IOSR Journal of Electrical and Electronics Engineering (IOSR-JEEE)
e-ISSN: 2278-1676, p-ISSN: 2320-3331
PP 34-38
www.iosrjournals.org

Transmission Pricing Simulator in Competitive Power Market

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ABSTRACT: *Transmission Pricing has been an important issue on the ongoing debate about power system restructuring and deregulation. The purpose of the transmission pricing is to recover cost of transmission encourage efficient use & investment. This paper aims to establish a methodology for evaluating the wholesale or retail prices in a power market which ensures not only the recovery of expense for utilities or regional networks but also provide reasonable electricity prices for consumers, reflecting the market competition. In the power market under consideration it is assumed that there are multiple IPPs (Independent Power Producers) bidding electric power to a utility or regional network, and that the utility supplies electric power to customers by a fixed transmission network. By looking at current publications on electricity markets liberalization it becomes obvious that the question is no longer if competition should be introduced but how to organize markets in order to achieve an optimum performance. Power delivery is nowadays a bundle of many services including mainly generation, transmission and distribution. This paper focuses on problems related to energy transmission and its pricing in an open electricity markets. This paper presents a software tool for transmission price determination in electricity market. It also presents and analyses several approaches for transmission cost allocation in a centralized pool based electricity market environment that include composite marginal transmission pricing mechanism. It also highlights the need of pricing simulator with techno-economical analysis of trading philosophy with background calculations performed by MATPOWER. The transmission price computation considers the physical impact caused by the market agents in the transmission network. It includes existing system costs and also costs due to the initial congestion situation and losses costs. The paper includes a case study for the IEEE- 9 bus power system.*

Keywords: *Transmission Pricing, Optimal power flow.*

I. INTRODUCTION

Traditionally, generation resources have been scheduled so has to minimizes system wild production coat while meeting various technical and operational constraint including demand-supply balance over the system [1],[3].Recently the electric power industries around the world are moving from convention monopolistic or vertically integrated environment to de regulated and competitive environment [2], [4].Where each participant is concern with profit maximization rather than system wide cost minimization [3].As a consequence, the conventional lead cost approaches for generation resource schedule can not exactly handle real world situation any longer. Electric power industry throughout the world are moving towards market based competition with an official objective for higher operational efficiency .two widely know market employed in an electric utility are based on pool and bilateral model. The pool model are motivated by the need to accommodate the special characteristic of electric power network within the electricity trading process .This model relies on the actions of pool operator for attaining the economy dispatch .In contrast, the bilateral model is motivated by the concept that the free market trading is the best way to achieve the competition in the electricity wholesale[5],[6].However ,both models usually required the common transmission system to transmit the dispatch energy from the supplier to customer. In an electricity market which applies both market model, system operation based on conventional economy dispatch would not be sufficient to cover the requirement form both pool and bilateral market .since the conventional economy ditch normally takes in to account the trading information of pool and bilateral market sequentially .there for the dispatch result may violate the system the operating constraints e.g. transmission line capacity, bus voltage limit, generation capacity etc.To obtain the better dispatch result for both pool and bilateral participant, this paper proposes a transmission mechanism through independent system operator. Both pool and bilateral trading information are combined in the objective function of optimization process, which is subjected to appropriate system operation constraint .therefore the dispatch solution can be assured that the system operation constraints are satisfied. With the proposed pricing simulator benefit both pool and bilateral market to obtain the best social welfare benefit. In this pricing simulator, the concept of actual social welfare maximization which is based on real price payment is employed as a key of optimization mechanism [3].The real prices considering the loss and congestion charges.

II. POOL AND BILATERAL MARKETS

In competitive environment, two market model widely use throughout the word i.e. pool and bilateral market, can be jointly implemented in an electricity market [1],[2].The implementation of this pricing simulator depends on the tag allocated to the load and generation to get the market structure policy. In the pool model, there are two main sides on entities participating in the market i.e. customer and supplier .The pool operator consider the electricity transaction bids and offers from this two entities and dispatches them in an economic manner .Depending on the price and MW bidding . In general the customer and supplier do not directly interact to each other but only through the independent system operator After all bids and offer have been received an optimization tool will be used to solve the problem which includes tax allocated to the load and generator which also includes tax on losses[7].

