# Review Paper on Transmission Loss Allocation using Artificial Neural Network

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*Abstract*---Due to introduction to deregulation in the power system transmission loss allocation has become an important issue to be solved. Today's power system networks are pool operated, bilateral contract and hybrid model therefore the allocation of losses to the market participant varies. Also due to the nonlinear nature of the power flow and power loss it's very difficult to allocate loss amongst the participant properly. Various methods of allocating transmission loss have been presented in this review paper and also the use of artificial neural network for transmission loss allocation has been cited.

**Keywords:** Neural network; transmission loss; loss allocation; bilateral contracts.

## I. INTRODUCTION

Transmission loss in electric power system is a natural phenomenon. For consumption of electric power it has to be moved from generation to distribution through electric wires. Power is also consumed by wire due to their resistance. The power consumed in this way is referred to as "loss". Most of this loss is attributable to the heating of the power lines by the electrical current flowing through them. The loss (i2R) is then lost to the surrounding of the power lines. Transmission loss represents about 6% to 9% of total generation, a quantity worth millions of rupees per year. In a traditional power system total transmission loss is optimized while keeping the running cost at the minimum. In a deregulated power system, due to competition in the generation sector, allocation of transmission losses has to be done to individual generator. In a deregulated power system transmission loss has to allocate to individual supplier, generators and contracts. Generation level or power flow are not modified by loss allocation; however it does modify the distribution of payments and revenues at the network buses among suppliers and consumers. In a deregulated power system, every supplier has to supply the power they want to sell plus the transmission loss corresponding to that transaction. That's why; system operator has to allocate losses to every individual load and generation. Depending on the contract, a supplier may supply the contracted load and the corresponding loss or supply the load and pay for the loss. In later case, the loss may be supplied by a contracted generator or ISO may buy the power to meet the loss from a spot market. The allocation will vary to some extent, depending upon who will supply the loss. Transmission loss allocation became a contentious issue as it corresponds to a huge amount of money. Transmission loss is a highly non-linear function of these factors. Transmission loss is non-separable entity and this is the main problem associated with loss allocation. Any attempt to separate it is further complicated by its non-linear in nature. The challenge that is faced by a typical power pool and an ISO is how to allocate the transmission loss and what should be the criterion for charging other utilities. Utilities in general, look for locational signal, consistency, simplicity, accuracy and predictability in a loss allocation method. It is an extremely hard task to accommodate all these considerations in a complex phenomenon like transmission loss allocation. In a deregulated environment, the economic and market related factors are as important as technical factors. Although no ideal or standard loss allocation method exists, some methods have been reported in literature. But all these methods require time consuming and complex mathematical computation and therefore limited acceptance by the industry.

## II. LITERATURE REVIEW

*A. A.j.Conejo, J.M Arroyo, and A.L. Guijarro* described the Pro Rata (PR) procedure .The transmission loss allocated to a generator or consumer is proportional to its level of energy generation. In PR procedure network is ignored and therefore it is not consistent with existing power flow. Two methods are presented in this paper called "Marginal Procedure" and "Proportional Sharing" and are also discussed. In "Marginal Procedure", losses are assigned to generators and consumers through incremental transmission loss co-efficient (ITL). Normalization has to be performed after allocation, since this method results in over recovery. The standard marginal procedure based on ITL coefficients depends on the selection of the slack bus because ITL coefficients do depend on the slack bus. The ITL coefficient of the slack bus is zero by definition, thus the slack bus is allocated no losses. This is a drastic limitation for this method that requires that pool agents agree beforehand on the selection of the slack bus.

Proportional sharing procedure requires the assumption of proportional sharing principle.

*B. Antonio J. Conejo, Francisco D. Galiana, and Ivana Kockar* described a loss allocation method called "Z-bus allocation". It is based on the exact network equations as defined by the complex impedance matrix and the complex nodal injections. The calculations are based on the sparse admittance matrix. It uses complex current flows instead of power flow. Power flow solution required to get injected bus current and power has to be converted to current. Advantage of this method and innovative feauture is that,unlike other proposed approaches, it  does not require any simplifying assumptions and exploits the full set of network equations.The method is based upon solved load flow and is easily understood and implemented. This process of loss allocation emphasizes current rather than power injections, a perspective that is intuitively reasonable and leads to a

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natural separation of system losses among the network buses.

*C. R. Allan, D. Kirschen, G.Strbac* have proposed a transmission loss allocation method by tracing the generator and load contributions to line flows. This method detects the contributions of each load and of each generator to the line flows instead of marginal contributions. Since the allocation method had been proposed on the basis of maximum flows in the lines, it does not reflect the actual load condition.

*D. J. Bialek* had proposed another method of loss allocation in which power flows in the lines are traced and a proportional sharing principle is used.

*E. J.W.M. Cheng* addressed different challenges associated with bilateral contracts in a deregulated power system network. In this paper authors described modeling of bilateral contracts using a transaction matrix. The two-dimensional matrix that includes power generators and load demands is termed as a transaction matrix.

