International Journal of Pure and Applied Mathematics
Volume 114 No. 10 2017, 449-456
ISSN: 1311-8080 (printed version); ISSN: 1314-3395 (on-line version)
url: http://www.ijpam.eu
Special Issue

ijpam.eu

Novel Approaches for Transmission System Expansion Planning-TLA

Mr.Luke John Baktha Singh Immaraju[1], Dr.B.Venkata Prasanth[2], Dr.V.Ganesh[3]

[1]iljbakhtsingh@gmail.com, +91 9490697986,Andhra Pradesh, INDIA.
[2] QISCET, Ongole, INDIA
[3]JNTUCEP, Pulivendula, INDIA

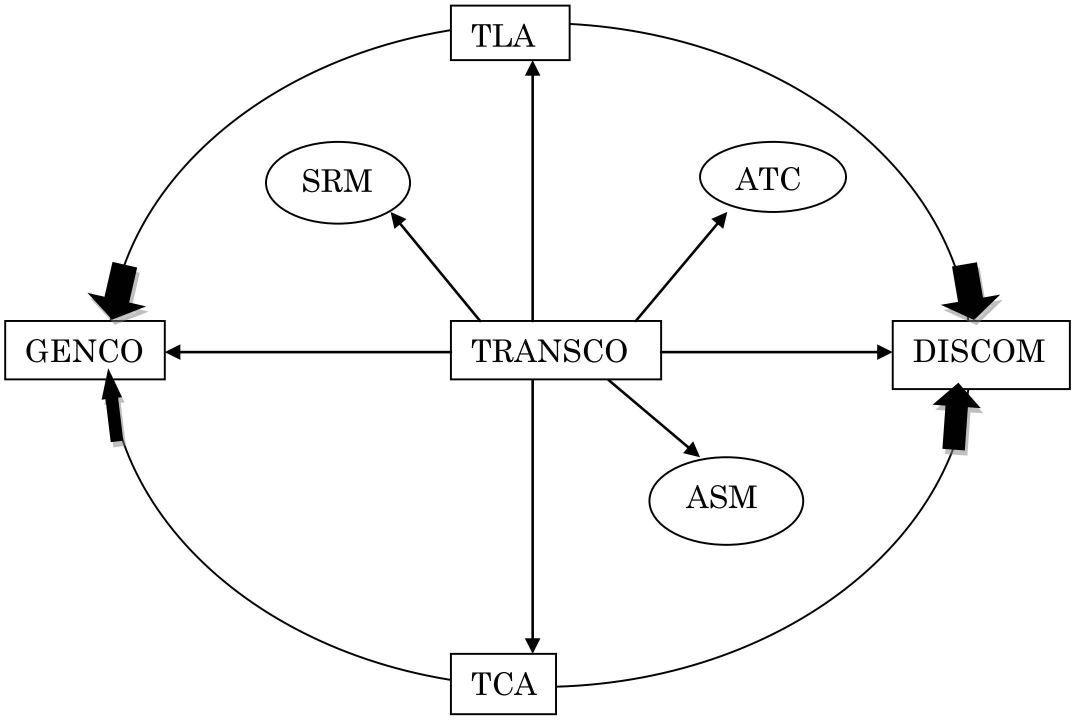
Abstract: The "change" is the word which commonly effect daily in the technology. Without change, the world will be stop. Especially the use of electricity day by day increases and consumers expected reliability. Here we can define the reliability under this as the best for least. Hence the quality of power system is expected. Transmission line design plays major role for effective utilization of an electrical power. The transmission loss and allocation of unbundled market participants is essential in the present deregulated electricity markets. In this paper, we concentrated to allocate the transmission line loss. The evolution of market various techniques to rate consumable generated electrical power should take into consideration leads unfair access to distribution networks. With this, Electrical power losses of consumer network must be impartially allocated among the all distributed gencos and discoms. The methods which gives allocation of the electrical power transmission cost and losses are mainly divided into two categories. Those are postage stamp, Megawatt-mile, Nodal and proportional sharing have been supported on an arbitrary allotment of electrical power losses between consumers and generators. First two belongs to one category and the next two other. The procedure is based on network laws and does not consider any assumptions. Considering the real power input and real power loss contribution factors, loss allocation can be done. Case study of the proposed loss allocation procedure is conducted on 5 bus and 2 bus system.

