iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 3 **Issue:** VI **Month of publication:** June 2015

DOI:

www.ijraset.com
IC Value: 13.98
Volume 3 Issue VI, June 2015
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

Noval Method for Loss Allocation in Radial Distribution Systems

Sk.Mahammad Rafi[1], G.Srinivasulu Reddy[2]
[1]M.Tech, Electrical Power Engineering, Narayana Engineering College, A.P, India
[2]M.Tech, Ph.D., Department of EEE, Narayana Engineering College, A.P, India

Abstract— ***this paper presents an exact method for real power loss allocation to consumers connected to radial distribution networks in a deregulated environment. The proposed method has the advantage that no assumptions are made in the allocation of real power losses as opposed to the algorithms available in the literature. A detailed comparison of the real loss allocation obtained with the proposed 'Exact method 'with two alternative algorithms, namely, pro rata (PR), and quadratic loss allocation schemes are presented. Pro rata procedure is based on the load demand of each consumer, quadratic allocations are based on identifying the real and reactive parts of current in each branch and the losses are allocated to each consumer, and the proposed 'exact method' is based on the actual contribution of real power loss by each consumer. A case study based on 30 node distribution system is provided.***
Keywords— ***pro-rata (PR), pro-sented, radial distribution***

I. INTRODUCTION

Deregulation of the power industry was intended to break up the industry's traditional, vertically integrated structure of generators, transmission lines, and distribution facilities into separate entities with generators competing for sales across common transmission lines to local distribution outlets. Under such a system, generators would be in competition with each other to serve more than one utility distributor. Thus, the generators selling electricity at the lowest cost would have the most utility customers. Unlike generation and sale of electrical energy, activities of transmission and distribution are generally considered as a natural monopoly. The cost of transmission and distribution activities needs to be allocated to the users of these networks. Allocation can be done through network use tariffs, with a focus on the true impact they have on these costs. Among others, distribution power losses are one of the costs to be allocated. The main difficulty faced in allocating losses is the nonlinearity between the losses and delivered power which complicates the impact of each user on network losses. Different techniques have been published in the literature for allocation of losses, most of them dedicated to transmission networks and can be classified into three broad categories – pro rata procedures, marginal procedures and proportional sharing procedures.Pro rata procedure is the simplest one, in which, the total losses are allocated to loads or generators based on the load active power demand or bus generation. In marginal procedures, losses are assigned to generators and demands through the so-called incremental transmission loss (ITL) coefficients. In proportional sharing procedures, losses are allocated to the generators and consumers by using the results of a converged power flow plus a linear proportional sharing principle. Conjoin. Have displayed another system for distributing transmission losses to generation and loads based on the networks Z-bus matrix. Conejos have also presented a comparison of four different practical algorithms for transmission loss allocation. Fang and Naan proposed a compact system for distribution of system misfortunes which takes into consideration the influence of both active and reactive power injected into grids. Costa and Matos have addressed the allocation of losses in distribution networks with embedded generation by considering quadratic loss allocation technique. Daniel et al. presented an approach for transmission loss allocation using a modified Y bus. Presented methods for transmission fixed cost allocation based on min–max fairness criteria and optimization approach. Carpenter. Proposed a branch current disintegration technique for misfortune portion in spiral dissemination frameworks with dispersed generation. Carpenter. Also presented a detailed characterization of different loss allocation techniques for radial distribution systems with distributed generation. Balata and da Costa presented a transmission loss application based on perturbation of optimum theorem. In their approach, from a given ideal working point got by the ideal force stream the heaps are annoyed and a new operating point that satisfies the constraints are obtained by sensitivity analysis, which is used for obtaining the coefficients of the losses. Limed. Introduced a new method for allocating losses in a power system using a loop-based representation of system behaviour. Lied. Presented a means of allocating transmission losses and costs taking into account pool and bilateral contract hybrid regulated power market. Beaker. Presented probabilistic game approaches for network cost allocation. Alturki and Lo presented a loss allocation method using current adjustment factors to allocation real and receptive losses all the while with no extra estimation aside from the substitution of line reactance rather than resistance. Ferreira. Introduce a method for transmission cost portion in view of ideal re-dispatch. Savierand das accessible designation of force misfortunes to shoppers joined with outspread dissemination organize previously, then after the fact system reconfiguration in a deregulated situation. Prestart et al. displayed a methodology of transmission misfortune assignment in which, relationship between the transport current infusions and the generator or burden streams is initially decided utilizing an influence invariant lattice and after that Z-bus matrix is modified, which allowed the real power of the system to be communicated regarding generator or burden ebbs and flows. Choudhury and Go swami solved the issue of transmission loss distribution of deregulated power system through the application of artificial neural network. As there is no unique or existing ideal procedure is available, any loss allocation algorithm should have most of the desirable properties such as consistent with the results of power flow, depend upon the amount of energy either produced or consumed, depend on the relative location within the network, easy to understand, and easy to implement. In the light of the above developments, this work proposes simple loss allocation method, called 'Exact Method' for real powerless allocation to consumers in radial distribution systems. It is assumed that consumers have to pay for losses. Real power loss allocation to each consumer obtained with the proposed method is compared with two different practical approaches for loss allocation, to be specific, professional rata (PR) and quadratic misfortune distribution plans. In this work, the principle point of theory has been to add to another burden stream procedure for explaining outspread appropriation systems. The proposed technique includes just the assessment of a basic arithmetical articulation of accepting end voltages The proposed method is very efficient. It is also observed that the proposed method has good and fast convergence characteristics. Loads in the present formulation have been presented as constant power. However, the proposed method can easily include composite load modelling, if the composition of the loads is known. Several radial distribution feeders have been solved successively by using the proposed method. The speed requirement of the proposed method has also been compared with other existing methods. Any Loss allocation algorithm should have most of the desirable properties as stated below:

