Case Study Of Analytical Performance Of 11kv Urban Distribution Feeder

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Abstract: Due to huge daily need of electrical power in all fields of human activities, there is a need of large power generation and thus there is a requirement of construction of new electric power stations by the Nations at their own levels as well as interconnected systems. Thus, the need of growing power generation and utilization, there is a requirement to expand continuously electric machines manufacturing industry applying modern techniques including need of Computer aided methods. However, in support to the effective utilization of this high amount of power generation using the very large size machines at power station, sub-transmission and distribution systems which constitute the link between electricity utilities and consumers should be of efficient functioning to sustain the growth of the power sector and the economy of the country. But the distribution sector plays a vital role for the effective consumption of electrical power with economy to provide electrical energy at a suitable prize and at a minimum voltage drop to reduce the voltage regulation. This is based on the effective operating of State Electricity Boards in an economical way at minimum voltage drop and reduce the regulation of voltage. The present calculation work had an attempt for the comprehensive designing for the existing distribution network (11kV Urban Distribution Feeder) alongwith the capacitor bank size and design with an objective to minimize the investment cost, total power losses, reliability indices for a study timeframe in the above distribution feeder. The result showed better voltage profiles and power losses in the distribution system had been improved in this calculative attempt.
Keywords: Distribution, Machines, State Electricity Boards, Urban.

I. INTRODUCTION ABOUT FEEDERS

Energy is the primary and most universal measure of all kinds of works by human beings and nature. Most people use the word energy for input to their bodies or to the machines and thus think about crude fuels and electric power. The per capita income of U.S.A is about 50 times more than per capita income of India, and so also is the per capita energy consumption. The per capita energy consumption in U.S.A is about 8000 KWh per year whereas the per capita energy consumption in India is 150 KWh. U.S.A with 7% of world's population consumes 32% of the total energy consumed in the world, whereas India, a developing country with 20% of the world's population consumes only 1% of the total energy consumed in the world. Sub-transmission and distribution systems constitute the link between electricity utilities and consumers. Efficient functioning of these segments of the electricity utility is very useful for the growth of the power sector and the economy of the country. Thus, the distribution sectors require economical system to provide electrical energy at a suitable prize and at a minimum voltage drop to reduce the voltage regulation. So, we require the economical way to provide the electrical energy by State Electricity Boards to various consumers at minimum voltage drop and reduce the regulation of voltage. The feeder voltage and feeder current are two constraints which should be within the standard range. As the distribution network is located far away from the sources of power generation and the other infrastructure of electrical power system. So, there will be voltage drop, line losses and system reliability comes into the act. Long distance to supply loads causes a significant amount of voltage drop across the distribution lines. Augmentation of the feeder power lines as well as design of capacitor banks and voltage regulators is various methods adopted by State Electricity boards to decrease the voltage drop. The present work emphasis the comprehensive designing for the existing distribution network with an objective to minimize the investment cost, line losses, reliability indices for a study timeframe, with allocation and resizing of conductors.

The electricity sector in India is predominantly controlled by government sector entities via central public sector corporation, such as National Thermal Power Corporation (NTPC), National Hydroelectric Power Corporation (NHPC) and various state level corporations (state electricity boards-SEBs). Due to India's economic rise, the demand for energy has grown at an average of 3.6% per annum over the last 30 years. About 76% of the electricity consumed in India is generated by thermal power plants, 21% by hydroelectric power plants and 4% by the nuclear power plants. The details are as under in table 1 [1]. The total installed capacity in India is 307.278GW till 31.11.2016.

Table 1: Electricity Sector in India [1]

Sr. No.	Generation	Total capacity till 31.11.2016
1.	Thermal Power	212.468 GW
2.	Hydro Power	43.112 GW

3.	Nuclear Power	20 nuclear reactors in operation, generating 5.780GW
4.	Renewable Power	45916.95 MW

PUNJAB STATE POWER SECTOR: Punjab State Electricity Board (PSEB), in its present form came into existence under Section 5 of the Electricity (Supply) Act-1948 on May 2, 1967 after the reorganization of the State for generation, transmission and distribution of electricity in Punjab. The installed capacity generation in Punjab is as shown in table 2 [2].

Table 2: Installed capacity generation in Punjab [2]

Sr. No.	Name of Project	Detail of Power machines with installed capacity (MW)	Share of Punjab (MW)	Generation during 2013-14 (MU)	Generation upto 31.11.2016 (MU)
1.	**OWN PROJECTS**				
a)	**Hydro Electric Projects**				
1.	Shanan PH	4x15+1x50=110.00	110	355.87	355.87
2.	UBDC	3x15+3x15.45=91.35	91.35	361.624	361.624
3.	Anandpur Sahib	4x33.5=134.00	314	735.00	735.00
4.	RSDHEP	4x150=600	452.4	1575.89	1575.89
5.	Mukerian	6x15+6x19.5=207.0	207	1246.74	1246.74
6.	Nadampur Micro	2x0.4=0.80	0.8	10.82	10.82
7.	Daudhar Micro	3x0.5=1.50	1.5		
8.	Rohti Micro	2x0.4=0.80.	0.8		
9.	Thuhi Micro	2x0.4=0.80	0.8		
10.	GGSSTP Ropar (Micro)		1.7		
	Total		1000.35	4285.94	4285.94
b)	**Thermal Projects**				
1.	GNDTP Bathinda	4x110=440.00	440	1635.46	2487.633
2.	GGSSTP, Ropar	6x210=1260.00	1260	8805.87	9984.65
3.	GHTP, Lehra Mohabat (Bathinda)	2x210+2x250=920.00	920	6664.994	6664.994
4.	RSTP, Jalkheri	1x10=10.00			
.	Total		2630	16306.27	16306.27
	Total (a + b)		3630	20592.21	20592.21
2.	Share from BBMM Projects		1161.00	4382.31	4382.31
3.	Share from Central Sector Projects		3071	20785.71	20785.71
4.	PEDA & Industrial Captive Plants installed in State		997	649.15	649.15
	Grand Total (1+2+3+4)		**8859.00**	**46409.38**	**46409.38**

