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Pricing of Transmission Network Usage using MATPOWER

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ABSTRACT

The liberalization of electricity market has led to a higher demand for transparency in congestion management. This paper studies the suppliers' participation in the nodal price congestion component. In the present work, the nodal prices have been divided into a component for the generation and the losses and a system congestions' component. The nodal prices have been computed and analysed using a modified version of MATPOWER. In addition this paper investigates the consequences of system participants bids behaviour and its influence on the power system situation. Results from a 9-nodes test system as well as from a realistic high voltage network are also presented.
Keywords: OPF, Power Market, Transmission Pricing, IEEE bus, Pool Market, bid

I. INTRODUCTION

Almost all existing and proposed transmission pricing models are cost based. That means, they allocate all or part of the existing and new transmission systems to wheeling customers. Based on this, transmission pricing paradigms can be defined which convert the transmission costs into transmission charges . Three basic paradigms are:

- ✓ Rolled-in (embedded) transmission pricing
- ✓ Marginal transmission Pricing
- ✓ Composite transmission pricing

The power markets throughout the world are classified based on two dispatch philosophies: centralized dispatch and decentralized dispatch . The decentralized dispatch markets are the ones in which rolled-in paradigm of transmission pricing is commonly employed. On the other hand, the centralized dispatch markets employ the marginal or the composite pricing paradigm.

An alternative way of classifying transmission pricing schemes is based on when they are calculated, i.e., ex-ante or ex-post . In the ex-ante schemes, the entities taking part into the power market activities know the transmission prices a priori. While, in ex-post schemes, the transmission charges are calculated only after the real time has elapsed and power flow snap-shot is available. These schemes can further be categorized into transaction based and non-transaction based. The transaction based schemes essentially should have a defined source point and a sink point (bilateral transaction). On the other hand, non-transaction based schemes refer to the power exchange (PX) trades, where it is not possible to identify source-sink pair. Figure 7.1 shows the broad categorization of various transmission pricing schemes.

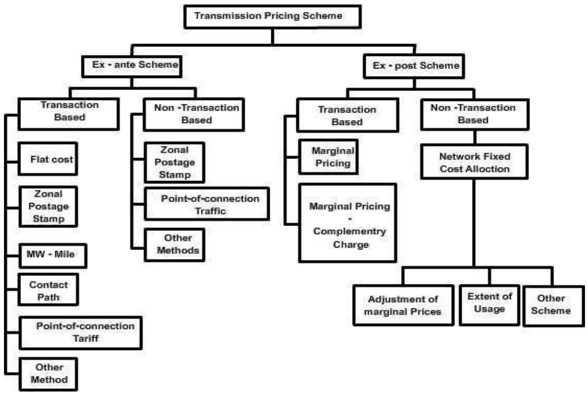

Figure 1. Classification of transmission pricing schemes

In the above figure, the transmission pricing schemes are classified on the basis of whether they are calculated ex-ante or ex-post. Generally, the ex-ante schemes are made up of pricing methods under rolled-in paradigm. As mentioned earlier, the total costs to be recovered are known a-priori and then they are transformed into transmission prices. The ex-post schemes, on the other hand, rely upon the incremental or marginal pricing mechanism. Moreover, the incremental schemes lack the property of recovering transmission sunk costs and hence rely upon schemes under the domain of rolled-in paradigm to overcome this lacuna. This gives rise to the composite paradigm.

II. PRINCIPLES OF TRANSMISSION PRICING

To operate the power system under the regime of transmission open access, a trade-off has to be solved: Economic marketing of energy has to be given importance while at the same time; it should be ensured that the whole system operates in a reliable and secure manner. The main purpose of any transmission pricing scheme is not limited to recovery of the sunk costs involved in bringing up the transmission infrastructure. The transmission pricing scheme should do much more than that. In line with the above, following principles should be followed while designing the transmission pricing schemes.

- ✓ The transmission prices should be devised so as to promote the efficiency of day-to-day operation of bulk power market.
- ✓ The transmission prices should signal locational advantages for investment in generation and demand.
- ✓ They should signal the need for investment in the transmission system.
- ✓ The transmission prices should recover the costs of existing transmission assets.
- ✓ Transmission pricing mechanism should be simple and transparent.
- ✓ The mechanism should be politically implementable.

