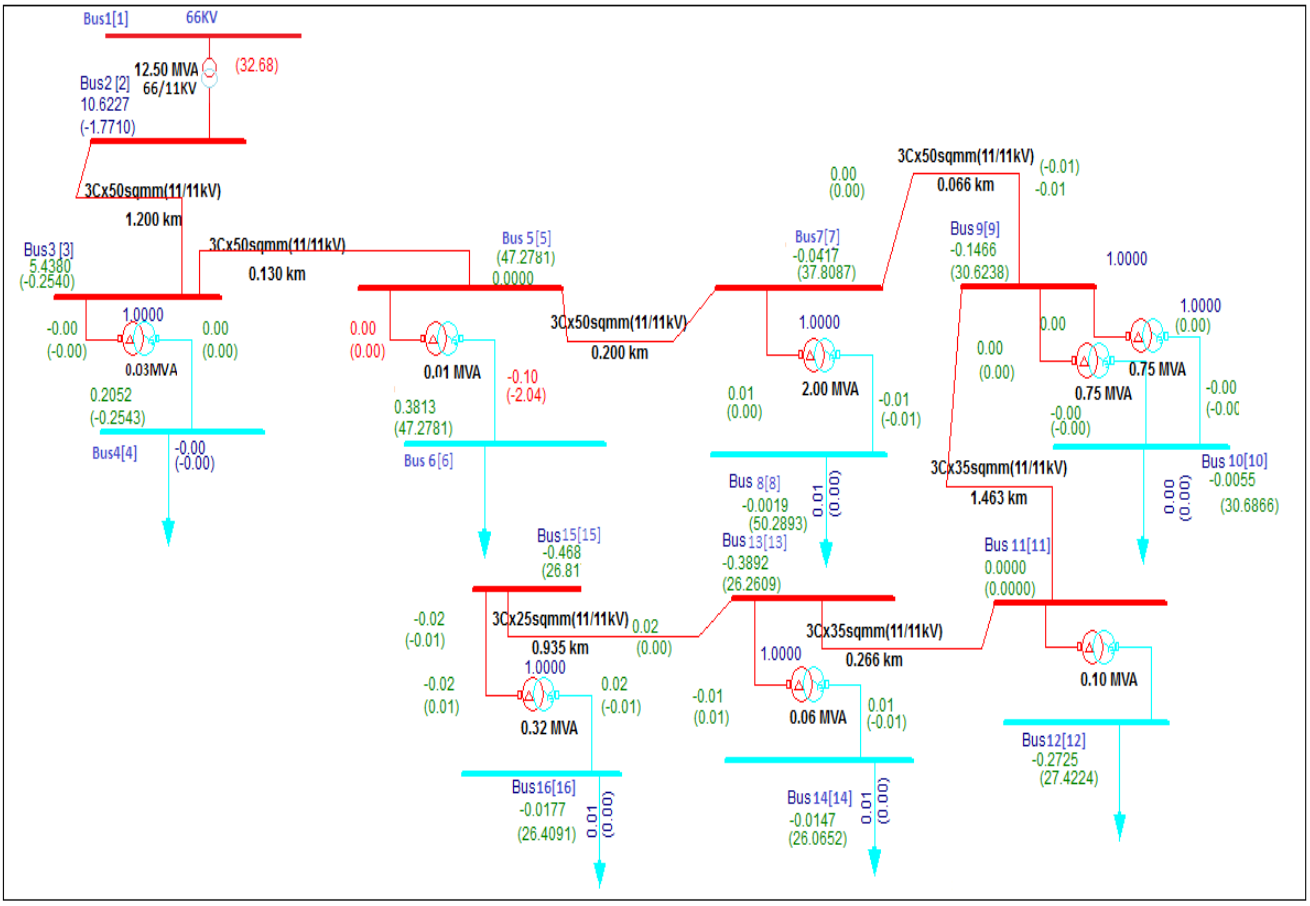

Fig.4 Power Flow Diagram of 11KV Kochar Urban Feeder by Mipower Software

The base MVA has been taken as 100MVA and nominal system frequency 50Hzs. The 11KV feeder has three sizes of ACSR conductor namely 50mm^2, 35mm^2 and 25mm^2 with total line length as 4.3 KMs. The number of transformer loads, transmission lines and other detail has been given in the power flow diagram itself. Mipower software has been used for power flow study by Newton Rephson method [6].

