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PRICING OF ENERGY AND TRANSMISSION SERVICES IN POWER SYSTEM

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ABSTRACT

Reformation in the power supply industries has given rise a competition in Electricity market. The distribution of the transmission cost is a very important concern in this power supply market. The transmission pricing of energy must be economical, transparent, efficient and ensure the consistent operation of the Electricity market. This paper shows the review of diverse transmission pricing of energy techniques and methods. The Transmission cost allocation by nodal pricing and power flow tracing techniques along with the congestion management, optimization techniques and the transmission line loss allocation are included in this paper.

Keywords: Loss distribution, Nodal Pricing of energy, Optimization Techniques, Power Flow Tracing, Congestion and Transmission services Pricing.

1. INTRODUCTION

In the Restructured Power system the transmission pricing is considered as one of the most difficult problem because the nature of the power supply in the power system and the require to satisfy the demand of the consumers requirement. The monopolistic market in the transmission sector banned the introduction of the competition in the transmission area. So there is always a requirement of well-organized transmission pricing which will improve the transmission price by properly allocating the charge among the several Transmission service users.

The distribution of transmission charges for different transmission services to all the customers should be on non discriminatory basis and should be easy and visible. The transmission tariff construction should be such that it should reflect the implanted expenditure, future development cost and the working cost. The embedded costs in the Transmissions are enormous as compared to the other operating price so the pricing formation should be very efficient to recover the cost from all its users connected. Shirmohammaddi has discussed basic concepts and issues about the transmission pricing in the vertically included unit and have shown that the transmission pricing has been one of the most serious and very important issue in transmission of power. The charge associated with the transmission services are shown in the Fig.1.

2. TRANSMISSION COST COMPONENTS

Operating cost:- The operating cost of a transmission of power is defined as the fuel cost which is the utility in order to accommodate the transaction due to the power generation rearrangement and re-dispatch. The generator rearrangement is influenced by the start up of the generating unit and rotating reserves.

Opportunity cost: Opportunity expenditure of a transmission transaction is defined as the benefits the grid company takes as a result of the operating limitation subjected to specific transaction.

Reinforcement cost: System development cost deals with the investment to advance new users and also support promoting expansion in the new developing countries.

If an electricity transmission network will be overloaded by load demand or a specific new connection or development of industries, the capacity of the network will have to be improved. The increasing of capability of the network is usually called reinforcement.

Embedded cost: Existing system cost comprises of the cost which was invested in establishment of the Transmission system and maintaining the same cost for better performance of existing power system. This termed mainly used as the embedded cost of existing system and the Operation & Maintenance cost.

Shirmohammaddi et al. in 1996 have put ahead the main pricing schemes which describes the basic concept of the pricing pattern which are rolled in methods, the incremental methods and both the embedded cost which are shown with the block diagram in the Fig.2

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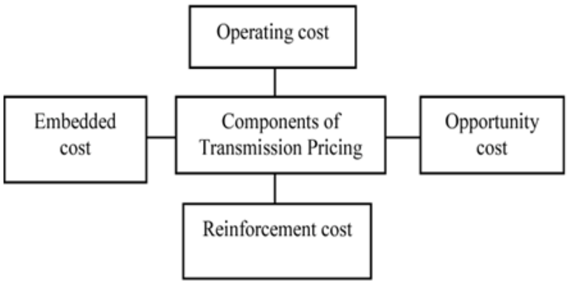

Fig1. Components of Transmission Pricing

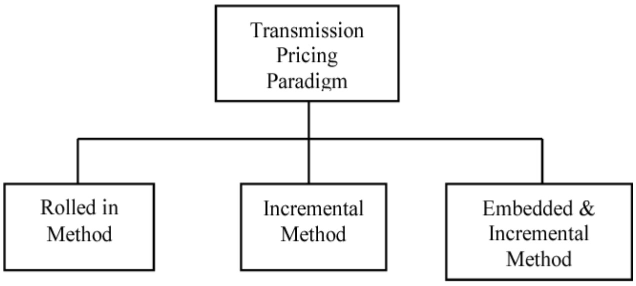

Fig.2 Transmission Pricing Methods

3. TRANSMISSION PRICING PATTERN

Rolled in methods: In this scheme the transmission system existing price and the price involved in the transmission system operation and maintenances are allocated between the different transmission system users.

Incremental Methods: This is the complex method but give accurate pricing of power transmission. This method allocates the variable or the incremental transmission cost to the user for power transmission operation risk assessment and future enhancement.

Embedded and Incremental Methods: In this method charges are evaluated by considering both the embedded and incremental cost for providing the services to the consumers according to the load requirement.