Out of these, the first three objectives are concerned with derivation of appropriate economic signals to either utility or the consumer. However, the fifth objective states that the signals should not be so complicated that one can not decipher the same and react to it. Fourth and sixth objectives are associated with the allocation strategy of the pricing mechanism. Briefly speaking, the first objective speaks about the short term efficiency, numbers 2-4 with long term efficiency and 5, 6 with implementation.

There are different transmission pricing mechanisms prevailing in different parts of the world. They differ on a lot of parameters like: whether they use incremental methods to price the transactions or they go for rolled-in cost methods; whether generator pays the wheeling charge or the consumer pays for it, or both pay a part of it in some proportion, etc. It is expected that while designing a transmission pricing mechanism, following cost components for providing transmission service should be taken into account :;

- Operating Cost: This includes the cost mainly due to generator rescheduling, maintaining system voltage, reactive power support and line flow limits.
- Opportunity Cost: It is the cost which a transmission company (Transco) has to forgo due to operating constraints that are caused by the transmission transaction.
- Reinforcement Cost: This cost is charged to only firm transactions and includes capital cost of new facilities required to meet the transaction.
- Existing System Cost: The investment cost of existing transmission facilities used by the transmission transaction.

III. METHODS OF TRANSMISSION PRICING

This section provides principles for transmission pricing. Although transmission costs represent only about 2 percent of investor-owned utilities operating expenses, they are nonetheless important. Workable competitive power markets require ready access to a network of transmission and distribution lines that connect regionally dispersed end-users with generators. Because power flows at one location impact electric transmission costs across the network, transmission pricing may not only determine who gets access and at what price but also encourage efficiencies in the power generation market [8].

Transmission constraints can prevent the most efficient plants from operating. These constraints also can determine the location of generation that affect the amount of power losses for transmission. Transmission prices that ignore these concepts will produce an inefficient system. Transmission pricing that considers transmission constraints (congestion pricing) should encourage the building of new transmission and/or generating capacity that will improve system efficiency.

2.1 Pricing Options

Costs categorized as Congestion Cost and Transmission Line Pricing can either be assigned directly to users causing the congestion or shared among all users. If the transmission system becomes congested so that no more power can be transferred from a point of delivery to a point of receipt of power, thus more expensive generation may have to operate on one side of the transmission than the other. For a competitive market, regardless of the form of transmission pricing utilized, this would result in a difference in generation prices between the two locations. (If any low cost power generated on one side of a constraint could be sold at the higher price on the other side of the constraint, assuming the difference is more than the transmission cost, in the absence of the congestion.) The differences in electricity prices is the "economic price of transmission", which is related to the congestion cost and cost of losses. For such absence of congestion pricing for transmission service, the "economic rents" would represent a windfall to the generation suppliers that are able to sell through the congested interconnection. Hence, transmission prices will recover congestion rents from suppliers who are able to complete transactions through the constrained interface .

There are various ways to allocate revenues from congestion pricing. For example in California, such types of revenues are used to reduce the access fees that all transmission customers pay. Another proposal thought is to create a system of transmission congestion contracts. These would establish set of rights to either make power transfers or receive compensation for the inability to do so through redistribution of congestion rentals to the holders of transmission congestion contracts.

This paper evaluates the following eight transmission pricing algorithms:

a) Postage Stamp;
b) MW-Mile (original);
c) Unused absolute MW-Mile;
d) Unused reverse MW-Mile;
e) Unused zero counter-flow MW-Mile;
f) Used absolute MW-Mile;
g) Used reverse MW-Mile and
h) Used zero counter-flow MW-Mile.

a. THE POSTAGE STAMP METHOD

One of the traditional methods is the postage stamp method (PS), also known as the rolled-in method [12]. According to this method, the network usage from the side of a transaction is measured by the magnitude of the transaction Pi, without taking into account how the transaction affects the power flows over the various lines in the network[7]. The amount to be paid by transaction is:

$$PS_i = K \frac{P_i}{\sum_{j=1}^{n} P_j} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots [1]$$

Where

K : the total cost to be covered by the market participants

PSi : the amount charged to participant according to the postage stamp method

Obviously, since the postage stamp method does not take distances into account, it leads to cross-subsidization of long-distance transactions by short-distance transactions. Despite this fact, this method is widely implemented because of its simplicity.

b. FEATURES OF SIMULATOR BASED ON CONGESTION MANAGEMENT

The congestion management system was formulated according to a flowchart as shown. Readily available information on the current state of affairs can be found on the FRONT PANEL of associated online website. Here one can find a detailed time related information, an overview of key decisions, introduction of new working methods and modifications related to the dispatch, rates, competitive bidders, technical know-how, transaction details, history etc.