II. LITREATURE SEARCH

Transmission & Distribution (T&D) losses represent a significant proportion of electricity losses in both developing and developed countries. The major portion of occurrence of T&D losses is the distribution systems of the states, which makes the gap large between the demand and supply of the electricity. Electric power providers have a duty to ensure that the consumers are always supplied with the required voltage level. However, the consumers at the extreme end of the feeders have been experiencing low voltage levels in somewhere all the countries, which is because of the reason that voltage drops is a major concern in 440V (low voltage) distribution systems and not very particular about voltage drop in the high voltage sides leaving it unattended. Soloman Nunoo et al in [3] presented a paper analysing the causes and effects of voltage drop on the 11KV GMC sub-transmission feeder in Tarkwa, Ghana. Studies showed that the voltage drop, total impedance, percentage efficiency and percentage regulation on the feeder are 944V, 4.56Ω, 91.79% and 8.94% respectively. Which all are beyond the acceptable limits. From the result, it is also realised that the causes of voltage drop on the feeder was mainly due to high impedance level as compared to the permissible value and this high impedance is caused by:-

(i) Poor jointing and terminations.
(ii) Use of undersized conductors.
(iii) Use of different types of conductor materials
(iv) Hot Spots etc.

The work concluded by proposing a number of solutions as well. In this paper, it was observed that the outage level of GMC Feeder is currently high of which stands at an average of ten times with a least duration of 10 minutes. These outages are mostly caused by:

(i) Over-grown of vegetation very close to the line, which comes in contact to the feeder in the events of strong winds.
(ii) Over-sagged conductors as a result of long spans between poles and
(iii) Obsolete headgear accessories, equipment and bent conductors.

Vujosevic, L. et al in [4] presented a paper estimating that the voltage drop in radial distribution networks can be applied for all voltage levels, therefore it was indicated in the work that in distribution system, voltage drop is the main indicator of power quality and it has a significant influence at normal working regime of electrical appliances, especially motors. This work was mainly focused on low voltage distribution system. Konstantin et al in [5] presented a paper analyzing a power distribution line with variation of power consumption. In the presence of uncertainty the statistical description of the system is required to assess the risks of power outages. In order to find the probability of exceeding the constraints for voltage level and find the distribution by use of algorithm. The algorithm is based on the assumption of random but statistically distribution of loads on distribution lines. In the paper, the efficient implementation of the proposed algorithm suitable for large heterogeneous systems is a challenging task that requires a thoughtful selection of suitable the techniques of the power distribution system that would allow fast evaluation. C.G. Carter-Brown et al in [6] presented a paper, in which a model is developed to calculate MV and LV voltage and voltage drop limits based on differential network-load combinations. The result of the model are suitable accurate for the calculation of guidelines for optimum voltage drop limits. Medium and low voltage (MV and LV) electricity distribution networks should supply customers at voltages within ranges that allow the efficient and economic operation of equipment and appliances. The permitted voltage variation is usually defined in regulations. Voltage variation is a key constraint in electricity weak networks and voltage management is applied to compensate for the voltage drop in the impedance of the distribution feeders through improving the load power factors or changing the effective ratio of the transformers and voltage regulators. C.G. Carter-Brown et al in [7 & 8] presented a paper, which comprises of the various factors for voltage drop apportionment or voltage variation management in Eksom's distribution networks, in which voltage regulation is a term used to describe the variation of voltage. This paper, which consists of optimal voltage regulation limits and voltage drop apportionment in the distribution systems, in which the planner/ designer of a future network assumes the network will be operated in a reasonable manner (voltage control, tap settings, balanced loads and appropriate configuration of normally open points) and apportions the allowable voltage variation between the MV and LV terminals. Sarang Pande et al in [9] presented a paper, in which a method for energy losses calculation is presented. This paper demonstrates the capability of Load factor and load loss factor to calculate the power losses of the network. The results obtained can be used for financial loss calculation and can be presented to regulate the tariff determination process. S.A. Qureshi et al in [10] presented a paper in his research to develop and guide lines for distribution engineers to show that by reducing the energy losses of the distribution systems available capacity of the system may be conserved without outing up additional capacity. A generalized computer program is used to evaluate any given HT/LT system and propose capacitor banks at different locations of feeders, different conductor sizes in different portions of system. This results in improving the stability as well as energy handling capacity of the system at minimum cost. It indicates the benefits in terms of reduced current and losses, which can be achieved by using the computer software. Amin M. et al in [11] presented a paper in his research that WAPDA power system is heavily overloaded because the system has been expanded without proper planning and increasing the required level of capital expenditure. Due to this unplanned expansion in the system, the supply conditions were sacrificed to meet the required targets. Due to this over-increasing demand for power all around, the distribution system of WAPDA remains under pressure. The methodology to increase the capacity of the system was outlined as

(i) Data collection of given power distribution system.
(ii) Analysis of power distribution system at different loads, voltage levels, conductor sizes, current levels etc.
(iii) Designing of power distribution network by simulating on computer using feeder analysis software applicable in WAPDA for calculation of parameters of system such as power factor, voltage drops, power losses, cost involved with respect to benefits gained in specific period of time etc.
(iv) Calculation of exact rating of capacitors required to improve the power factor, length of conductor to be replaced with conductor size.

(v) Energy and cost saving through the system improvement.

Beg D. et al in [11] presented a paper, which comprises of that system losses include transmission losses and distribution losses. The distribution losses make major contribution to the system losses and are about 70% of the total losses. Distribution losses being major share of the system losses needs special attention for achieving remarkable reduction in loss figure. Technical losses result from the nature and type of load, design of electrical installation/ equipment, layout of installations, poor maintenance of the system, under size and lengthy service lines, over-loading and sub-standard electrical equipments.

III. VOLTAGE DROP CALCULATION OF URBAN DISTRIBUTION FEEDER (11KV NAI ABADI FEEDER)

The single-line diagram of the 11kV Nai Abadi Urban Feeder is obtained from Punjab State Power Cooperation Ltd. is available in fig. no. 1 and hereby re-drawn in fig. no. 2 in the ETAP software [12].

