Different Pricing Parameters And Simulator Used For Competitive Power Market

Ms. Archana Jaisingpure[1], Dr. V. K. Chandrakar[1], Dr. R. M. Mohril[3]

Corresponding Author: [1]Research scholar, Yashwantrao Chavan College of Engineering,Nagpur.Email: archana.shirbhate@rediffmail.com
[2]Professor, G.H. Raisoni College of Engineering , email: vinod.chandrakar@raisoni.net
[3]Professor and Head , Department, Electrical Engineering, Yashwantrao Chavan College of Engineering,Nagpur.

Abstract : Transmission pricing for trade offs in power market is proposed. Different pricing parameters is an essential provision in simulator associated with congestion, re-dispatch and facilitate techno-economical analysis of trading philosophy with background calculations performed by optimized power flow package and front-end software with Graphic User Interface facilities. The online pricing simulator will be analyzing the transmission pricing based on certain pricing indices with optimization tools working in tireless fashion to readjust the biddings and contract handling making on line power trading very effective. The eight transmission pricing schemes are being evaluated .The proposed approach has been tested on IEEE14 Bus and on IEEE 30 Bus system using MATLAB simulation program to illustrate the different results derived among the pricing schemes. This paper will prove beneficial for power trading parties involved in power transaction for techno-economic analysis with chosen indices as an added facility available on line.

Keywords : Optimal Power Flow (OPF), Transmission pricing, Open Access.

1. Introduction

Throughout today's unbundled power systems, it is assumed that the transmission system is a natural monopoly, and therefore, it should be regulate compensate for the revenue requirements of the owners of transmission system and encourage its future expansion, transmission pricing schemes should be designed fairly. Also the schemes must aim to achieve the objectives of maintaining system security by encouraging proper operation and maintenance of exiting and investment in new facilities. In this paper, based on a simple economic principal, a novel method for allocation of the fixed cost of transmission system to agents using these facilities is developed. This method introduces the concept of critical capacity of a line and considers congestion in the transmission system to allocate the share of the transmission system revenue requirement that each agent has to provide. Identifying and charging the agents who cause congestion is very important as it sends the correct economic signal to transmission network users. This is a novel feature of these method, thus making it most suitable for systems where congestion does occur.[1-2]

Transmission pricing of electricity is a basic ingredient of the competitive power market that are currently being developed world wide. Several methodologies have been implemented or proposed for the allocation of all or part of the existing network cost to the users of transmission system (consumers & generators) . Some of them (postage stamp , contract path , MW – mile , etc.) are based on "extent of use " paradigm , while others are based on incremental transmission pricing paradigm.. The methods described in detailed & analyzed in this paper , which are addressed to allocate the entire cost of a network among all the network users on the same basis . This approach is preferable in the competitive power markets with full open transmission access[3-4].

This paper presents an overview of transmission pricing methodologies under open access. Transmission costs involves both technical & regulatory issues, & as a result, the methods available in the literature differ in their definition & major of the "extent of use" of transmission resources. The cost of basic transmission services corresponds primarily to the fixed transmission cost i.e. also referred as the transmission capacity cost or existing system cost are embedded transmission facility cost. Electric utilities traditionally allocate the fixed transmission cost among the users of firm transmission service based on Postage-Stamp Rate & Contract Path methods.

MW – Mile methodology may be regarded as the first pricing strategy proposed for the recovery of fixed transmission costs based on the actual use of transmission network. In this method charges for each wheeling transaction are based on the measure of transmission capacity use . This is determined as a function of the magnitude, the path & the distance travelled by the transacted power . Since the charge for basic transmission service is usually the largest component of the overall charge of transmission services, a considerable amount of research effort has focused on the development of usage-based cost allocation schemes & various implementations of MW – Mile methodology have been proposed in the literature .