*F. Anderson and Yang* proposed a structure to determine the use of transmission system. A power flow comparison is used to determine the use of transmission line, instead of proportional sharing,. Power flow comparison method uses load flow study to find a generator's contribution by superimposing the generator on the base load. The difference obtained from the two load flows are attributed to generator's account. This method goes in sequence for each generator to calculate its effect on load flow studies. Loss allocation depends on the sequence of generator used. Results vary widely for different sequences.

*G. **Fand and David*** discussed power dispatch issue in a power network structure dominated by bilateral and multilateral transmission contracts. A framework of price-based operation under deregulated structure was developed and a solution to optimal transmission dispatch is proposed. This paper concentrates on dispatch curtail challenges with bilateral and multilateral contracts in a power system.

*H. A.G. Expósito, JMR Santos, TG Garcia and E.A.R Velsaco* have proposed a method based on unbundling of branch flows. The method presented in this paper is modified incremental loss factor method and is applicable on a nodal basis. In this paper four methods are proposed for splitting branch flows; quadratic allocation, proportional allocation,geometric allocation and fast geometric allocation.

*I. A.Bhuiya, N.Chowdhury* proposed two methods of loss allocation namely, Incremental Load Flow Approach (ILFA) and Marginal Transmission Loss Approach (MTLA). In this method, load is increased in a discrete step, at each load bus, while the loads at the other buses are kept constant. The differential transmission loss resulted is attributed to the corresponding generator. The increment of load is done in alternate sequence, in discrete steps, from zero to their respective levels. This method is consistent with solved load flow and rewards counter flow in the system but it requires a high computation time. The later method is based on Kron's transmission loss expression and results in an iterative process. In order to reflect the effect of bilateral contracts, Kron's loss expression is modified and expressed in terms of loads instead of generations. In MTLA, a generators share of transmission loss can be found by making an incremental change in the generator's active power demand and all the other loads are kept fixed. This method requires many complex mathematical analyses and operations.

*J. J.S. Daniel, R.S. Salgado and M.R. Irving present* in his paper proposed a methodology to allocate the active power transmission loss among agents of a power pool. The approach is based on the inclusion of the admittances equivalent to bus power injections in the bus admittance matrix. For a given power-flow solution, the relation between the load/generator current injections and the branch currents is determined using a modified bus admittance matrix, that allows the power loss of each transmission line to be expressed in terms of bus current injections. The method proposed is simple to implement and flexible enough to allow the assignment of loss parcels to a preselected set of buses. The proposed loss allocation strategy, based on a modification of the bus admittance matrix, can be applied for any conventional or optimal power flow solution, which requires a moderate computational effort. It requires only a single steady-state power-flow solution, the approaches based on the integration of Lagrange multipliers of OPF. From analysis of the numerical results it is observed that the basic requirements of any allocation process are satisfied. The attribution to loss of each power network user is accurately evaluated such that the revenue reconciliation is achieved naturally without need for scaling factors. The load if increases with respect to a base case, indicating that the level of cross-subsidy is low, the loss variation are assigned predominantly to the buses with modified demand. These features emphasize the potential of the proposed. Approach to solve problems of active power transmission loss allocation.

*K. S. V. N. L. Lalitha1* proposed a direct method to find the loss allocation. This method is based on simple circuit laws and does not involve any assumptions. Real power injection and real power loss contribution factors are considered and loss allocation can be done. In this paper, contribution factors of each complex power injection at a bus to the complex line loss in each of the transmission line are found out, starting from a converged load flow solution. And also at the same time, contributions of each of the transmission lines to the complex power injection at a bus are to be determined. These contributions are used to allow allocation of loss among the buses based on the usage. Starting from a converged load flow solution without any assumptions, the loss allocation factors are derived. In this paper, a real power loss allocation methodology based on the contribution factors is established. Another main feature of the pro-posed method is that, effect of reactive power generation and load can be easily established using the proposed methodology. The contribution factors derived does not involve any assumptions, therefore there is every chance that these factors can play a vital role in the determination of Location Marginal Prices in the present day electricity markets.

*L. M.K.Rai, Pawan Kumar* Proposed the artificial neural network which computes loss allocation much faster than other methods. The proposed method is a suitable candidate for being a part of a real time decision making process as it

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has a relatively short execution time. Most independent system variables can be used as inputs to this neural network which in turn makes the loss allocation procedure responsive to practical situations. Moreover, transmission line status (available or failed) was included in neural network inputs to make the proposed network capable of allocating loss even during the failure of a transmission line. The neural networks proposed were utilized to allocate losses in two types of energy transactions: bilateral contracts and power pool operation. Circuit Theory and Orthogonal Projection loss allocation methods were utilized to develop training and testing patterns.

*M. R. Haque, N. Chowdhury* presented in his paper an artificial neural network based transmission loss allocation method. The method can provides solutions on a realtime basis and is computationally efficient. Most independent system variables can be used as inputs to this neural network which in turn makes the loss allocation process responsive to practical situations. Little difficulty is there to train the proposed ANN. Solution is provided in quick manner by the trained ANN. Negative loss allocation can be yielded by proposed ANN to reward generators or loads that causes counter flow in the network. ILFA was utilized to generate training data and instead of ILFA any other method of loss allocation can be utilized for that purpose. Two activation functions used with threshold adaptation improved convergence characteristics of the ANN.

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