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## Electricity Pricing in Deregulated Power Sector

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**ABSTRACT:** This paper presents a method for allocating embedded cost of transmission to its consumers through transactions under deregulated environment of power system. There are many methods to calculate the embedded cost in the different way and procedures. In this paper there are comparison between those methods and try to find the fairest among them. There are IEEE 9 bus and IEEE 30 Bus system is used for the calculations with the help of Matlab coding. For the calculation of price we take some transaction on different buses and load. This transaction are taken in MW. This transaction are bilateral and free from direction of power flow, active and reactive power both are considered and power factor included. We calculate the power flow at the different busses using load flow. Load flow give power flow in line and this power is useful to calculate the cost of transmission cost. Then we calculate the cost of electricity price with transaction and without transaction. Auction mechanism is used in deregulated power sector for transparent and better way to compute electricity pricing.

**KEYWORDS:** Embedded cost, transactions, deregulation, Bilateral Transaction, Matlab, Load Flow.

### I. INTRODUCTION

In the deregulated power sector 'correct' pricing of transmission services is useful in providing economic signals for efficient short-run operations, recovery of costs, long-term capital investments and fair allocation of costs among participants. In deregulated power sector there are overall power system is restructured in three main parts, they are generation, transmission and distribution. Electricity price is mainly depend on the transmission system and this is free from generation and distribution. In deregulation environment there are many method for calculation of embedded cost.

Electricity markets with different model have been developed in many countries all over the world. This paper briefly reviews the pricing mechanism used by power market in the world. In this comparative analysis has been studied to compare the various pricing methods and effectiveness.

### II. PURPOSES OF PRICING

All industries re-structuring plans, regardless of the jurisdiction, envision only one transmission system run "for the public benefit" as a type of monopoly franchise. Therefore, government regulation will set the tariff (prices), which means that transmission tariff structure, and the way it is determined and applied are elements of policy[1]. In general, policy makers and their advisers, i.e., economists, engineers, utility executives, consumer advocates, see pricing/cost allocation as having three goals:

- Recovery cost
- Encourage efficient use
- Encourage efficient investment

Recovery costs- Fees for transmission use must produce revenue to cover all the expenses of investment, operation, and maintenance, as well as provide a small, (regulated) level of profit for the owners.

Encourage efficient use- The price structure (relative cost as a function of the service sought,

e.g., amount of power transported, distance, etc. should give incentives for using the transmission system efficiently. The meaning of efficiency is the subject of much disagreement, but everyone agrees pricing should encourage it[2].



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Encourage efficient investment- The price structure and the way money is paid to owner should provide an incentive for investment in new facilities where they are needed.

In addition, some requirements can be defined for a pricing system, based on practical stipulations of the ISO and its customers. A pricing system must be:

Fair – Exactly what is fair and what isn't might be debatable, but most people will agree that any pricing system must be fair or equitable to all user.

Understandable – Any pricing system must be understandable to its customers. If a pricing mechanism is so complex that its users do not trust their ability to make good buying decisions, they will not use the product and will seek other ways to satisfy their needs.

Workable – A pricing system so complicated that it cannot be implemented economically is impractical. Many seemingly good ideas in pricing required measurement of power flow at so many points, and system analysis so detailed, that it is questionable if they can be implemented successfully, and it is doubtful that their cost is justifiable.

### III. AUCTION MECHANISM

In decentralized electricity markets, auction mechanisms are the easiest, efficient and most transparent way to compute the market clearing price. An auction operates under an explicit set of rules adhered to by all of the players that determine resource allocations and prices based upon the bids.

The single-side auction is used for pricing where one of the parties offering to sell (buy) a resource is willing to receive (pay) a specified amount. Each Genco submit a bid, which is an ordered pair  $(p@q)$  representing a price  $p$ , and quantity,  $q$ . These bids are stored in ascending order by price.

They are then accepted sequentially, adding the quantity of each bid to a running total until this total meets the demand. At this point no more bids are accepted, and the last one is accepted for only the amount of remaining demand[3].

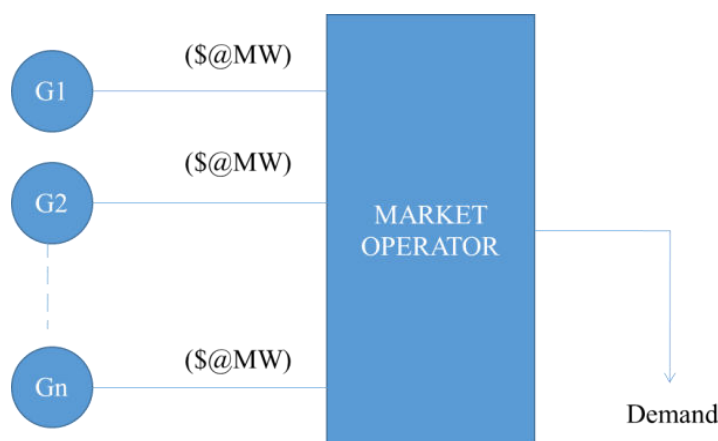


Fig. Model of the Market\



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## IV. OVERVIEW OF EMBEDDED COST METHODS