To be consistent with the results of a power flow;
To depend upon the amount of energy either produced or consumed;
To depend on the relative location in the distribution network;
To avoid volatility;
To be easy to understand;
To be easy to implement.

In the light of the above developments, this work proposes simple loss allocation method, called 'Exact Method' for real powerless allocation to consumers in radial distribution systems. It is assumed that consumers have to pay for losses. Real power loss allocation to each consumer obtained with the proposed method is compared with two different practical approaches for loss allocation, to be specific, professional rata (PR) and quadratic misfortune designation plan

II. PROPOSED METHOD FOR DISTRIBUTION LOSS ALLOCATION

In radial distribution systems, power is fed at substations and the power flows from substation to downstream. In this section, proposed exact method for loss allocation is briefly presented for the purpose of comparisons, pro rata (PR) and quadratic loss allocation schemes are used. Hence, loss allocation procedure with these two methods is also briefly presented

A. Proposed Exact Method

In a radial distribution system, load current of a consumer connected to busied (jj,k) beyond branch-jj can be written in the form:

$$IL\{ie(jj,i)\} = ILD\{ie(jj,i)\} - jILQ\{ie(jj,i)\} \tag{1}$$

If the total number of nodes beyond branch-jj is N (jj), the current through that branch can be written as:

$$I(jj) = \sum_{i=1}^{N(jj)} (ILD[ie(jj,i)] \quad jILQ[ie(jj,i)]) \tag{2}$$

Real power loss of branch-jj with sending end and receiving end voltages V_i and V_j is given by:

$$PLOSS(jj) = \mathcal{R}\{(V_i - V_j)^{*}.I(jj)\} \tag{3}$$

i.e.

Volume 3 Issue VI, June 2015
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

$$PLOSS(jj) = R\left\{\left(V_i - V_j\right)^* . \sum_{i=1}^{N(jj)} (ILD\{ie(jj,i)\} - jILQ\{ie(jj,i)\})\right\}$$

(4)

Let $\left(V_i - V_j\right)^* = a\{ie(jj,i)\} - jb\{ie(jj,i)\}$ **(5)**

$$pLOSS(jj) = R\left\{\sum_{i=1}^{N(jj)} (a\{ie(jj,i)\} - jb\{ie(jj,i)\}). (ILD\{ie(jj,i)\} - jILQ\{ie(jj,i)\})\right\}$$

(6)

Hence

$$PLOSS(jj) = \sum_{i=1}^{N(jj)} (a\{ie(jj,i)\}ILD\{ie(jj,i)\} + b\{ie(jj,i)\}ILQ\{ie(jj,i)\})$$

(7)