Conductor Size = 30 mm^2 (RABBIT) [13]

Conductor Size = 20 mm^2 (WEASEL)

Resistance of 30mm^2 conductor size, at $20^0C = 0.5449\Omega$

Resistance of 30mm^2 conductor size, at $65^0C = 0.6437\Omega$

Resistance of 30mm^2 conductor size, at $75^0C = 0.6657\Omega$

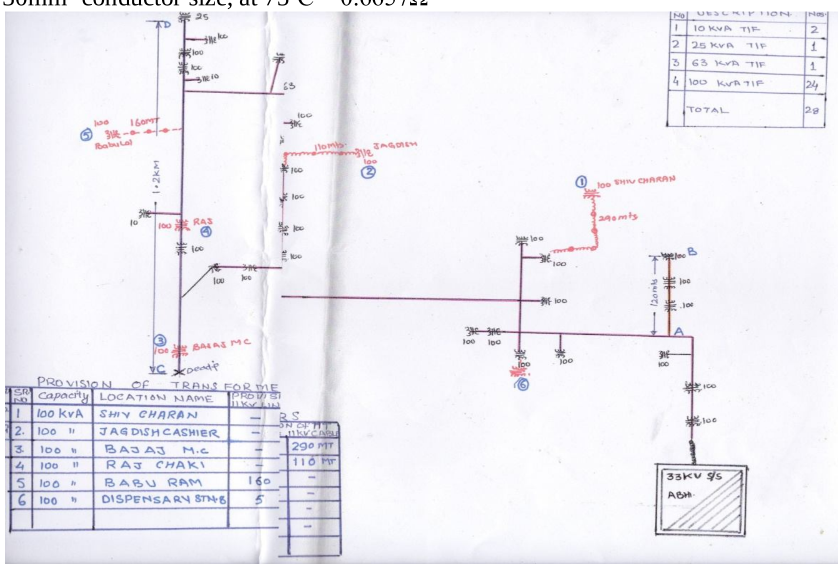

Fig. 1: Single Line Diagram of 11kV Nai Abadi Feeder

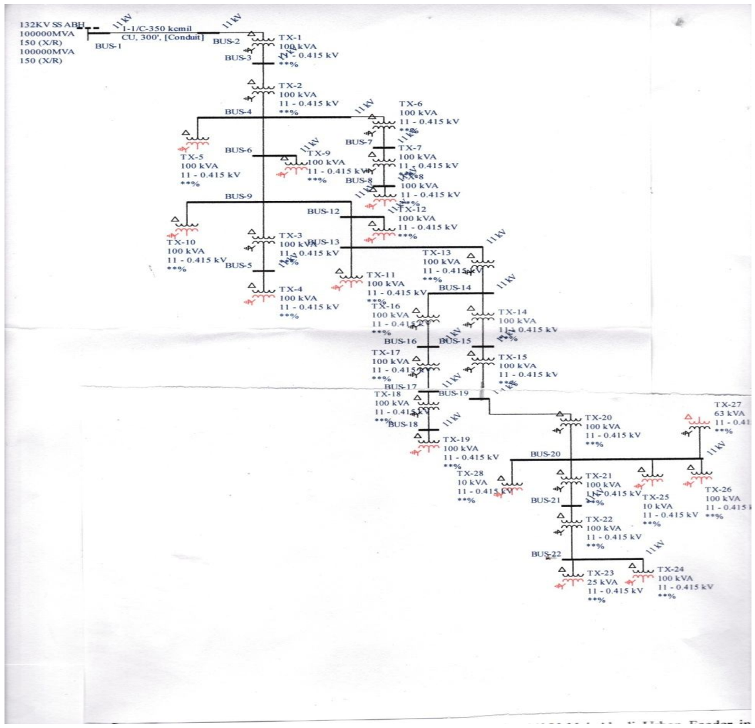

Fig. 2: Single Line Diagram of 11kV Nai Abadi Feeder redrawn in ETAP Software

I. DATA OF FEEDER

The data obtained from State Electricity Board of Subdivision is as shown in table no. 3.

Table 3: Voltage Drop Calculation Data of 11kV Nai Abadi Urban Feeder

Sr. No.	From- To	ACSR size	kVA	Km	Factor	Voltage drop
1	0-A	30mm^2	2251	0.300	0.0662	44.705
2.	AB	30mm^2	2151	0.400	0.0662	56.958
3.	BC	30mm^2	2051	0.100	0.0662	13.578
4.	CD	30mm^2	1951	0.010	0.0662	1.292
5.	DE	30mm^2	1651	0.300	0.0662	32.789
6.	EF	30mm^2	1551	0.200	0.0662	20.535
7.	FG	30mm^2	1351	0.100	0.0662	8.944
8.	GH	30mm^2	1151	0.200	0.0662	15.239
9.	HI	30mm^2	1051	0.010	0.0662	0.696
10.	IJ	30mm^2	988	0.010	0.0662	0.654
11.	JK	30mm^2	888	0.700	0.0662	41.150
12.	KL	30mm^2	788	0.200	0.0662	10.433
13.	LM	30mm^2	688	0.200	0.0662	9.109
14.	MN	30mm^2	588	0.800	0.0662	31.140
15.	NO	30mm^2	488	0.010	0.0662	0.323
16.	OP	30mm^2	388	0.200	0.0662	5.137
17.	PQ	20mm^2	225	0.020	0.0991	0.446
18	QR	20mm^2	125	0.200	0.0991	2.478
19	RS	20mm^2	25	0.500	0.0991	1.239
			Total Voltage drop			**296.844**

Maximum Demand = 140 Amp.

Demand Factor = $\dfrac{\sqrt{3} \times 11 \times \text{max. demand}}{\text{Total kVA}}$

$= \dfrac{\sqrt{3} \times 11 \times 140}{2251} = 1.185$

Actual Voltage drop = Total voltage drop x demand factor

= 296.844 x 1.185 =**351.76 units**

% voltage drop = $\dfrac{\text{Actual voltage drop}}{\quad} \times 100$

$$\% \text{ voltage drop} = \frac{11000 - \text{Actual voltage drop}}{11000 - 351.76} \times 100 = \mathbf{3.30\%}$$

351.76

Total circuit length of feeder = **4.460km**

On the basis of the above data, graph between the lengths of the various points on feeder versus voltage drop will be drawn in fig. no. 3.