III. Summary of Results

TOTAL REAL POWER GENERATED : 3.622 MW
TOTAL REACTIVE POWER GENERATED : 1.716 MVAR
GENERATION Pf : 0.904
TOTAL REAL POWER LOAD : 3.279 MW
TOTAL REACT. POWER LOAD : 1.501 MVAR
LOAD PF : 0.909
TOTAL REAL POWER LOSS (AC+DC) : 0.342180 MW
% REAL LOSS (AC+DC) : 9.448
(2)
TOTAL REACT. POWER LOSS : 0.215114 MVAR

IV. Calculation of Non-Technical losses

As distribution losses comprises technical as well as non-technical losses [7]. So non technical losses can be calculated subtracting technical losses from total distribution losses as under.

Distribution Losses as calculated (1) =21.88%
Technical Losses as calculated by Load
Flow Analysis by using MiPower Software (2) =9.448%
Non Technical Losses = Distribution Losses - Technical Losses
= (1) - (2)

= 21.880% - 9.448%
= 12.432%

These losses are on very high side.

Non-Technical losses are basically due to theft of energy in one or the other way. Maximum permissible limit for technical losses is 9% for urban and 10% for rural distribution system [8] but non technical losses are not desirable at all. So it is very important to reduce these losses and save revenue as far as possible. This will also lesson burden on consumers in the shape of lower electricity tariff.

V. Economic Consequences of Distribution Losses.

The economic consequences of distribution losses are far reaching. To cover up the lost energy, additional generating capacity may be required. The power which is lost as T&D losses in distribution system is still to be transmitted through these transmission lines substations etc which further adds to the energy losses already existing in that system. These losses affect the determinations of tariff which will be on higher side to recover the amount due to excess distribution losses.

VI. New Techniques suggested which are yet to be adopted or not being adopted vigorously.

- Mapping/ Data compilation of distribution feeders.
- Correct calculation/Computation of technical losses.
- Installation of energy meters on secondary side of each distribution transformers.
- Prepaid energy meters.
- Use of Aerial Bunched Cable.
- Installation of pillar-box for domestic/NRS connection energy meters.
- Checking of temporary tube well connections which have been rejected on technical ground during paddy season.
- Repeated checking of tube well connection having H.P.tariff.
- Every tube well connection should have energy meter to access correct consumption.
- Repeated checking of seasonal factories i.e. Ice factories/ Rice shellers to avoid accumulation of consumption units with the connivance of utility staff.
- Implementation of energy audit scheme.
- Mitigating power theft making theft of energy as cognizable offence with punishment up to 3 years imprisonment.

VII. Conclusion

This paper demonstrates the capability of load power flow analysis system to calculate the technical losses and there by non technical losses in 11KV feeder. For this Newton Raphson method of load power flow study has been used through MiPower software. The data used is readily available with the engineers of power distribution utility. The non technical losses calculated are 12.432% which are on very high side. As per survey undertaken of this 11KV feeder there is Jhuggi Jhopri’s cluster under distribution area of 25KVA Mohinder Singh Wala transformer and they directly tap the bare conductor of LT line. Two nos. energy meters are dead stop and show zero consumption. Two connections of 10KVA single phase transformer are having energy meters inside the commercial/ residential premises having no terminal plates. So pilferage of energy from incoming terminals cannot be ruled out. Small power connections on 100KVA Sandeep Singh Bala Chack is having naked joints in incoming cable so theft of energy by small power consumers may be there. All the domestic / non residential supply connections on 63 KVA Vijay Kumar transformer are having energy meters inside the respective premises and these have not been shifted outside in sealed pillar box. Thus calculation of non-technical losses of this feeder will be beneficial to the utility to know the theft/pilferage going on in this area. Removing naked joints from incoming cables, shifting of energy meters outside the premises in sealed pillar boxes, replacement of slow/defective meters, proper sealing of terminal plates and meter boxes, distribution of power supply to small power consumers having load more than 10 KW by HVDS system, checking of temporary tube well connections rejected on technical ground during paddy season and continuous checking of seasonal factories will definitely decrease the non technical losses of this feeder.

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