Show in above Eq. (7), real power loss into branch-jj can be allocated to consumers beyond branch-jj. Real power loss of branch-jj allocated to consumer connected to node ie (jj,k) be specified by:

$$\text{for } jj = 1, 2, \ldots . nb \text{ and } k = 1, 2, \ldots \ldots, N(jj)$$

B. Pro Rata (Pr) Allocation Method

The PR method proportionally allocates losses to the consumers based on the kW load demand. In order to take into account reactive load of each consumer, instead of considering real power demand of the consumer, kVA load demand is considered. The total kVA demand of the system can be written as:

$$TkVA_D = \sum_{p=2}^{nb} kVA_p \quad (3.1)$$

Note that substation is marked as node 1, i.e., p = 1.

Hence, power loss allocated to consumer at node p is given by:

$$ploss_p = Ploss \frac{kVA_p}{TkVA_D} \quad (8)$$

$$\text{i.e. } ploss_p = K_D kVA_p, \quad (9)$$

Where

$$K_D = \frac{Ploss}{TkVA_D}$$

It may be noted that the demand loss allocation factors K_D are identical for all buses. Hence, pro rata procedure is simple to understand and implement but they ignore the relative location of the consumers within the network. That is, two identical demands located respectively near substation and far away from the substation are equally treated, and this is unfair to the load located near the substation.

Volume 3 Issue VI, June 2015
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

C. Quadratic Allocation Method

In quadratic loss allocation scheme, since the power losses growquadratically with power flows, the following constraint is imposed.

$$\frac{\alpha\{ie(jj,i)\}}{[ILD\{ie(jj,i)\}]^2} = \frac{\alpha\{ie(jj,k)\}}{[ILD\{ie(jj,k)\}]^2} \qquad (10)$$

And

$$\frac{\beta\{ie(jj,i)\}}{[ILQ\{ie(jj,i)\}]^2} = \frac{\beta\{ie(jj,k)\}}{[ILQ\{ie(jj,k)\}]^2} \qquad (11)$$

From Eqns. (12) and (13), we get,

$$\alpha\{ie(jj,i)\} = \frac{2.[ILD\{ie(jj,i)\}]^2}{[ILD\{ie(jj,i)\}]^2 + [ILD\{ie(jj,k)\}]^2} \qquad (12)$$

Similarly, from Eqns. (3.15) and (3.17), we get,

$$\beta\{ie(jj,i)\} = \frac{2.[ILQ\{ie(j,i)\}]^2}{[ILQ\{ie(jj,i)\}]^2 + [ILQ\{ie(jj,k)\}]^2} \qquad (13)$$

Based on this principle, the power loss of the branch-jj of the network allocated to consumers beyond branch-jj, for i = 1, 2. . . N (jj) are:

$$ploss\{jj, ie(jj,i)\} = R(jj).\left\{[ILD\{ie(jj,i)\}]^2 + [ILQ\{ie(jj,i)\}]^2 + \sum_{\substack{k=1 \\ k\neq i}}^{N(jj)} ILD\{ie(jj,i)\}.ILD\{ie(jj,k)\}.\alpha\{ie(jj,i)\} + \sum_{\substack{k=1 \\ k\neq i}}^{N(jj)} ILQ\{ie(jj,i)\}.ILQ\{ie(jj,k)\}.\beta\{ie(jj,i)\}\right\} \qquad (14)$$

The global value of losses to be supported by consumer results from the sum of the losses allocated to it in each branch-jj of the network, i.e.,

$$Tploss(l) = \sum_{jj=1}^{nb-1} ploss(jj,l) \quad \text{for } l = 2,3,\dots.nb$$

Note that node 1 is substation. Eq. (14) indicates that each consumer has allocated losses only at branches to which power flow contributes.

III. CASE STUDIES AND ANALYSIS

A. Case Study 9-Bus Radial Distribution System

In this case study, a distribution system having nine buses, as shown in Fig. 3.1 is considered. The line and load data for this system are given in Appendix A in Table A1. In Case-1, the real and reactive power loads as shown in Appendix A is taken. For the purpose of explanation of the proposed technique when there is current injection, Case-2 is considered in which the line and load data is same as those given in Appendix A in Table A2 except that the reactive power load at node no. 8 is taken as negative (injection).