Keywords: Deregulation, TLA, Power transmission system

Introduction

In earlier years, all countries follows the power system which is known as Vertically Integrated System (VIS). In this system, the main components of the power system: Generation, Transmission and Distribution are combined together and act as a one network. This VIS was changed by the government and the decision taken by the government will be the final. In this VIS, there was no other to run the system and the government is one and only leader to change the system. This system is also known as bundled power system. In this VIS, any consumer has to get the power from Generation, Transmission and distribution Companies only. But, there is no possibility of getting the power directly from Generation Company and this is one of the drawbacks of this VIS. Another disadvantage of this system is there is no competition as there is no other person in the system. Without competition, the market industry cannot develop. For the betterment in power industry, many countries have introduced a new system known as deregulated power system (Unbundled Power system) and also called as restructured power system. Here three components of the power system are unbundled and act as individual networks. The

main objective of this system is to create the competition in the power system market and to provide the optimum cost services to the customers.
The fig shows the block diagram representing the connectivity between the modules in restructured power system. Where,
GENCO: Generation unit/Companies, TRANSCO: Transmission unit/Companies
DISCOM: Distribution Unit/Companies ATC: Available transfer Capability
TLA: Transmission Loss Allocation TCA: Transmission Cost Allocation



ASM: All Security Management SRM: System Reliability Management

Transmission loss allocation (TLA) is major module in deregulated electricity markets. Since the gencos are the inputs and discoms or customers are the outputs and all are connected as one network, regulation of participant can have significant effects on others making it difficult to estimate the cost, each participant is responsible for it. It is difficult to achieve an efficient transmission loss allocation scheme that could fit all market structures in different locations. As the research is going on transmission pricing indicates that there is no generalized agreement on pricing methodology. In practice, each restructuring model has chosen a method that is based on a particular characteristic of its network.

TLA Methods:

The following methods are discussed in this paper for the transmission loss allocation.
Those are:
1. PRO RATA Method
2. POSTAGE STAMP Method
3. PROPORTIONAL DISTRIBUTING Method
4. BUS wise Loss allocation Method

Before the discussion, the network losses can be calculated as follows
Let G= Power generated by the Generator
D= Power consumed by the consumer
L= Power loss at transmission line

Then,
G = D + L
G=$\sum_{i=1}^{n} Gi$ D=$\sum_{i=1}^{n} Di$
G_i is the power generated by i^{th} bus
D_i is the demand of the i^{th} bus

1.PRO RATA Method:

This is the method which is used in Spain only. In PR procedure firstly, the total transmission losses are estimated and allocated to the consumers only. Therefore this method cannot use alone. First, the losses are assigned globally to generators and consumers, 50% losses to each case. Then, a proportional procedure is used: that is the losses allocated to the generators are proportional to the utilization. The PR procedure is easy to understand and implement. But it ignore the network.

$$L_j = L \frac{Dj}{D}$$

Where L_j is the losses allocated to the j^{th} bus of load, D_j is the power consumed by j^{th} bus,
And D is the total power consumption.
The drawback of this method is, if the tow identical loads are connected to the one bus and those are located at the different distance this procedure will treat them equally. This is unfairness.

2. POSTAGE STAMP METHOD

The most common and simplest method for transmission loss allocation is postage – stamp method, which depends only on the amount of power transferred to the demand and the how much duration it is used, and it is not depend on the network nodes. A consumer, who uses the transmission system less, actually subsidizes others who use the system bulk amount. The procedure is as follows.
Transmission loss allocation to the generator= $\frac{L}{2}\frac{Pi}{P}$
Where P_i is the power generated by i^{th} bus
P is the total power generated.
Transmission loss allocation to the load i.e. consumer = $\frac{L}{2}\frac{Di}{D}$
Where D_i is the power consumed by the i^{th} bus consumer and D is the total power consumption.

An algorithm for this method is as follows.

Step1: Select the generation and load pattern for n bus systems
Step2: Generate the power to satisfy the consumer
Step3: Estimation of transmission losses for n bus system
Step4: Estimation of losses of generators and loads by using the above mathematical relations.
Step5: Transmission loss allocation

3. PROPORTIONAL DISTRIBUTING Method

Proportional distributing method on top of electrical network laws requires the assumption of the proportional distributing principle, which states the response of any system is directly proportional to its excitation. If we use this principle, the losses are allocated by means of linear. This allocation does not depend on slack bus. In order to allocate the losses we do consider the simple procedure that is the losses with certain node in an electrical network proportionally shared by the all paths going electricity market.

Based on this, this method is considered as simple method for the loss allocation. There is no ideal procedure to allocate the transmission losses, the following properties are considered.

i. The losses to be constant with respect to the power flow
ii. The losses must depend on the energy which may be either produced or consumed.
iii. The allocated losses must be transparent.
iv. The allocated losses must approved the government such that politically no issues.
v. These losses provide correct conditional paths to the network.

PROCEDURE FOR TLA

$$P_{pq}(\text{gross})=\frac{Ppq}{Pp}\sum[Au(p,q)]Pk \text{ for}$$

q belongs to α_p^d

Where α_p^d is the set of nodes supplied from node p. P_p is the nodal power, K is the k^{th} bus i.e. at the generation side, P_k is the k^{th} bus power generation, P_{pq} is the real power flow (where p is the upstream q is downstream)

A_u is the upstream distribution matrix.