**Postage stamp rate:** Every transmission customer pays a single rate for any transmission transaction within a defined region, regardless of the contractual origin and contractual destination of the electricity transmitted. That rate is the same rate for every customer[4]. The rate is an “average rate” because the total costs of the region's transmission network are divided by the total units transmitted, resulting in an average cost per unit “A postage stamp rate means that every customer pays the same averagerate regardless of whether the cost caused or benefit derived by thatcustomer from a given transaction varies from the average.”

$$C_{aT} = \frac{P_w}{P_{peak}} * \frac{C}{8760}$$

where

$P_w$  = Transacted power

$C$  = Annual fixed cost

$P_{peak}$  = Peak load of the system

**Contract path method:** This method is based upon the assumption that the power due to transaction is confined to flow along a specified electrically continuous path through the transmission system.

This method is easy to implement, but the embedded capital cost of those facilities which lies along the assume path is only taken into consideration. Moreover neither reverse flows or parallel flows are considered[5].

$$C_{bT} = \frac{P_w}{P_{min. path}} * \frac{C}{8760}$$

where

$P_w$  = Transacted power

$C$  = Annual fixed cost

$P_{(min. path)}$ = minimum power path

**Boundry Flow Method:** Boundry Flow (BF) Method is used for calculating the change for transmission transaction across the border of a grid. Boundry Flow method is useful when more then one transmission company is involved transaction. Moreover the distance wheeled is not taken into account in this method.

**Equivalent Bilateral Exchange method:** This method is on the principle of equivalent bilateral exchanges, which states that after all physical law governing the flow of power have been met, each demand is assigned a fraction of each generation and each generator is assigned a fraction of each demand in a uniform manner. Transmission cost allocation based on this principle present several advantages, namely, independence from the choice of the slack bus, recognition of counter-flows, and transmission use charge that are stable and always positive.

**MW-mile method:** According to MW-mile method, embedded cost of transmission system are allocated proportionally to the change in the line MW flows caused by the transmission transaction and length of the line in miles. This method is also called line-by-line method. This method is possibly the fairest among all the above methods. However it requires lot of computations, in particular for large number of simultaneous transactions. Moreover reactive power is not considered in this method.

$$C_{aT} = \frac{C \sum_f (\Delta MW_f)_T L_f}{8760 \sum_T (\sum_f (\Delta MW_f)_T L_f)}$$

where

$\Delta MW_f = |MW_f (withT)| - |MW_f (withoutT)|$

$L_f = \text{Length of transmission facility } f$

$(MW_f)_T = \text{MW flow in facility } f \text{ due to transaction } T$

**MVA-mile method :** In all the above methods reactive power change in the transmission facilities caused by transaction party are not considered. MVA-mile method can take into consideration both active and reactive power loading of the transmission network caused by the transaction and hence allocates ambedded cost of transmission accordingly. Hence a transaction causing more reactive power loading will be allocated more cost than other transaction.



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$$C_{bT} = \frac{C \sum_f (\Delta MVA_f)_T L_f}{8760 \sum_T (\sum_f (\Delta MVA_f)_T L_f)}$$

where

$$\Delta MVA_f = |MVA_f(\text{with } T)| - |MVA_f(\text{without } T)|$$

$$L_f = \text{Length of transmission facility } f$$

$(MVA_f)_T$  = MVA flow in facility  $f$  due to transaction  $T$

**MW-cost Method:** According to proposed MW-cost method, embedded costs of transmission system are allocated proportionally to the change in MW flows of each facility caused by the transmission transaction and cost of that facility.

$$C_{aT} = \frac{C \sum_f (\Delta MW_f)_T C_f}{8760 \sum_T (\sum_f (\Delta MW_f)_T C_f)}$$

Where

$$\Delta MW_f = |MW_f(\text{with } T)| - |MW_f(\text{without } T)|$$

$$C_f = \text{Cost of transmission facility } f$$

$(MW_f)_T$  = MW flow in facility  $f$  due to transaction  $T$

**MVA-cost method:** It has been recognized that the use of transmission resources is best measured by monitoring both real and reactive power. This proposed MVA-cost method can take into consideration both active and reactive power loading of the transmission network caused by the transaction and hence allocates embedded cost of accordingly.

$$C_{bT} = \frac{C \sum_f (\Delta MVA_f)_T C_f}{8760 \sum_T (\sum_f (\Delta MVA_f)_T C_f)}$$

Where

$$\Delta MVA_f = |MVA_f(\text{with } T)| - |MVA_f(\text{without } T)|$$

$$C_f = \text{Cost of transmission facility } f$$

$(MVA_f)_T$  = MVA flow in facility  $f$  due to transaction  $T$

## V. CALCULATION FOR IEEE 9 BUS SYSTEM AND RESULTS

The method of allocation of embedded cost have been analyzed on IEEE 9 Bus system. The system has been modified, in order to include different transaction. It is assumed that each system generator is an independent generating company (genco)[6]. All generating companies (genco) are supplying power to retailers or load centers at different buses through a power pool. In addition to this, two simultaneous bilateral transactions as given in table 1 and shown in fig.1 are added to this system[7].