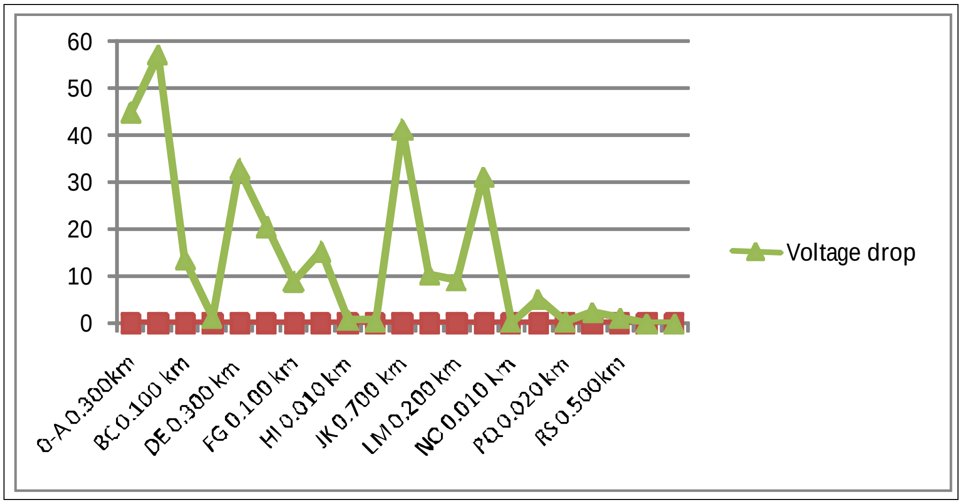

Fig. 3: Graph between Length of Feeder V/s Voltage Drop

II. *ESTIMATION OF CURRENT IN FEEDER LINES*

On the basis of the data of feeder, the calculation of current flowing through the feeder lines can be calculated as shown in table no. 4.

$$\text{Current, I} = \frac{\mathbf{kVA}}{\sqrt[2]{3}\ \mathbf{kV\ length}}$$

Table 4: Estimation of Current in Feeder Line

Section	Length in km	Voltage Drop (Volts)	kVA	Current in feeder lines
0-A	0.300	44.705	2251	118.14
AB	0.400	56.958	2151	112.90
BC	0.100	13.578	2051	107.65
CD	0.010	1.292	1951	102.40
DE	0.300	32.789	1651	86.66
EF	0.200	20.535	1551	81.40
FG	0.100	8.944	1351	70.91
GH	0.200	15.239	1151	60.41
HI	0.010	0.696	1051	55.16
IJ	0.010	0.654	988	51.85
JK	0.700	41.150	888	46.61
KL	0.200	10.433	788	41.36
LM	0.200	9.109	688	36.11
MN	0.800	31.140	588	30.86
NO	0.010	0.323	488	25.61
OP	0.200	5.137	388	20.36
PQ	0.020	0.446	225	11.81
QR	0.200	2.478	125	6.56
RS	0.500	1.239	25	1.31
Total	**4.460 km**	**296.844**		

From the above calculations, it is assumed that the current estimated on feeder line as reference current value at power factor of 0.88 (lagging).

III. *ESTIMATION OF CURRENT AT DIFFERENT POWER FACTOR*

On the basis of the current estimation at reference power factor of 0.88 (lagging), estimation of currents at other power factors, say 0.65 (lag) and unity power factor is also hereby calculated and is as shown in table no. 5 on the basis of required expression.

$$\text{Current, } I \propto \frac{1}{\cos \phi}$$

Table 5: Calculation of Currents in Feeder at Various Power Factors

Section	Current at 0.65 power factor	Current at 0.88 power factor (reference)	Current at unity power factor
0-A	159.94	118.14	103.96
AB	151.75	112.90	98.63
BC	145.74	107.65	94.73
CD	138.63	102.40	90.11
DE	117.32	86.66	76.26
EF	108.53	81.40	71.63
FG	96.00	70.91	62.40
GH	81.78	60.41	53.16
HI	74.68	55.16	48.54
IJ	70.20	51.85	45.62
JK	63.10	46.61	41.01
KL	56.00	41.36	36.40
LM	48.89	36.11	31.78
MN	41.78	30.86	27.15
NO	34.67	25.61	22.53
OP	27.56	20.36	17.92
PQ	15.99	11.81	10.39
QR	8.88	6.56	5.77
RS	1.77	1.31	1.15

IV. CALCULATION OF VOLTAGE DROP AT VARIOUS POWER FACTORS

As the values of current at various power factors had been determined as per above table. Now voltage drop can be estimated at various power factors and also at various temperatures of conductors.

a) At power factor 0.88 (reference) and at various temperature

Resistance of 30mm^2 conductor size, at 20^{0}C = 0.5449Ω

Resistance of 30mm^2 conductor size, at 65^{0}C = 0.6437Ω

Resistance of 30mm^2 conductor size, at 75^{0}C = 0.6657Ω

On the basis of the above parameters, the voltage drop calculations had been estimated in table no. 6 at various temperatures i.e. 20^{0}C, 65^{0}C and at 75^{0}C.

Voltage drop at any temperature = I x Resistance (R) at that temp.

Table 6: Voltage Drop Calculations at Power Factor 0.88

Section	Current at 0.88pf.	Voltage drop at 20^{0}C (reference)	Voltage drop at 65^{0}C	Voltage drop at 75^{0}C
0-A	118.14	65.55	76.04	78.64
AB	112.90	62.64	72.67	75.15
BC	107.65	59.73	69.29	71.66
CD	102.40	56.82	65.91	68.16
DE	86.66	48.08	55.78	57.68
EF	81.40	45.16	52.39	54.18
FG	70.91	39.34	45.64	47.20
GH	60.41	33.52	38.88	40.21
HI	55.16	30.60	35.50	36.72
IJ	51.85	28.77	33.37	34.51
JK	46.61	25.86	30.00	31.02
KL	41.36	22.95	26.62	27.53
LM	36.11	20.03	23.24	24.03

MN	30.86	17.12	19.86	20.54
NO	25.61	14.21	16.48	17.04
OP	20.36	11.29	13.10	13.55
PQ	11.81	6.43	7.60	7.86
QR	6.56	3.57	4.22	4.36
RS	1.31	0.71	0.84	0.87
		581.99	**687.51**	**711.01**

The above calculation in table no. 6 is hereby plotted as graph below in fig. no. 4.