$[A_u]_{pq}$= 1 for p=q, $-\frac{|Pqp|}{pq}$ for $q\epsilon\alpha_p^u$, and 0 otherwise.

$$P_{pq}(\text{gross})=\frac{Ppq}{Pp}\sum[Ad(p,q)]PDk \text{ for}$$

q belongs to α_p^u

P_{DK} is the demand at k^{th} bus, P_{pq} is the real power flow (where q is the upstream p is downstream), A_d is the downstream distribution matrix.

$[A_d]_{pq}$= 1 for p=q, $-\frac{|Pqp|}{pq}$ for $q\epsilon\alpha_p^d$, and 0 otherwise.

In order to allocate the 50% losses to the generating stations and 50% losses to the load, the final generation and demand per bus are calculated as follows,

$P'_p=(P_{pq}(net)+P_p)/2$

$P'_{Dq}=(P_{pq}(gross)+P_{Dp})/2$

At last final the transmission losses allocation to the every generator bus and consumer bus are calculated as follows,

$L'_p = P_p - P'_p$

$L'_{Dp} = P'_{Dq} - P_{Dq}$

4. BUSWISE ALLOCATION METHOD

In this method, it is not required to consider the assumptions and hence network laws will be considered. It will be based on true power injection and true power losses contribution factors of the buses. It does not require any assumptions in the network.

TRANSMISSION LOSS ALLOCATION:

In this method the load flow solution data will be considered as follows,

$S_{pq} = V_p I^*_{pq}$ ------→(1)

The voltage at node p is given by

$V_p = \sum_{k=1}^{n} Z_{pk} I_p$ -----→(2)

$I_{pq} = (V_p-V_q)/Z_{pq}+V_p/Z_{pq}^{sh}$ ----→(3)

Substituting equation (2) in equation (3)

$I_{pq} = (\sum_{k=1}^{n} Z_{pk}I_p-V_q)/Z_{pq}+(\sum_{k=1}^{n} Z_{pk} I_p)/Z_{pq}^{sh}$ ----→(4)

Substituting (4) in (1)

$S_{pq} = \sum_{k=1}^{n} factor1^k_{pq}$ ---→(5)

1^k_{pq} represents contribution of k^{th} bus to p-q line flow of power.

Similarly the complex power flow in line

$S_{qp} = \sum_{k=1}^{n} factor2^k_{pq}$ ----→(6)

Factor 2^k_{pq} represents contribution of the k^{th} bus to p-q line complex power

$S_{line\ loss} = S_{pq} + S_{qp} == \sum_{k=1}^{n} factor^k_{pq}$ →(7)

Where factor k_{pq} is the contribution of the k^{th} bus to the p-q line loss and also the power injected at p-q bus.
Let [R] matrix is the real part of $S_{line\ loss}$
Then by using [R] power losses allocated as follows
a. Determination of algebraic sum of the absolute contribution of all buses to the real power loss of
line p→q(say "p^{th}line") i.e. cumulative power loss "Cploss(p)" where
Cploss(p) = $\sum_{k=1}^{n} R(k,p)$ --→(8)
b. To find the real power sponsored by the line p-q (l^{th} line) a power loss factor is given by
C(k,l) = $\frac{R(k,l)}{cploss(l)}$*rloss(l) --→(9)
c. At last final the total loss allocation of k^{th} bus is given as follows
LA(k) = =$\sum_{l=1}^{n\ lines} C(k,l)$ --→(10)

CASE STUDY

A case study of above methods on IEEE-5 bus system is illustrated to test the performance. This system is having two generators and four loads and is represented by the bus power injections. The solution of the power flow obtained by NR method. Let us assume the real power loss for 5 bus system is 9.602MW. Table–A shows the results of loss allocation for the three methods of IEEE 5 bus system
Table–A shows the results of loss allocation for the three methods of IEEE 5 bus system
Table-A

Bus	Loss allocation in MW (total loss = 9.604MW)		
	2nd method	3rd method	4th method
1	3.671	4.1768	4.26
2	1.7132	0.863	0.66
3	1.3098	1.3416	1.46
4	1.164	1.1892	1.3
5	1.746	2.0334	1.924
Total	**9.604**	**9.604**	**9.604**

Table-B shows the results of transmission loss allocation for the three methods of IEEE 30–bus system
Table-B

Bus	Loss allocation in MW (total loss = 9.604MW)		
	2nd method	3rd method	4th method
1	17.6628	18.7134	19.666
2	3.933	2.0644	1.088
3	0.1594	0.098	0.15
4	0.5048	0.407	0.486
5	6.2576	-17.2568	6.112
6	0	0	0
7	1.5146	25.5244	1.472
8	1.9928	1.1738	1.974
9	0	0	0
10	0.3852	0.3738	0.612
11	0.6642	0.6446	0.844