Transaction	From Bus No.	To Bus No.	Value of Transaction		
			MW	MVAR	Power Factor
T1	3	4	5	2.18	0.9
T2	2	5	15	7.9	0.85

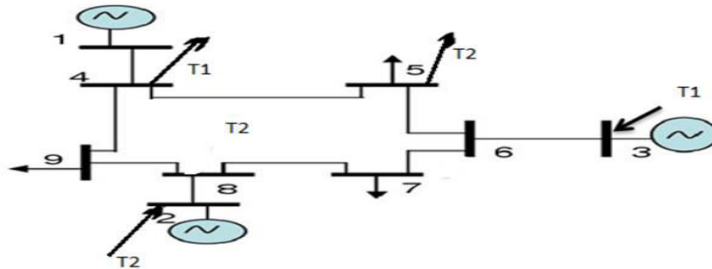
TABLE 1: Transaction for 9 bus system

For the given IEEE 9 Bus system Annual Fixed Charge Rate (AFCR) is assumed 15% and the calculation is based on this data.

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IEEE 9-bus system with 2 Transaction

Transaction (MW)	MW-mile (Rs/hr)	MVA-mile (Rs/hr)	MW-cost (Rs/hr)	MVA-cost (Rs/hr)
T1	5	365	359	399
T2	15	367	370	368
Pool	315	368	371	372

TABLE 2: Analysis of embedded cost allocation by different methods

Transaction (MW)	Postage stamp (Rs/hr)
T1	16
T2	49
Pool	1034

TABLE 3: Analysis of embedded cost allocation by postage stamp methods

Transaction (MW)	Contract Path (Rs/hr)
T1	220
T2	687.5
Pool	192.5

TABLE 4: Analysis of embedded cost allocation by contract path methods

## VI. CALCULATION FOR IEEE 30 BUS SYSTEM AND RESULTS

Now we take IEEE 30 Bus system. In addition to this, three simultaneous bilateral transactions in MW and MVA are as given in table1 and shown in fig.1 are added to this system and power factor of the system is assumed.

Transaction	From Bus No.	To Bus No.	Value of Transaction		
			M W	MVAR	Power Factor
T1	27	10	10	5.27	0.85
T2	1	8	20	8.72	0.9
T3	22	30	30	18	0.8

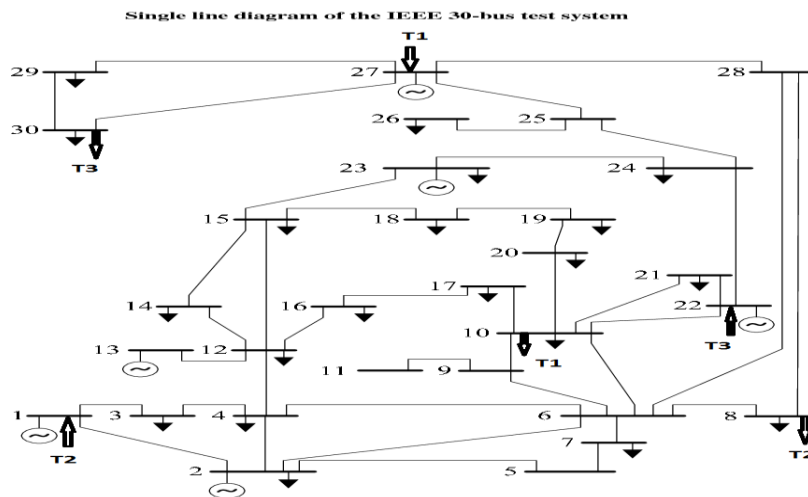
TABLE 1: Transaction for 30 Bus system

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For the given IEEE 30 Bus system Annual Fixed Charge Rate (AFCR) is assumed 15% and the calculation is based on this data. In this system we take 20 retailers or load centers at different buses through a power pool. In addition to this, three simultaneous bilateral transactions as given in table 1 and shown in fig.2 are added to this system[10,11].



IEEE 30-bus system with 3 Transaction

Transaction (MW)	MW-mile (Rs/hr)	MVA-mile (Rs/hr)	MW-cost (Rs/hr)	MVA-cost (Rs/hr)
T1	10	542	1150	136
T2	20	1833	1329	1203
T3	30	3958	5554	645
Pool	189.2	987	1650	1666

TABLE 2: Analysis of embedded cost allocation by different methods



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Transaction (MW)		Postage Stamp (Rs/hr)
T1	10	144.5
T2	20	289
T3	30	433
Pool	189.2	2730

TABLE 3: Analysis of embedded cost allocation by postage stamp methods

## VII. CONCLUSION

The methods for allocating transmission system cost to simultaneous transaction and pool participant have been analysed. The results of MW-cost and MVA-cost method have been compared with the best conventional methods. From the analysis it is very much clear that MW-cost and MVA-cost method is fairest among all the existing methods as it is able to overcome all drawbacks of existing methods[16] It can be accurately and conveniently applied under all circumstances to a morden deregulated power system.

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