The primary objective of this paper is to provide a summary of recent techniques used for designing fair & equitable access for the recovery of fixed transmission costs. Numerical examples are provided to compare the results using different methods. In the original MW-Mile methodology , the usage of transmission facilities is measured by absolute flow values , & the transmission facility costs are allocated in proportion to the ratio of flow magnitude contributed by a particular transaction & the sum of absolute flows caused by all transmission users . The following equation may give a more general expression of MW-Mile rule [5-6].

Transmission line pricing is related to open access policy in deregulated electricity market. Fixed costs in transmission is referred as embedded transmission facility cost. This cost can be interpreted as operation, maintenance and planning of transmission system. It resembles to sharing of communication networks by different service providers. Such market players are charged for power transaction over the allocated part of transmission. The advent of liberalization of the electricity market in Europe has seen the growth of cross-border trading of energy. Transmission line pricing is a major issue in open access faced by the electric power industry. Transmission providers will be required to offer the basic transmission service in conjunction with a number of mandatory and/or voluntary ancillary services. Basic transmission service along with ancillary services, such as operating reserves, regulation, load following and voltage control, are the functions necessary for maintaining the reliability of the system and undertaking commercial transactions across the grid .

The cost of the transmission services corresponds primarily to the fixed transmission cost. Electric utilities traditionally allocate the fixed transmission cost among the users of firm transmission service based on Postage-Stamp Rate and Contract Path methods.

In the postage-stamp rate method, transmission users are not differentiated by the “extent of use” of transmission facilities but charged based on an average embedded cost and the magnitude of transacted power. Contract path method, on the other hand, assumes that the transacted power would be confined to flow along an artificially specified path through the involved transmission systems. Accordingly, the transaction will be charged a postage-stamp rate that may be calculated either separately for each of the transmission systems or as a grid average. In reality, however, the actual path taken by a transaction may be quite different from the specified contract path thus involving the use of transmission facilities outside the contracted systems.MW-Mile methodology is regarded as the first pricing Strategy related to recovery of fixed transmission

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costs based on the actual use of transmission network. In this method charges for each wheeling transaction are based on the measure of transmission capacity use. This is determined as a function of the magnitude, the path and the distance traveled by the transacted power. Since the charge for basic transmission service is usually the largest component of the overall charge, lot of research effort has focused on the usage-based cost allocation schemes, and various implementations of MW-Mile methodology have been proposed in the literature.

Allocation of ancillary services is a rather complicated problem. Unlike the basic transmission service, the cost of ancillary service often involves several cost components. For instance, the cost of operating reserve may involve capacity cost, energy cost and opportunity cost. Moreover, the costs of some ancillary services may vary greatly as a function of time, location, and level of system load. Although some newly proposed cost allocation methods can determine the contributions to real power losses and reactive power support from individual users, very few publications are available for the allocation of regulation, load following and operating reserves. These ancillary services are usually distributed among the transmission users in proportion to their scheduled/metered generation or demand. The primary objective of this paper is to provide a pricing simulator with more facilities for designing fair and equitable access fees for the recovery of fixed transmission costs. Real-time congestion pricing strategies associated with transmission constraints in a competitive electricity market are also included. Numerical case study is provided to facilitate the proposed pricing methodologies.

In the restructured electricity market, transmission company plays a vital role due to its involvement in the determination of charges for transmission pricing. In the traditional regulated power market, pricing have accounted for a small portion of the overall transmission network capacity usage. However, recent trends are stimulated renewed interest in pricing of transmission or distribution facilities of a system to transmit power of and for another entity. It is also states that, pricing is the use of some seller to buyer involving transmission network of a third party. Transmission cost is due to re-dispatching of generators and transmission losses [7-8] Transmission pricing is carried out:

1.To recover the capital and operating costs

2.To encourage efficient use and investments.

3. To provide equal opportunity to all users.

4. To offer a simple and understandable price structure.

5.To easy implementation.