12	0.744	0.6	0.654
13	0.6642	0.5358	0.82
14	0.4118	0.3936	0.412
15	0.5448	0.5446	0.54
16	0.2324	0.216	0.212
17	0.5978	0.5986	0.552
18	0.2126	0.2358	0.218
19	0.631	-7.7496	0.616
20	0.1462	8.638	0.15
21	1.1624	1.2846	1.094
22	0	0	0
23	0.2126	0.2332	0.206
24	0.578	-2.9862	0.608
25	0	0	0
26	0.2324	-2.9646	0.324
27	0	0	0
28	0	0	0
29	0.1564	1.6352	0.232
30	0.7042	7.3872	1.248
Total	**40.30**	**40.30**	**40.30**

Observations:

a. 2nd method does not consider the network. It allocate the losses to the generators and loads marginally and it is independent of transmission line distance.
b. In proportional sharing principle method, with the consideration of network the looses were allocated.
c. In bus wise allocation method, losses were allocated by using the circuit laws.
d. In postage stamp method, the participant with more contribution will more benefited compared with others.
e. In proportional sharing principle method, the customers were not benefitted reasonably.
f. Hence bus wise allocation is the good method to allocate the transmission losses accurately compared with the remaining.

CONCLUSION

From the above four methodologies the following conclusions can be drawn Pro rata method is similar to the postage stamp method. Postage stamp method is the simple and clear to implement. It does not take the system in to account and distributes the fixed real power loss to the members independent of line distance between the generating stations and consumer.

Proportional Distributing method takes the network in to consideration and distributes the electrical power losses proportionally to all the power proceedings. But here assumptions are made that the at any node of the network power inflow equal to the power outflow. It is independent of the choice of the slack bus.

Bus wise transmission line loss distribution method will produce the better results compared with the above. Hence this method is suggestible for TLA.

References:

[1] "Power System Restructuring and Deregulation – Trading, Performance and Information Technology" Edited by Loi Lei Lai, John Wiley & Sons Ltd, Chichester.

[2] A.J.Conejo J. M. Arroyo, and A. L. Guijarro, "Transmission Loss Allocation: A Comparison of Different Practical Algo-rithms", IEEE Transactions on Power Systems, vol. 17, No. 3, pp. 571-576, August 2002.

[3] J.W. Bialek, S. Ziemianek, and N. Abi-Samra, "Tracking-based loss allocation and

economic dispatch," Proceedings of 13th PowerSystems Computation Conference, Trondheim, Norway, July 1999, pp.375–381.
[4].Juan Carlos Mateus, and Pablo Cuervo Franco, "Transmission Loss Allocation Through Equivalent Bilateral Ex-changes and Economical Analysis," IEEE Trans. Power Syst., vol. 20,no. 4, pp. 1799–1807, Nov. 2005.
[5] F. D. Galiana, A. Conejo, and I. Kockar, "Incremental transmission loss allocation under pool dispatch," IEEE Trans. Power Syst., vol. 17, no.1,pp.184–188, Feb. 2002.
[6]. Qiefeng Ding, Ali Abur, "Transmission Loss Allocation Based on a New Quadratic Loss Expression" IEEE Transactions on Power Systems, vol.21, no. 3, August 2006, pp. 1227-1233.
[7] Q.Ding and A. Abur, "A Unified transmission loss allocation method", International Journal of Electric Power & Energy Systems, Volume 29,Issue 5, June 2007, Pages 380-386.
[8] J.N.Y. Cheung, T. Czaszejko, and A. B. Morton, "Transmission loss evaluation in an open electricity market using an incremental method," IET Generation Distribution, vol. 1, no. 1,pp. 189–196, Jan. 2007.
[9] Kyung-Il Min, Sang-Hyeon Ha, Su-Won Lee and Young-Hyun Moon, " Transmission Loss Allocation Algorithm using Path-Integral Based on Transaction Strategy", IEEE Transactions on Power Systems, Vol. 25, No. 1, Feb. 2010, p.p. 195-205.
[10]. SobhyM.Abdelkader, "Characterization of Transmission Losses," IEEE Transactions on Power Systems, Vol. 26, No. 1, Feb. 2011.
[11]. Keshmiri, S.N.; Ehsan, M, "Transmission loss allocation using normalized loss weight factors", Proceedings of Third International Conference on Electric Utility Deregulation and Restructuring and Power Technologies, 2008, pp.431-465.
[12]. Keshmiri, S. Nasser; Gao, Wenzhong, "Transmission Loss Allocation Using Normalized Loss Weight Factors in Bilateral Contracts Environment", Proceedings of North American Power Symposium (NAPS), 2009.