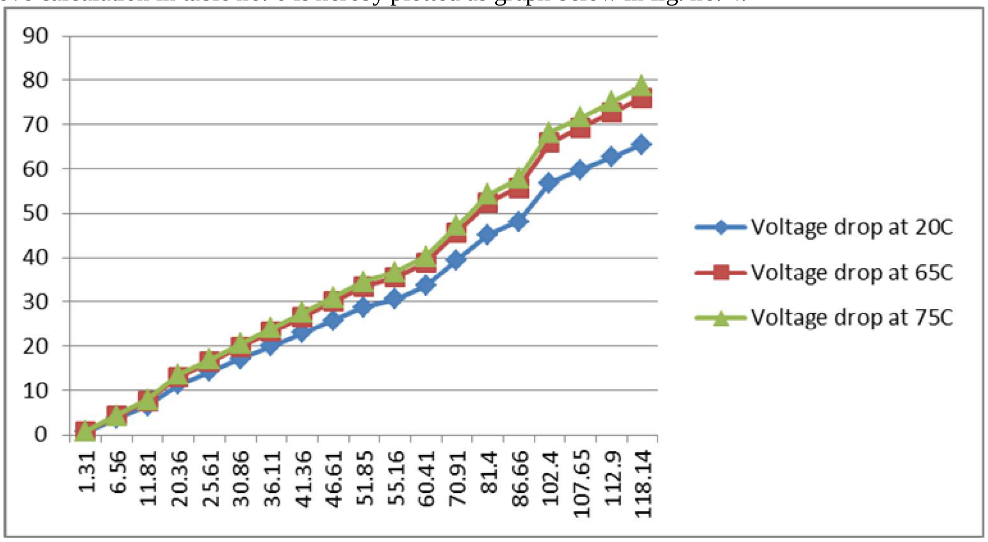

Fig. 4: Graph between Voltage Drop Vs Current at 0.88 Power Factor

b) At power factor 0.65 (lagging) and at various temperature

Resistance of 30mm^2 conductor size, at 20^{0}C = 0.5449Ω

Resistance of 30mm^2 conductor size, at 65^{0}C = 0.6437Ω

Resistance of 30mm^2 conductor size, at 75^{0}C = 0.6657Ω

On the basis of the above parameters, the voltage drop calculations had been estimated in table no. 7 at various temperatures i.e. 20^{0}C, 65^{0}C and at 75^{0}C.

Table 7: Voltage Drop Calculations at Power Factor 0.65 (Lag)

Section	**Current at 0.65pf. (lag)**	**Voltage drop at 20^{0}C (reference)**	**Voltage drop at 65^{0}C**	**Voltage drop at 75^{0}C**
0-A	159.94	87.15	102.95	106.47
AB	151.75	82.68	97.68	101.01
BC	145.74	79.41	93.81	97.01
CD	138.63	75.53	89.23	92.28
DE	117.32	63.92	75.51	78.10
EF	108.53	59.13	69.86	72.24
FG	96.00	52.31	61.79	63.90
GH	81.78	44.56	52.64	54.44
HI	74.68	40.69	48.07	49.71
IJ	70.20	38.25	45.18	46.73
JK	63.10	34.38	40.61	42.00
KL	56.00	30.51	36.04	37.27
LM	48.89	26.64	31.47	32.54
MN	41.78	22.76	26.89	27.81
NO	34.67	18.89	22.31	23.07
OP	27.56	15.01	17.74	18.34
PQ	15.99	8.71	10.29	10.64
QR	8.88	4.83	5.71	5.91
RS	1.77	0.96	1.13	1.17
		786.40	**928.99**	**960.74**

The above calculation in table no. 7 is hereby plotted as graph below in fig. no. 5.

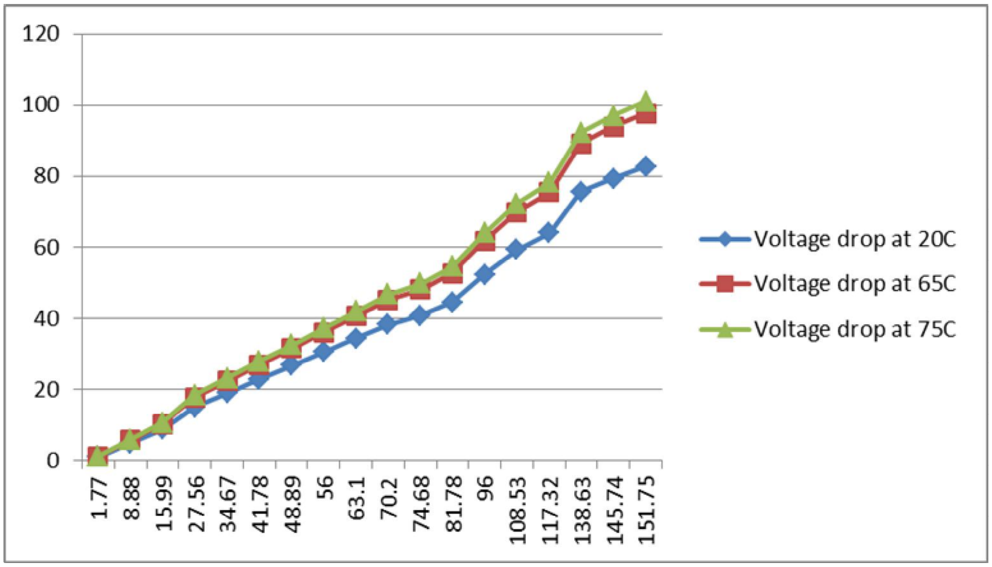

Fig. 5: Graph between Voltage Drop Vs Current at 0.65 (Lag) Power Factor

c) At power factor Unity and at various temperatures

Resistance of 30mm^2 conductor size, at 20^{0}C = 0.5449Ω
Resistance of 30mm^2 conductor size, at 65^{0}C = 0.6437Ω
Resistance of 30mm^2 conductor size, at 75^{0}C = 0.6657Ω
On the basis of the above parameters, the voltage drop calculations had been estimated in table no. 8 at various temperatures i.e. 20^{0}C, 65^{0}C and at 75^{0}C.