This paper analyses all eight pricing methodologies. Previously all these methods have been evaluated [7] but best method for pricing is not identified. Particularly, in this paper, we have tested pricing methodologies under various load conditions and Moreover, it is clear that Unused reverse MW-Mile method gives minimum pricing method even when the load changes. The proposed has been tasted on IEEE 14 bus and IEEE 30 bus system using MATLAB simulation programs. The working flow charts of eight pricing method has been presented in this papr. We have done the calculation in an optimal Power Flow solution. A Graphical representation of the allocation obtained by this method which is given in figures.

2. TRANSMISSION PRICING

This section provides principles for transmission pricing. Although transmission costs represent only about 2 percent of an 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[9-10].

There are various ways to allocate revenues from congestion pricing. For example in California, such type 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:

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

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.

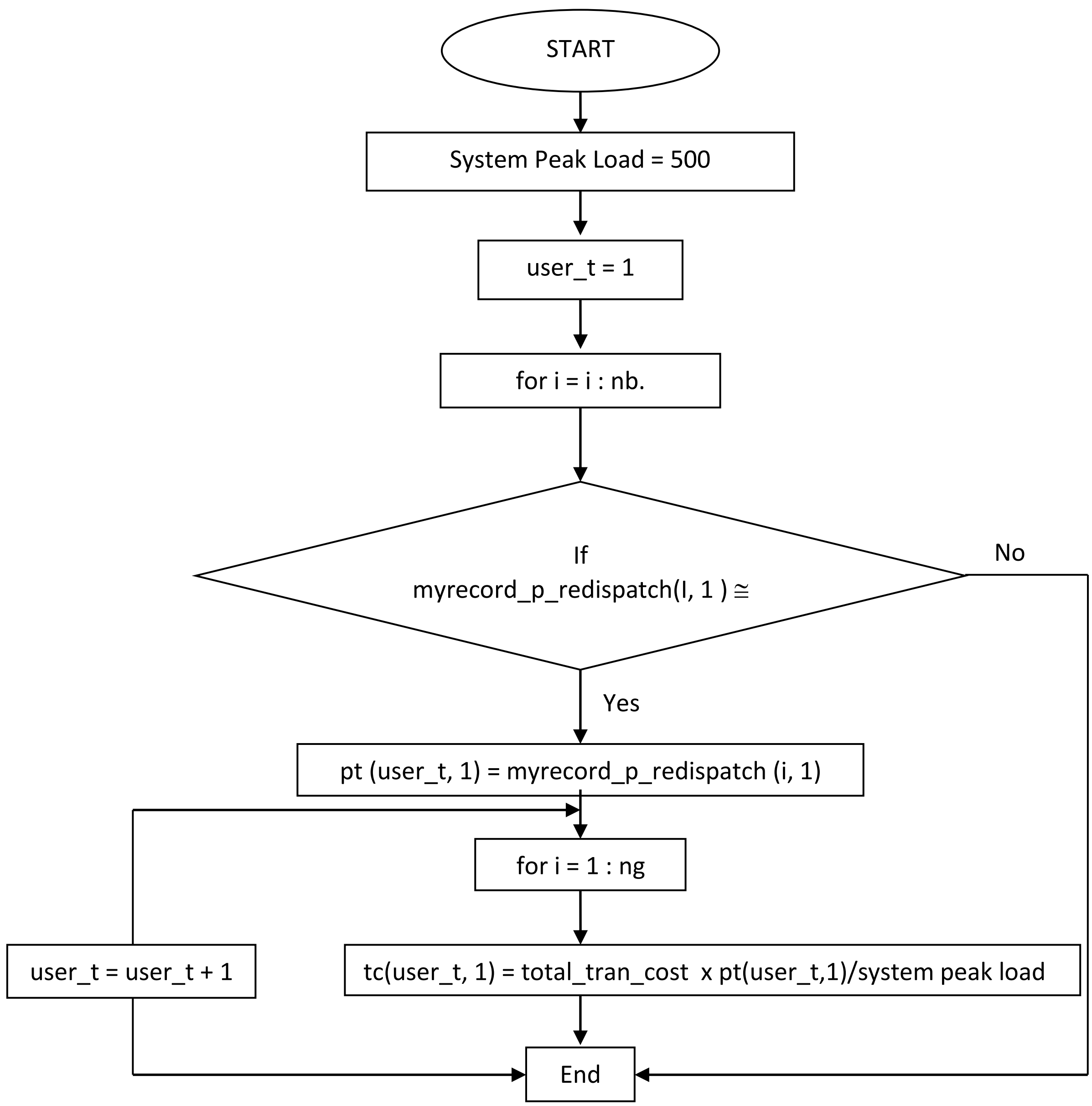

Fig.1: Flowchart for Postage Stamp Method

b. The MW-Mile Method

MW-Mile methodology may be regarded as the first pricing strategy proposed for the recovery of fixed transmission costs based on the actual use of transmission network. In this method charges for each wheeling transaction are based on the measure of transmission capacity use. This is determined as a function of the magnitude, the path and the distance traveled by the transacted power.

The distance relating transmission-pricing method known as the Mw-Mile method is also a rolled-in- transmission pricing method. Transmission line capacity usage consists of two components: The amount of power transmitted, and the length over which the power is transmitted. In this methodology transmission price is a function of the transacted power. The maximum transaction-related flow on every line is multiplied by the line length & a factor reflecting the cost per unit capacity of the line. The price is proportional to the transmission usage by the transaction. Moreover, the statistical analysis of the wide set of different operating states results shows that each consumer is predominantly supplied by the same set of lines. On this conclusion the transmission service price could be obtained in advance.