Volume 3 Issue VI, June 2015
ISSN: 2321-9653

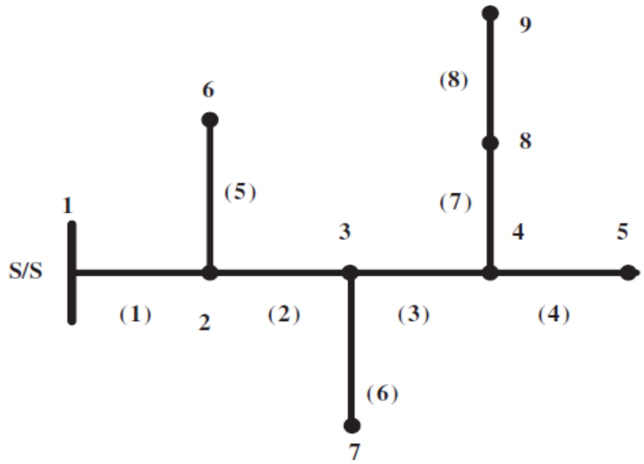

Fig 3.1 Sample distribution system with nine buses

Table .A1
Load flow solution details for 9-bus Radial Distribution System

Branch	Sending end	Receiving end	Voltage, p.u.	Angle, p.u.	Active Power Loss, kW	Reactive Power Loss, kVAr	Active Power Flow, Kw	Reactive Power Flow, kVAr
1	1	2	0.98437	0.00071	12.46	8.41	771.61	573.11
2	2	3	0.97665	0.0013	4.58	3.09	551.54	435.08
3	3	4	0.97399	0.00143	1.09	0.74	384.96	288.00
4	4	5	0.97389	0.00143	0.00	0.00	30.00	18.00
5	2	6	0.98406	0.00073	0.01	0.01	45.61	33.61
6	3	7	0.97649	0.00133	0.00	0.00	12.00	6.00
7	4	8	0.96428	0.00544	4.45	1.26	341.87	262.06
8	8	9	0.95751	0.00824	1.44	0.41	157.43	120.40

In Case-1, the total active and reactive power loads are 747.60 kW and 559.20 kVAr and total real and reactive power losses of the radial distribution system after a converged load flow are 24.0389 kW and 13.9210 kVAr with minimum voltage of 0.95751 at bus 9. The load flow solution details are shown in the Table 5.1.For Case-1, allocation of real power losses to different consumers, voltages and load currents at different nodes are given in Table 5.2. It can be seen from the table that the real power losses allocated to consumer at bus nos. 8 and 9 are 7.4565 kW and 7.9497 kW. It can be seen that the real power loss allocated to consumer at bus no. 9 is higher than that at bus no. 8, even though the real and reactive power losses at boson. 9 are lower than that at bus no. 8. This is due to the fact that the proposed method allocates losses based on actual contribution of the losses. Table 5.3 shows the power loss allocation for each customer for 9-bus system and the same is observed with the help of

International Journal for Research in Applied Science & Engineering Technology (IJRASET)

3.2 Case Study with example 30-Bus Radial Distribution System

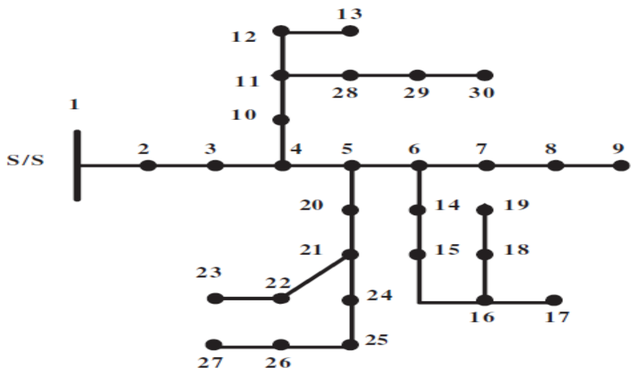

Fig3.2 Distribution system with 30 bus system

A practical 11 kV distribution system having 30 buses, as shown in Fig. 5.4 is considered to compare the four distribution loss allocation methods. The line and load data for this system. The loads considered are either industrial or commercial type.