Table 8: Voltage Drop Calculations at Unity Power Factor

Section	**Current at Unity pf.**	**Voltage drop at 20^{0}C (reference)**	**Voltage drop at 65^{0}C**	**Voltage drop at 75^{0}C**
0-A	103.96	56.64	66.91	69.20
AB	98.63	53.74	63.48	65.65
BC	94.73	51.61	60.98	63.06
CD	90.11	49.10	58.00	59.98
DE	76.26	41.55	49.08	50.76
EF	71.63	39.03	46.10	47.68
FG	62.4	34.00	40.16	41.53
GH	53.16	28.96	34.22	35.38
HI	48.54	26.45	31.24	32.31
IJ	45.62	24.85	29.36	30.36
JK	41.01	22.34	26.39	27.30
KL	36.4	19.83	23.43	24.23
LM	31.78	17.31	20.45	21.15
MN	27.15	14.79	17.47	18.07
NO	22.53	12.27	14.50	14.99
OP	17.92	9.76	11.53	11.92
PQ	10.39	5.66	6.68	6.91
QR	5.77	3.14	3.71	3.84
RS	1.15	0.62	0.74	0.76
		511.73	**604.52**	**625.18**

The above calculation in table no. 8 is hereby plotted as graph below in fig. no. 6.

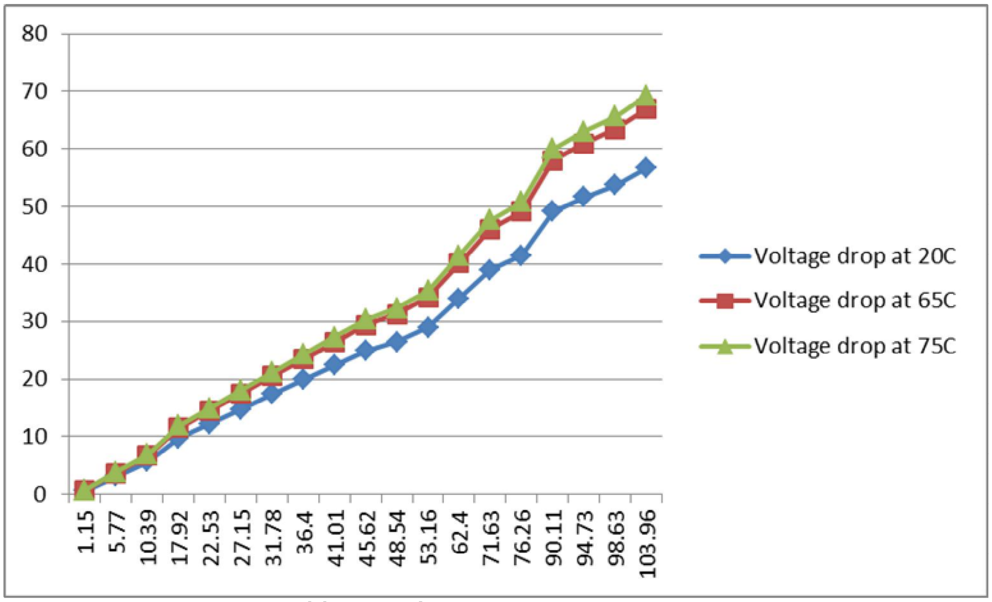

Fig. 6: Graph between Voltage Drop Vs Current at Unity Power Factor

V. ALTERATION OF ACSR CONDUCTOR SIZE

Alteration of ACSR conductor means the size of conductor used for obtaining voltage profile in the distribution feeder can be modified, so that voltage will be reached at the end consumer will be within the limits as per desired norms.

a) Alteration of conductor with specific size

The size of conductor used in the 11kV feeder, which is 30mm^2 and 20mm^2, can be modified with 30mm^2 (RABBIT) and 25mm^2 (FERRET).

Existing Conductor Size of feeder = 20mm^2 (WEASEL)
Proposed Conductor Size of feeder = 25mm^2 (FERRET)
Resistance at 20^{0}C of proposed conductor = 0.6795Ω
Resistance at 65^{0}C of proposed conductor = 0.8027Ω
Resistance at 75^{0}C of proposed conductor = 0.8301Ω

Thus, proposed voltage drops can be estimated at various power factors and also at various temperatures of conductors.

b) At power factor 0.88 (reference) and at various temperature

Resistance at 20^{0}C of proposed conductor = 0.6795Ω
Resistance at 65^{0}C of proposed conductor = 0.8027Ω
Resistance at 75^{0}C of proposed conductor = 0.8301Ω
On the basis of the above parameters, the proposed voltage drop calculations had been estimated in table no. 9 at various temperatures i.e. 20^{0}C, 65^{0}C and at 75^{0}C.

Table 9: Proposed Voltage Drop Calculations at Power Factor 0.88

Section	Current at 0.88pf.	Voltage drop at 20^{0}C (reference)	Voltage drop at 65^{0}C	Voltage drop at 75^{0}C
0-A	118.14	64.37	76.04	78.64
AB	112.90	61.51	72.67	75.15
BC	107.65	58.65	69.29	71.66
CD	102.40	55.79	65.91	68.16
DE	86.66	47.22	55.78	57.68
EF	81.40	44.35	52.39	54.18
FG	70.91	38.63	45.64	47.20
GH	60.41	32.91	38.88	40.21
HI	55.16	30.05	35.50	36.72
IJ	51.85	28.25	33.37	34.51
JK	46.61	25.39	30.00	31.02
KL	41.36	22.53	26.62	27.53

LM	36.11	19.67	23.24	24.03
MN	30.86	16.81	19.86	20.54
NO	25.61	13.95	16.48	17.04
OP	20.36	13.83	16.34	13.55
PQ	11.81	8.02	9.47	9.80
QR	6.56	4.45	5.26	5.44
RS	1.31	0.89	1.05	1.08
		587.38	**693.88**	**714.25**

The above calculation in table no. 9 is hereby plotted as graph below in fig. no. 7.