III. TRANSMISSION PRICING

When discussing transmission pricing it is necessary to define what is meant by or included in the transmission service .The following definition is given: "The Transmission function will facilities a competitive electricity market by impartially preventing energy transportation service to all energy buyer and seller, while fairly recovering the cost of proving those services". For cost recovery the customer (generator or load) have to be charge a price, which has to be define clearly to allow correct economy and engineering decision on upgrading and expanding generation, transmission and distribution facilities. Those pricing of the transmission service must meet the following requirement.

Promote economic efficiency
Compensate grid companies fairly for providing transmission services
Allocate transmission costs reasonably among all the transmission users both load and generation
Maintain the reliability of the transmission grid

IV. THE SYSTEM OPERATOR SERVICE

In the most liberalized electricity markets a special entity the so called system operator exists. "This monopoly can be either a non-profit or a for –profit-entity"[1]. The for-profit-entity in the U.S. is called Transco (short for Transmission Company). It owns, operates and manages the transmission system as a natural monopolist. A Transco could maximize its profit by withholding transmission capacities, thus it is heavily regulated.

The other choice is to introduce a non-profit-entity which is usually called Independent System Operator (ISO) or Independent Grid Operator (IGO). In contrast to the Transco the ISO does not own-but manage the transmission network. It does not have a motive to withhold transmission capacities in order to maximize its profit. Thus it is only slightly regulated. In the following term Transco will be used for an institution that owns and operates the network whereas ISO refers to an Independent System Operator.

All though the structure of transmission market may differ from country to country, there are four objectives in order to keep the market functioning.

Provide a non-discriminatory access to the grid.
Offer a reliable, efficient and environmentally adopted transmission of power on the grid.
Keep the system in balance..Provide ancillary service (reserves, black start possibility, and voltage and frequency control).

V. MATPOWER FOR OPF

Optimal power flow is a central decision making tool from 1962, OPF has had a long history of development. Now OPF has become a successful algorithm that could be applied on an everyday basis, in different kind of power market. The OPF is use for a wide range of task from calculating the minimum cost generation dispatch to setting generation voltage, transformer taps.

MATPOWER is a package of MATLAB M-file for solving power flow and optimal power flow problems. It is used as a simulation tool for researchers and education that is easy to use and modify MATPOWER is designed to give the best performance possible while keeping the code simple to understand and modify .It was initially developed as part of the power Web Project.

.It also solves the congestion of initial dispatch and provides good offers to re-dispatch.

VI. PRICING CONCEPTS

This section provide principles for transmission pricing [6],examines transmission pricing options, and discusses the role which the new Independent System Operators (ISO) will play in transmission and practices the recently created ISO's have adopted.

Although transmission costs represent only about 2 percent of invertor-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 disperse end-users with generators because power flow in one location impact electric transmission coast across the network, transmission pricing may not only determine who get access and what price but also encourage the efficiencies in the power generation market.

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

In addition to the meeting revenue requirement, transmission pricing should ideally do the following:

Promote effect day-to-day operation of the bulk power market.

Encourage investment and determine the location of generation.

Encourage investment and determine the location transmission lines.

Compensate owners of transmission assets; and be fair and practical to implement.

VII. COST AND TAX CONSIDERATION

A given interconnected power system is subjected to optimal power flow with the help of software tool such as MATPOWER.

The different important components of the cost of transmission transaction are :

Operating cost: Production (fuels) cost due to generation dispatch and rescheduling resulting from the transmission transaction.

Opportunity cost: Benefits of all transaction that the utility foregoes due to operation constraints that is cost by the transmission transaction.

Reinforcement cost: Capital cost of new transmission facility needed to accommodate the transmission transaction.

Existing system cost: The allocated cost of existing transmission facility use by the transmission transaction.