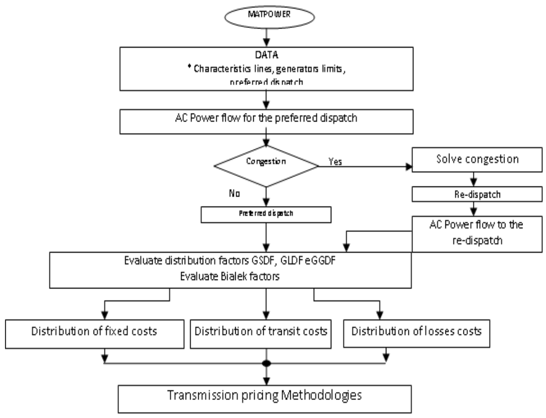

Figure 2. Flowchart for re-dispatch based congestion management.

This flowchart clearly states optimal power flow with and without congestion and calculation of performance and cost parameters thereafter.

IV. OF TRANSMISSION PRICING PARAMETERS FOR IEEE 9 BUS CASE STUDY

The single line diagram of IEEE-9 bus test system is shown in Fig. 2 The data is given in Annexure-A. It illustrate the different results and characteristics between the pricing schemes for each pricing method. The obtained results are shown in Fig 3. This Fig. gives the solution when the system condition before changing. Fig. 4 and Fig5 gives idea when load changes by 5 percent, 10 percent and the . Tabular representation is given in table 8.2 and 8.3. Numerical examples are provided to compare the results using different pricing methodology. At the end of the thesis, a case study is carried out to access the effectiveness of the methodology developed.

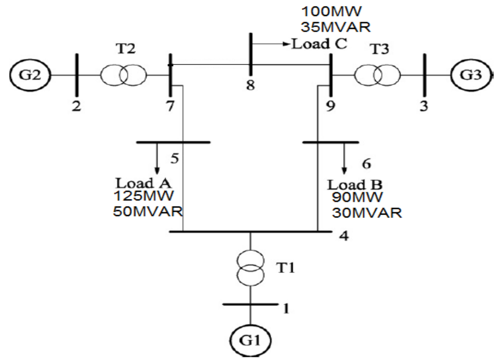

Figure 2. Single Line Diagram of IEEE 9 bus test system

Table 1. Tabulated Transmission Pricing based on different methods when load demand is actual

	G1(Pricing) in $	G2(Pricing) in $	G3(Pricing) in $
Postage Stamp	24711	29923	21676
MW-Mile (original)	57562	40759	40000

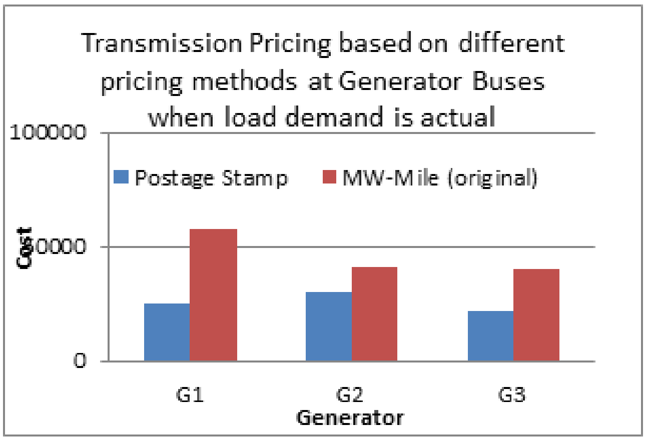

Figure 3. Transmission Pricing based on different pricing methods at Generator Buses when load demand is actual

V. CONCLUSION

In this paper, a power system simulation package referred to as MATPOWER is used extensively to study the Optimal Power Flow (OPF) of the system. In this paper, as a first remedy is shown to be an efficient in managing congestion in the competitive market. The use of in aiding congestion management is shown to provide additional benefit to the system, in terms of both clearing the congestion. With , the contracts after market Re-dispatch are more or less the same as the originally scheduled, which is highly appreciated by both suppliers and customers. The results were tasted IEEE 30 bus system. Simulation were carried out in MATLAB. Here we find the TLR sensitivity and decide where we have to apply for solving congestion and then we verify the simulation results. It has been observed that from simulation results on various systems, clear possibility of optimized location of and relaxation of congestion. Perfect location of ease out congestion proves to be of technical as well as economical benefits.. For location leads to better results. The results are verified by MATPOWER.

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