Khan and Agnihotri has prepared the comprehensive review of the embedded transmission pricing method based on the power flowing techniques method to the consumers, but the topics covered are only limited to the general methods which are based on the power flow tracing techniques [7]. Garg et al. has given a very brief review of the Transmission pricing practices discussing the regulations for the power transmission system, the methodology and the recent trends are described. An overview of the embedded cost and the incremental cost are discussed by Murali, and a review of the various cost allocation method in the transmission system is also presented [4], [6]. This paper gives an overview of the approaches included in transmission cost allocation in Section-1. Section-3 discusses the transmission network congestion pricing. The studies based on the optimization methods in transmission pricing are presented in Section-4. Section-5 present the views based on transmission losses allocation and followed by Conclusion in Section-6.

4. METHODS OF TRANSMISSION COST ALLOCATION

A. Nodal Pricing Approach:-

In nodal pricing approach there is variation of the price according to the change in the geographical location of power generation, therefore it is also called as the Location subsidiary Pricing method. There is much power generation in case of Nodal pricing method. The deal rights are paid by these massive surplus. The right holder in the contract has right to inject power in one node and remove it from the other in the transmission network system [8]. The nodal pricing approach can be calculated by operating the system after 2 MW use and before 2 MW use and calculating the difference between the two cost of operations [7].

In a study by Srivastava and Verma have come forward with an come close to for maintaining the wanted locational signal, the generator and the electrical loads with the higher tariff plans are sorted in order to minimize them completely. Locational based pricing concepts were used to develop a nonlinear programming difficulty formulation for evaluation of the reactive power (MVAr) pricing and implementing the FACTS devices to reduce the overall operating cost and their effect on the transmission pricing method [11]. Gang et al. in 2007 have proposed a power transmission and wheeling pricing method in which the real (MW) and the reactive power (MVAr) are converted into economic flows by using nodal pricing techniques [10]. An approach has been accepted by Gil et al. in 2008 to create nodal price dissimilarity by introducing the generation and the nodal addition penalties in economic dispatch for the allocation of the transmission network cost amount [9]. In another study, it has been evaluated that transmission pricing for the existing market participants also deals with the mutual transaction in electricity market taking into account the best possible dispatch and the transmission pricing using best power flow [11]. Reta et al. developed a logarithm function to estimate the transmission power system cost recovery in ideal and real power systems [13]. The nodal pricing method is not sufficient to recover total transmission expenditure so Ghayeni et al. has projected a pricing methodology in which the marginal pricing is combined pricing for recovery of the total transmission cost [10]. With the proceed advancement in the research in transmission system pricing Cebeci et al. came up with a method which assures zonal tariff by physically combining the nodal transmission use of tariff in terms of weighted average approach [6].In another study Éricaetal have come forward with an methodology which is the mixture of the Long Run Marginal Cost (LRMC) method and minimization maximization method to deal with the detached transmission tariff [12].

B. Power Flow Tracing Methods

To recover fixed transmission costs and transmission pricing of the power system, the tracing methods are used. The tracing scheme proportionally shares nodal in flows among the nodal out power flows and which can be used with both DC power flow and as power flow analysis. This method includes two power flows in each transmission line, one entering in the line and the other in exiting the line and generation and loads at each infinite bus. Upstream- or down stream-looking algorithm can be used in this technique. The upstream-looking algorithm allocates the transmission usage charge to individual Generators and losses are reduced to load where as in downstream- looking algorithm, the transmission usage charge is assigned to individual loads only [10].

Ching-Tzong and Ji-Horng have taken the method of the power flow tracing techniques along with the bus sorting with ordering rule is done to fasten the computation [16]. The real and reactive power combinations are taken into account for calculation of contribution of the each generator in each transmission line and contribution of each generator in the transmission losses. The author also proposed a method of MVA(km) method by applying AC power flow and came out with the result that the apparent power for wheeling prices is more reasonable than MW mile method. This method can be used for the transmission service pricing and security analysis [10]. Again, in 2008, Abhyankar et al. proposed the power flow tracing method as the linear constrained optimization problem which persuaded the bilateral transaction [11]. In 2010, Abhyankar and Khaparde developed an approach to determine the Point of Connection (POC) rates for participants in decentralized market [12].The POC charges are calculated by optimal tracing and conventional tracing. In a similar study Kilyeni et al. have used the active (P) and reactive (Q) power flow tracing method based on the z-bus system matrix for transmission price allocation [20].