Power flow data and results are used as input data for the four loss allocation algorithms. The loss allocation based on pro rata procedure allocates losses irrespective of the geographical location of consumers. Hence, consumers having same load demands are allocated same losses, even though the power loss contribution of the consumer electrically closer to the substation is less as compared to those consumers electrically away from the substation. For example, consumer sat nodes 10 and 28 are having the same load demand. Hence, loss allocation based on pro rata procedure allocates same losses tooth the consumers, i.e., 4.3619kW. Whereas, loss allocation to consumers at nodes 10 and 28 based on quadratic and exact method are different. Quadratic loss allocation scheme allocated3.3633kW and 3.6847kW to the consumers at nodes 10 and 28, respectively, and proposed exact method allocated 4.2307kW and 4.4902kW to the consumers at nodes 10 and 28 respectively. It can be seen that all the methods except pro rata method allocated less power loss to consumer at node 10, which is electrically closer to the substation, as compared to losses allocated to consumer at node 28, which is electrically away from the substation.

Table.A2

Power loss allocation for each customer for 30-bus system

Customer (bus)	Pro Rata Method, kW	Quadratic Method, kW	Proposed Exact Method, kW
1	0.00000	0	0
2	13.68960	8.2261	6.078
3	14.81750	15.3791	9.4129
4	1.01740	0.0934	0.8758
5	2.54340	0.8941	2.3256
6	4.11770	2.5764	3.8002
7	0.97530	0.1018	1.0362
8	1.67580	0.4027	1.7311
9	14.30800	24.1146	16.707

10	4.36190	3.3633	4.2307
11	5.38900	5.1936	5.8312
12	2.92600	1.6229	3.2381
13	0.97530	0.1227	1.0802
14	2.79300	1.2349	2.6739
15	4.36190	3.4196	4.7542
16	4.36190	3.6994	5.1787
17	11.73660	19.8286	13.382
18	5.85210	6.5302	7.7601
19	3.70120	2.755	4.103
20	0.97530	0.0982	0.9951
21	4.93490	4.2056	4.7211
22	8.72370	12.0234	9.8188
23	2.93120	1.609	3.3272
24	9.27350	13.7866	10.345
25	5.19480	5.6113	6.1336
26	2.79300	1.7301	3.4556
27	1.95070	0.8136	2.6873
28	4.36190	3.6847	4.4902
29	3.14540	1.9975	3.3941
30	2.18620	0.9554	2.5071
Total Power Losses, kW	146.0739	146.0739	146.0739

Quadratic loss allocation technique makes use of assumption to obtain power loss of each branch allocated to consumers beyond that branch. The proposed 'exact method' allocates branch losses to different consumers based on actual contribution of the branch power losses by each consumer beyond that branch. In the present work, a load flow algorithm developed in for solving the radial distribution network has been used.

Volume 3 Issue VI, June 2015
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

IV. RESULTS AND ANALYSIS

In this thesis, the proposed algorithm for loss allocation to the customer is presented. For verification, the proposed algorithm is applied on 9-bus, modified 9-bus and 30-bus radial distribution networks. A computer program has been written in MATLAB 7.12 and run on Core 2 Duo 3.07 GHz processor and program details are given in Appendix C. Das method is used to carry out the load flow analysis. As conventional load flows are not suitable for radial distribution systems because they got diverges, due to high X/R ratio which results in singularity of Jacobin matrix.

Table 1: Voltage current and losses allocation of each customer for 9-bus system

Customer (bus)	Voltage, p.u.	Current, p.u.	Proposed Exact Loss Allocation, kW
1	1.00000	0	0
2	0.98437	0.0016-0.0010i	2.6412
3	0.97665	0.0015-0.0014i	3.7693
4	0.97399	0.0001-0.0001i	0.3311
5	0.97389	0.0003-0.0002i	0.8307
6	0.98406	0.0005-0.0003i	0.7633
7	0.97649	0.0001-0.0001i	0.2970
8	0.96428	0.0019-0.0014i	7.4565
9	0.95751	0.0016-0.0012i	7.9497

Table 2: Power loss allocation for each customer for 9-bus system

Customer (bus)	Pro Rata Method, Kw	Quadratic Method, Kw	Proposed Exact Method, Kw
1	0.00000	0	0
2	4.83490	2.5427	2.6412
3	5.23320	4.3645	3.7693
4	0.35930	0.0179	0.3311
5	0.89830	0.1357	0.8307
6	1.45430	0.232	0.7633
7	0.34450	0.0167	0.297
8	5.86120	8.6369	7.4565
9	5.05330	8.0924	7.9497
Total Power Losses, kW	24.0389	24.0389	24.0389