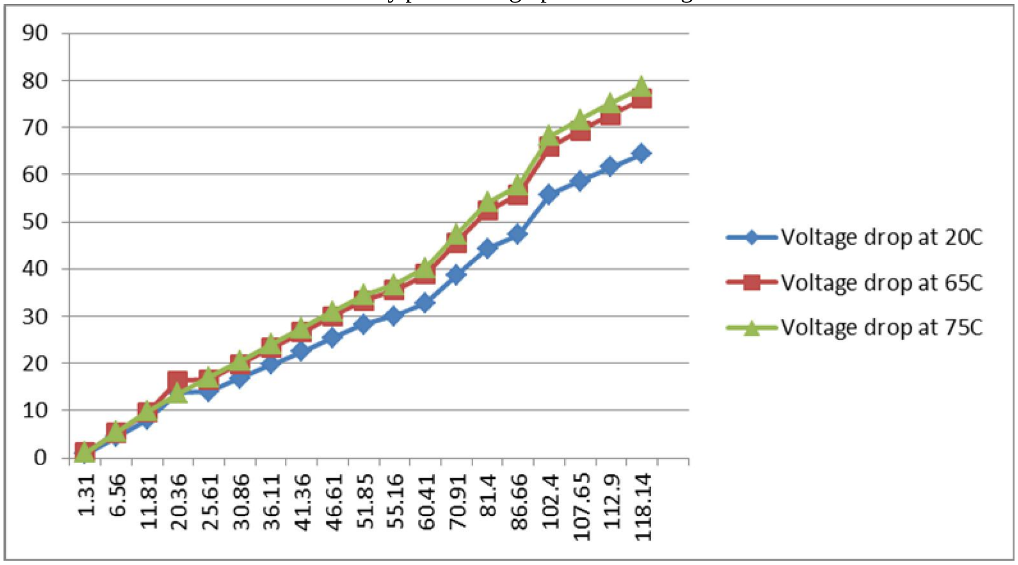

Fig. 7 Graph between Proposed Voltage Drop Vs Current at 0.88 Power Factor

c) At power factor 0.65 (lagging) and at various temperature

Resistance at 20^0C of proposed conductor = 0.6795Ω

Resistance at 65^0C of proposed conductor = 0.8027Ω

Resistance at 75^0C of proposed conductor = 0.8301Ω

On the basis of the above parameters, the voltage drop calculations had been estimated in table no. 10 at various temperatures i.e. 20^0C, 65^0C and at 75^0C.

Table 10 Proposed Voltage Drop Calculations at Power Factor 0.65 (Lag)

Section	Current at 0.65pf. (lag)	Voltage drop at 20^0C (reference)	Voltage drop at 65^0C	Voltage drop at 75^0C
0-A	159.94	87.15	102.95	106.47
AB	151.75	82.68	97.68	101.01
BC	145.74	79.41	93.81	97.01
CD	138.63	75.53	89.23	92.28
DE	117.32	63.92	75.51	78.10
EF	108.53	59.13	69.86	72.24
FG	96.00	52.31	61.79	63.90
GH	81.78	44.56	52.64	54.44
HI	74.68	40.69	48.07	49.71
IJ	70.20	38.25	45.18	46.73
JK	63.10	34.38	40.61	42.00
KL	56.00	30.51	36.04	37.27
LM	48.89	26.64	31.47	32.54
MN	41.78	22.76	26.89	27.81
NO	34.67	18.89	22.31	23.07
OP	27.56	15.01	17.74	18.34
PQ	15.99	10.86	12.83	13.27
QR	8.88	6.03	7.13	7.37
RS	1.77	1.20	1.42	1.47
		789.91	**986.26**	**965.03**

The above calculation in table no. 10 is hereby plotted as graph below in fig. no. 8.

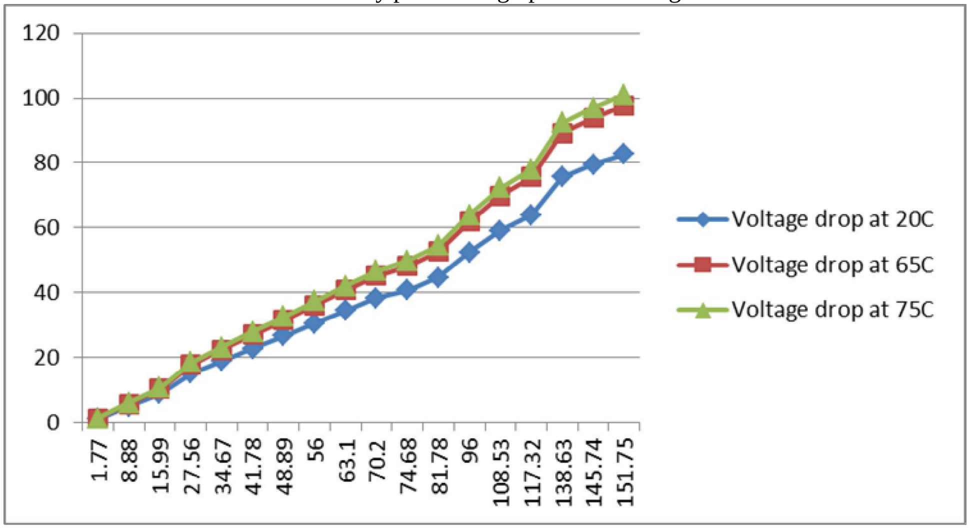

Fig. 8 Graph between Proposed Voltage Drop Vs Current at 0.65 (Lag) Power Factor

d) At power factor Unity and at various temperatures

Resistance at 20^0C of proposed conductor = 0.6795Ω
Resistance at 65^0C of proposed conductor = 0.8027Ω
Resistance at 75^0C of proposed conductor = 0.8301Ω
On the basis of the above parameters, the voltage drop calculations had been estimated in table no. 11 at various temperatures i.e. 20^0C, 65^0C and at 75^0C.

Table 11 Proposed Voltage Drop Calculations at Unity Power Factor

Section	Current at Unity pf.	Voltage drop at 20^0C (reference)	Voltage drop at 65^0C	Voltage drop at 75^0C
0-A	103.96	56.64	66.91	69.20
AB	98.63	53.74	63.48	65.65
BC	94.73	51.61	60.97	63.06
CD	90.11	49.10	58.00	59.98
DE	76.26	41.55	49.09	50.76
EF	71.63	39.03	46.10	47.68
FG	62.4	34.00	40.16	41.53
GH	53.16	28.96	34.22	35.38
HI	48.54	26.45	31.24	32.31
IJ	45.62	24.85	29.36	30.36
JK	41.01	22.34	26.39	27.30
KL	36.4	19.83	23.43	24.23
LM	31.78	17.31	20.45	21.15
MN	27.15	14.79	17.47	18.07
NO	22.53	12.27	14.50	14.99
OP	17.92	9.76	11.53	11.93
PQ	10.39	7.06	8.34	8.62
QR	5.77	3.92	4.63	4.78
RS	1.15	0.78	0.92	0.95
		514.07	**607.29**	**628.04**

The above calculation in table no. 11 is hereby plotted as graph below in fig. no. 9.