The first three components of the cost of transmission transaction (operating cost. Opportunity cost and Reinforcement cost) Considered what is commonly cost the incremental cost of the transmission transaction. Other terms are preventing use in the industry to refer the component of the cost of transmission transaction these terms include "Short Run Incremental Cost" to refer to operation and opportunity cost.

Another cost is "Long Run Incremental Cost" accossiated to Operating cost, Opportunity cost and Reinforcement cost.

The long term transactions that are accommodating via transmission system reinforcement in order to mitigate operating constraints usually do not incur opportunity cost.

For e.g., Will be shown as, Opportunity cost is calculated differently for firm and non-firm transactions .Generally, for a transmission transaction:

$TC = OPG + OPY+RFT+EXT$

Where OPG is the operation cost, OPY is the opportunity cost RFT is the Reinforcement cost and TC is the total cost of transaction. Taxes on the cost also categories as [8].

Taxfixload: This is tax as allocated to load at different buses.

Taxfixger: This is tax as allocated to generators.

Taxstrnsit: This is associated with transit related pricing issue.

Taxcongestion: This is extra tax to be levied in case of congestion

Taxlossess: This is tax levied on loads at buses of power system.

VIII. RESULTS OF IEEE 9 BUS CASE STUDY

The IEEE of bus test case represents a portion of the American Electric Power System. The data was kindly provided by Joe H.Chow's Book page No.70.

The one line diagram of an IEEE 9 bus system is as shown in the fig. The line data ,bus data and load are as shown in table 1 and 2.

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Single line diagram of IEEE 9 bus test system .The system consists of 3 synchronous generators and the system had 3 load points.

Associated flow results are given in the fig below. The data is on 100MVA base.

Figure 2: Single line diagram of IEEE 9 bus test system

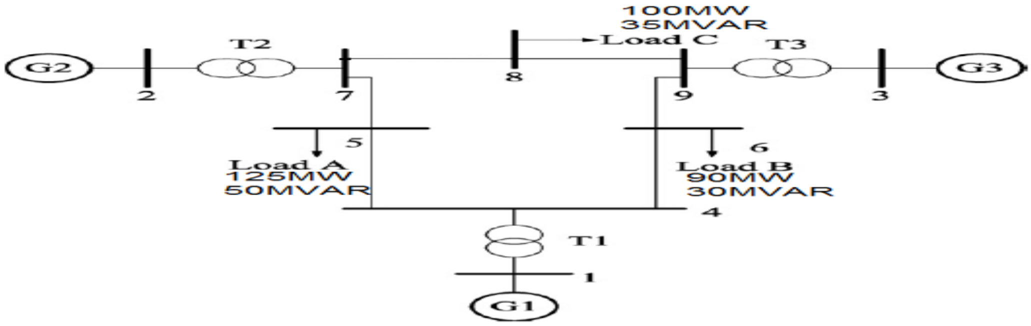


Table 1: Generator cost coefficient.

Unit	Bus No.	A ($/Mwh^2)	B ($/Mwh)	C $
G1	5	0.11	125	1
G2	8	0.085	100	1.2
G3	6	0.1225	90	1

Table 2: Flow Limits

Line No.	From	To	X(p.u.)	Flow Limit(MW)
1	1	4	0.0576	250
2	4	5	0.092	250
3	5	6	0.17	150
4	3	6	0.0586	300
5	6	7	0.1008	150
6	7	8	0.072	250
7	8	2	0.0625	250
8	8	9	0.161	250
9	9	4	0.085	250