TRANSMISSION PRICING CONGESTION MANAGEMENT

In 1999, Yang et al. had implemented a power flow or load flow comparison method and result came out to be much better than the Proportional sharing principal providing a detail guideline for controlling the line load flows [19]. Bautista and Quintana had used GGDF and GLDF to quantify usage of the power transmission system by considering the day ahead market result. A software tool has been offered for the management of the congestion and calculation of the transmission pricing [12]. The congestion problems are overcome by reducing the changes in the initial dispatch and the transmission prices of power are calculated taking in account the existing power system cost, losses cost, operational cost and initial congestion cost. Cradell have proposed a method for the calculation of marginal loss component of nodal prices during congestion period which shows the contribution of each market participant of marginal losses [20].In2008, Silva and Cuervo have adapted the pay and use concept which is based on the bilateral exchange for the allocation of the congestion related cost in the transmission network. The economical transmission rights have been used to collect the revenues in the congested network and the congestion and lost cost are determined in the proposed pricing scheme.

TRANSMISSION PRICING BY OPTIMIZATION

Genetic algorithm has been used for the development of the transmission planning methodology for the purpose of forming an economically adapted transmission system in open access environment. Abhyankar et al. have modified the tracing algorithm into a linear constrained optimization,problem that minimizes the overall deviation from the postage stamp allocation. They again proposed a mini max fairness algorithm using optimization based real power tracing for solving the complex cost sharing problem by allocating the cost in the equitable manner on per unit basis while meeting the constraints. Naresh et al. in 2011 had used real coded genetic algorithm for the allocation of the transmission cost to the generators and the loads by comparing the MVA- Km method using AC power flow and genetic algorithm. A review about the optimization techniques have been put forward by Kishore and Singla for the development of the model and cost of the transmission lines for better efficiency.

TRANSMISSION LOSS ALLOCATION

A new method has been proposed by Abdelkar in 2007for complex power flow tracing in both directions, that is, from generators to loads and vice versa. The upstream tracing & downstream tracing algorithms described here are seen to be adaptable and superior compared to similar methods as it takes losses into consideration during the tracing process, hence lessening the requirement for adding more nodes to represent losses and reduces computation burden as well. This method is unique as it is seen to be able to deal with unusual flow patterns, such as lines with reactive-power in feed from both ends and lines with different flow directions of active and reactive powers. Loop flow is the only area which requires further improvement to be well accommodated in this method. Meng & Jeyasurya in 2007 presented a simple power transmission pricing method which manages transmission prices and solve the congestion and loss problems in power transmission. This method helps calculate and allocate transmission costs, using a known power flow tracing method. Estimation of the Locational marginal price has been shown by authors by using tracing method. Abdelkader has propounded a new modified process for complex power flow tracing and loss distribution. The proposed model is similar to the ABCD model but instead relates the fractional flows caused by a load and generator at the receiving and sending end of the transmission line to the fractional flows caused by that load/generator through all lines following that transmission line in the upstream or downstream direction. The signal flow graph and block diagram algebra can be used for direct determination of the extraction factors between a specific node and a specific generator. Unlike the previous methods for power flow tracing, this proposed method can well accommodate loop flows and pass over it to continue the process of power flow tracing and loss allocation. A recent study has suggested a technique based on power tracing which identifies the actual transactions based on proportional sharing and power flow and determines the percentage of power injected by a generator reaching a load and in which path. Deetal. suggested that loads under the transaction should pay for the loss to the generators who are actually supplying power to satisfy this loss. Another study illustrates a reach ability set based power flow tracing method which determines the line losses assigned to each generator. It is shown that progressive line loss calculation is performed with faster speed and accuracy and less complexity of calculation by applying the reach ability set theory. The algorithm is tested on IEEE-14 power system and the comparative results illustrate that the numerical deviation is around14%, which is within the acceptable range but further improvement is required. A very recent work by Dusonchet et al. demonstrates the importance of the results provided by the power flow tracing methods and proves proportional sharing efficacy by obtaining exactly the same result while implementing two different tracing methods through Matlab scripts, on two electrical transmission test systems developed and simulated on purpose. The authors also proved that only few loads are responsible for power flowing on a transmission line, hence making it possible to describe exactly the load consumptions on which a system led Demand Response program should act in order to meet system issues. The paper also shows upcoming potential cooperation of power flow tracing in the field of renewable energy by studying their effects while finding the involvement of the power injected by these power systems to the networks elements [11].

5. CONCLUSION

This article presents an overview of the power system transmission cost distribution. The analysis focuses on the techniques of transmission cost distribution. Essential discussion has been made under each division. Each approach has its own benefits and flows. Nodal pricing method is quite efficient for allocation of incremental price but cannot recover the total transmission cost. Whereas the power flow tracing is easy to implement but it lacks in providing efficient economic signal. The management of the congestion prices is important as it enhances the system consistency and safety. The application of optimization methods in power transmission price allocation leads to some better outcome and fast responses. The losses in power transmission system should be allocated so that their pricing will be improved the efficiency of the electricity market. Furthermore the power system researcher must focus on the problems faced in the development of the efficient transmission pricing. The work can be extended with the detailed analysis of the transmission pricing arrangement of the different countries and making an intelligent pricing methodology for allocating the transmission price.

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