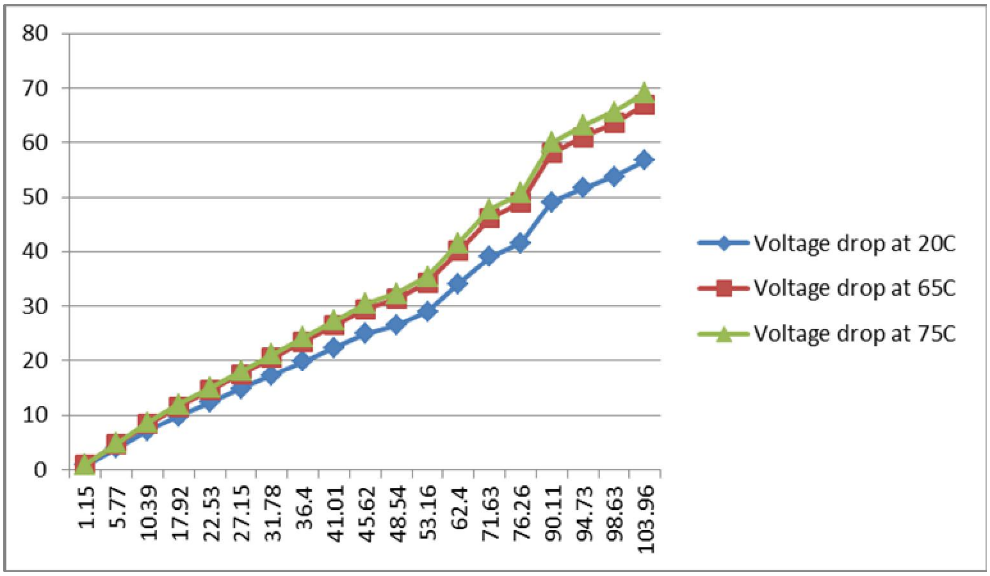

Fig. 9 Graph between Proposed Voltage Drop Vs Current at Unity Power Factor

Hence, it has been observed that the existing conductor size of 30mm^2 (RABBIT) and 20mm^2 (WEASEL) will be remain in use in all the sections of the feeder at 0.88power factor with 20^{0}C conductor temperature for its efficient use. It has also come in to notice that the section PQ to RS which is operating on 20mm^2 conductor and that can be replaced by use of 25mm^2 (FERRET) for the section from PQ to RS, for better voltage profile of feeder, due to its better current carrying capacity of 181A in comparison of 150A of 20mm^2 conductor and same linear coefficient of temperature rise of value 18.99 x 10^{-6} per ^{0}C and modulus of elasticity of 0.809 x 10^6 kg/cm^2.

VI. PROVISION OF INSTALLATION OF TRANSFORMERS

As per the data obtained from the State Electricity Board of Subdivision, the installed capacity of transformers in the existing feeder alongwith the load distribution on each transformer is calculated as shown in table no. 12.

Table 12: Calculation of Power Losses of 11kV Nai Abadi Urban Feeder

Sr. No.	Section	km	kVA	Existing Transformer Rating (kVA)	Type of Load	Sanction Load (kW)	No. of LT Poles	Current (A)
1.	0-A	0.300	2251	100	Domestic	7.5	4	13.04
2.	AB	0.400	2151	100	Domestic	10	6	17.39
3.	BC	0.100	2051	100	Domestic	2.5	3	4.35
4.	CD	0.010	1951	100	Domestic	15	8	26.09
5.	DE	0.300	1651	100	Domestic	10	6	17.39
6.	EF	0.200	1551	100	Domestic	12.5	8	21.74
7.	FG	0.100	1351	100	Domestic	7.5	4	13.04
8.	GH	0.200	1151	100	Domestic	7.5	4	13.04
9.	HI	0.010	1051	100	Domestic	7.5	4	13.04
10.	IJ	0.010	988	100	Domestic	7.5	4	13.04
11.	JK	0.700	888	100	Domestic	10	4	17.39
12.	KL	0.200	788	100	Domestic	7.5	4	13.04
13.	LM	0.200	688	100	Domestic	20.5	12	35.65
14.	MN	0.800	588	10	Domestic	5.5	3	9.57
15.	NO	0.010	488	100	Domestic	12.5	8	21.74
16.	OP	0.200	388	100	Domestic	10	4	17.39
17.	PQ	0.020	225	25	Domestic	6.5	3	11.30
18.	QR	0.200	125	63	Domestic	7.46	4	12.97
19.	RS	0.500	25	100	Domestic	7.5	4	13.04
	Total					164.46		

IV. CONCLUSION

As per the current calculations on the above feeder, it is found that there is a considerable amount of current flowing in the 11kV lines, such as section CD, EF, JK, LM and section NO. Thus, according to the current calculations evaluated above in table 3.62, it is observed that there can be provision of installation of new transformer of 100kVA capacity to share the load on these sections as proposed by the State Electricity board is as shown in table no. 13.

Table 13: Provision of Transformer in 11kV Nai Abadi Urban Feeder

Sr. No.	Section	Name of Location	Capacity of Transformer	Provision of 11kV lines
1.	CD	Dispensary St. No. 8	100kVA	5 mtr.
2.	EF	Shiv Charan	100kVA	-
3.	JK	Jagdish Cashier	100kVA	-
4.	LM	Balraj MC	100kVA	-
5.	LM	Raj Chaki	100kVA	-
6.	NO	Babu Ram	100kVA	160 mtr.

It is further submitted that the capacity of shared transformer as mentioned above is 100kVA, which is of higher rating. As the physical survey of the feeder, the location of the above sections is so narrow in space and thus, the HVDS system cannot be installed in these sections. However, the capacity of the transformer as shared transformer can be reduced to 63kVA ratings as the current ratings is on sharing basis.

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