Fig 3. TaxFixLoad in dollar's per MW

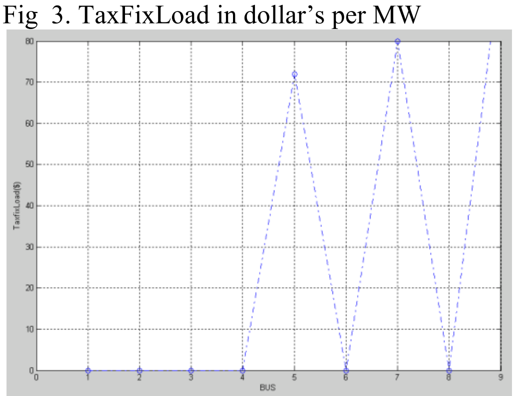


Fig 4. TaxFixGen in Dollar's per MW

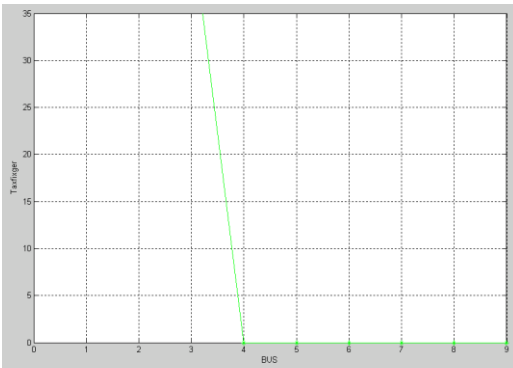
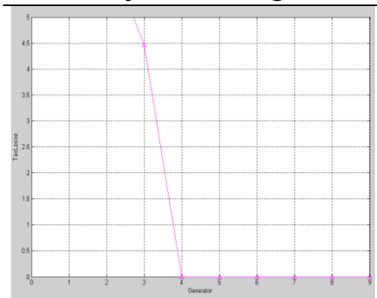


Fig 5. TaxLosses in Dollars per MW

Fig 6. Transit Tax and Congestion Tax at different Buses



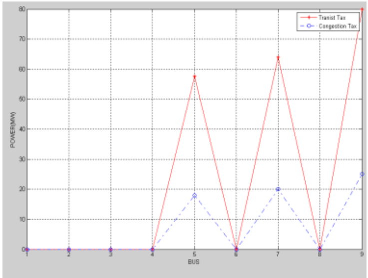
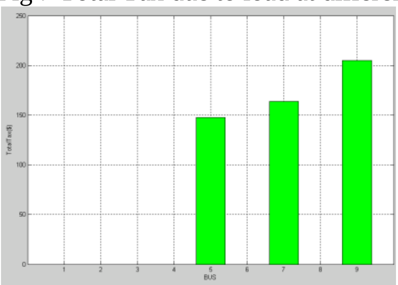
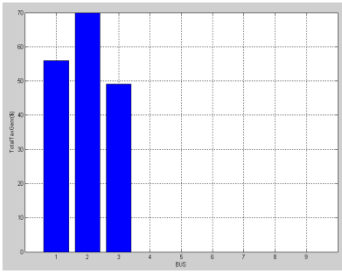


Fig 7 Total Tax due to load at different buses

Fig 8 Total Tax due to Generator at specific buses





IX. CONCLUSION

This paper present case study of standard IEEE 9 bus system in depth analysis of transmission pricing .In this paper, we presented a software tool that allows independent system operator to compute the transmission prices. Transmission crises are evaluated considering existing system cost, the losses cost, Initial congestion and the operation cost. The simulator offers a set of methods to calculate the distribution of these costs by the loads and generator.

A variant Module or used method has been use in the case study presented in this paper.The impact of each load or generator in the power system, can be effectively analyzed along with the cost calculation. Evaluation of tax and cost is an added economical figure with such software based programming tool with the use of MATPOWER.

X. ACKNOWLEDGEMENTS

I take this opportunity to express my deep sense of gratitude and whole hearted thanks to my guide Prof. Dr. V.K.Chandrakar, Principal, Raisoni Woman’s Engg college, Nagpur for his valuable guidance and constant encouragement.Inspite of his heavy schedule he is always ready to help and support .

I express my deep and sincere thanks to my co-guide Prof. Dr. R.M. Mohril H.O.D Electrical Engg dept Y.C.C..E.,Nagpur for his support and constant valuable guiedance.I also want to thanks to the principal of Anjuman Engg college,Nagpur Prof. Dr. Sajid Anwar for his constant support and encouragmenr.

Last but not the least I thanks to miss Yasmin Ansari For her support for the successful complitition of the paper.

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