Fig. 1 Comparison of different loss allocation methods for 9-bus system

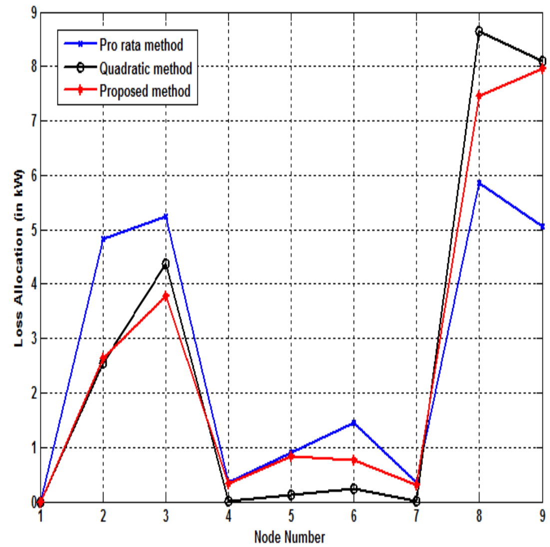

Table 3
Voltage current and losses allocation of each customer for modified 9-bus system

Customer (bus)	Voltage, p.u.	Current, p.u.	Proposed Exact Loss Allocation, kW
1	1.00000	0	0
2	0.98710	0.0016-0.0010i	1.8183
3	0.98110	0.0015-0.0014i	2.1586
4	0.97940	0.0001-0.0001i	0.2061
5	0.97930	0.0003-0.0002i	0.5182
6	0.98680	0.0005-0.0003i	0.506
7	0.98100	0.0001-0.0001i	0.2012
8	0.97160	0.0019+0.0014i	6.5648
9	0.96490	0.0016-0.0013i	4.8893

In Case-2, the total active and reactive power loads are 747.60 kW and 278.40kVAr and total real and reactive power losses of the radial distribution system after a converged load flow are 16.8624 kW and 9.7495kVAr with minimum voltage of 0.96488 at bus 9. It can be seen from Table 5.4 that the real power losses allocated to all the buses are reduced in this case due to the fact that the total power loss has reduced in this case. Real power allocated to consumers at bus nos. 8 and 9 inCase-2 are 6.5648 kW and 4.8893 kW respectively as compared to 7.4565 kW and 7.9497 kWin Case-1.Table 5.5 shows the power loss allocation for each customer for modified 9-bus system and the same is observed with the help of Fig.2.

Volume 3 Issue VI, June 2015
ISSN: 2321-9653

Table 4
Power loss allocation for each customer for modified 9-bus system

Customer (bus)	Pro Rata Method, kW	Quadratic Method, Kw	Proposed Exact Method, Kw
1	0.00000	0	0
2	3.39150	2.2878	1.8183
3	3.67090	3.4257	2.1586
4	0.25200	0.0174	0.2061
5	0.63010	0.1294	0.5182
6	1.02010	0.2166	0.506
7	0.24160	0.0164	0.2012
8	4.11140	4.3477	6.5648
9	3.54470	6.4214	4.8893
Total Power Losses, kW	16.8624	16.8624	16.8624

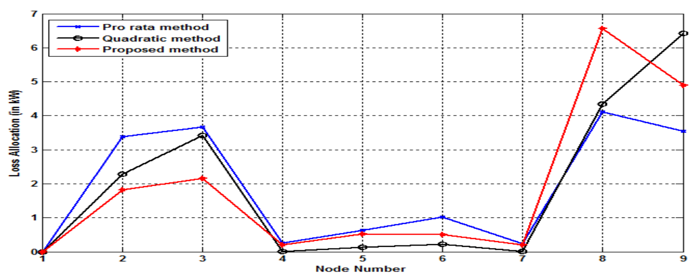

Fig. 2 Comparison of different loss allocation methods for modified 9-bus system

Table 5
Power loss allocation for each customer for 30-bus system

Customer (bus)	Pro Rata Method, kW	Quadratic Method, kW	Proposed Exact Method, kW
1	0.00000	0	0
2	13.68960	8.2261	6.078
3	14.81750	15.3791	9.4129
4	1.01740	0.0934	0.8758
5	2.54340	0.8941	2.3256
6	4.11770	2.5764	3.8002
7	0.97530	0.1018	1.0362
8	1.67580	0.4027	1.7311
9	14.30800	24.1146	16.707
10	4.36190	3.3633	4.2307
11	5.38900	5.1936	5.8312
12	2.92600	1.6229	3.2381
13	0.97530	0.1227	1.0802
14	2.79300	1.2349	2.6739
15	4.36190	3.4196	4.7542
16	4.36190	3.6994	5.1787
17	11.73660	19.8286	13.382
18	5.85210	6.5302	7.7601

19	3.70120	2.755	4.103
20	0.97530	0.0982	0.9951
21	4.93490	4.2056	4.7211
22	8.72370	12.0234	9.8188
23	2.93120	1.609	3.3272
24	9.27350	13.7866	10.345
25	5.19480	5.6113	6.1336
26	2.79300	1.7301	3.4556
27	1.95070	0.8136	2.6873
28	4.36190	3.6847	4.4902
29	3.14540	1.9975	3.3941
30	2.18620	0.9554	2.5071
Total Power Losses, kW	146.0739	146.0739	146.0739

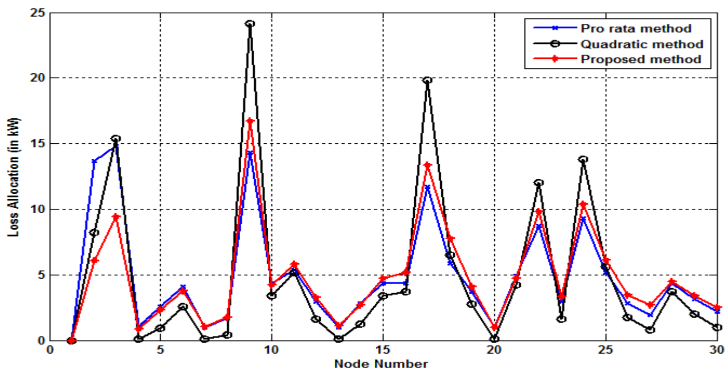

Fig. 3 Comparison of different loss allocation methods for 30-bus system

V. CONCLUSION

In this thesis, a simple loss allocation method for consumers connected to radial distribution networks has been proposed. A detailed comparison of real power loss obtained with the proposed 'exact' method with two different methods namely, pro rata, and quadratic loss allocation methods has been presented. From the case study, it can be seen that even though pro rata procedures simple and easy to implement, power loss allocated to consumers having same load demands are the same, which is injustice to the consumer electrically nearer to the substation. Quadratic loss allocation scheme is based on branch current flow and it allocates branch power loss to only those consumers beyond that branch. Quadratic loss allocation scheme makes the assumption that the loss allocation factor of a particular consumer is proportional to the square of real/reactive load current of that consumer. In the proposed 'exact method', losses are allocated to consumers without making any assumptions and can be implemented easily.

REFERENCES

[1] Kirschen D, Allan R, Strbac G. Commitments of individual generators to loads and Streams. IEEE Trans Power System 1997; 12(1):52–60.
[2] Bialek JW. Topological generation and load distribution components for supplement charge distribution in transmission open access. IEEE Trans Power System 1997; 12:1185
[3] Strbac G, Kirschen D, Ahmed S. Allocating transmission system usage on the basis of traceable contributions of generators and loads to flows. IEEE Transpose System 1998; 13:527–34.
[4] Kirschen D, Strbac G. Following active and receptive power in the middle of generators and loads utilizing real and imaginary streams. IEEE Trans Power System1999; 14:1312–9.
[5] Cornejo AJ, Galiana FD, Ivana Kockar I. Z-bus loss allocation. IEEE Trans Power System 2001; 16:105–10.
[6] Conejo AJ, Arroyo JM, Alguacil N, Guijarro AL. Transmission loss allocation: comparison of distinctive practical algorithms. IEEE Trans PowerSystem2002;17:
[7] Fang WL, Ngan HW. Succinct method for allocation of network losses. IEE Proc – GenerTransmDistrib 2002; 149(2):171– 4.
[8] Costa PM, Matos MA. Loss allocation in distribution systems with inserted Era. IEEE Trans Power System 2004; 19:384–9.