A method proposed by Bialek is one of most recognized. Initially, it has not taken into account transmission losses due to assumption that the power flow is same at the beginning & at the end of the branch .As Bialek explained in his papers, his main objective for developing power flow tracing methods has been to use them as a base for transaction based transmission service pricing method in deregulated power systems .MW-Mile method is a typical representative of these methods. There is a difference among methods in this group since some of them are based on contract paths whereas others are based on physical power flows, i.e. physical paths.[11]

In order to achieve a more precise measurement of network usage, numerous methods based on power flow data have been developed. The MW-mile method (MWM) was the first such method to be introduced . In order to determine the cost allocation, the network operator runs a power flow program for each single transaction and calculates the power flow due to this transaction over each system line. These power flows are then weighted by the specific transfer cost Cl of each branch l which is expressed in €/MW. The role of Cl , in the case that a pre-defined amount

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K must be proportionally allocated to the system users, is to differentiate the use of facilities with various costs. Thus, in this case Cl should not be confused with a direct payment, per MW, to the system operator. However, Cl may be indeed interpreted as direct, per MW, payment when other, than proportional share of a pre-defined amount K, allocation form is adapted. This case will be illustrated in a following section. The usage of any branch by transaction i will be:

$$f_{i,l} = C_i \left| P_{i,l} \right| \dots\dots\dots\dots\dots\dots.. [2]$$

where

fi,l : the usage of branch l by the market participant i

The absolute value in (4.31) denotes that the power flow direction is disregarded. The total system usage fi by transaction i is given by summing over all lines:

$$f_i = \sum_{l=1}^{n_l} f_{i,l} \dots\dots\dots\dots\dots\dots\dots\dots [3]$$

By allocating proportionally the total system cost, the contribution of transaction i will be:

$$MWM_i = K \frac{f_i}{\sum_{j=1}^{n} f_j} \dots\dots\dots\dots\dots.. [4]$$

where

MWMi : the amount charged to participant i according to the MW-mile method.

When the electricity market operates in an environment of competitive trade then each transaction agent is responsible to pay a part of the power system fixed cost. Similarly to the case of pool market, the form of a coalition between some players can be profitable by the existence of counter flows. Note that the allocation of fixed cost is made for each time interval and not at a peak load moment. Hence, power flows in opposite direction are the motivation for the cooperation between players rather than the difference between players' peak loads and coalition peak load [7].

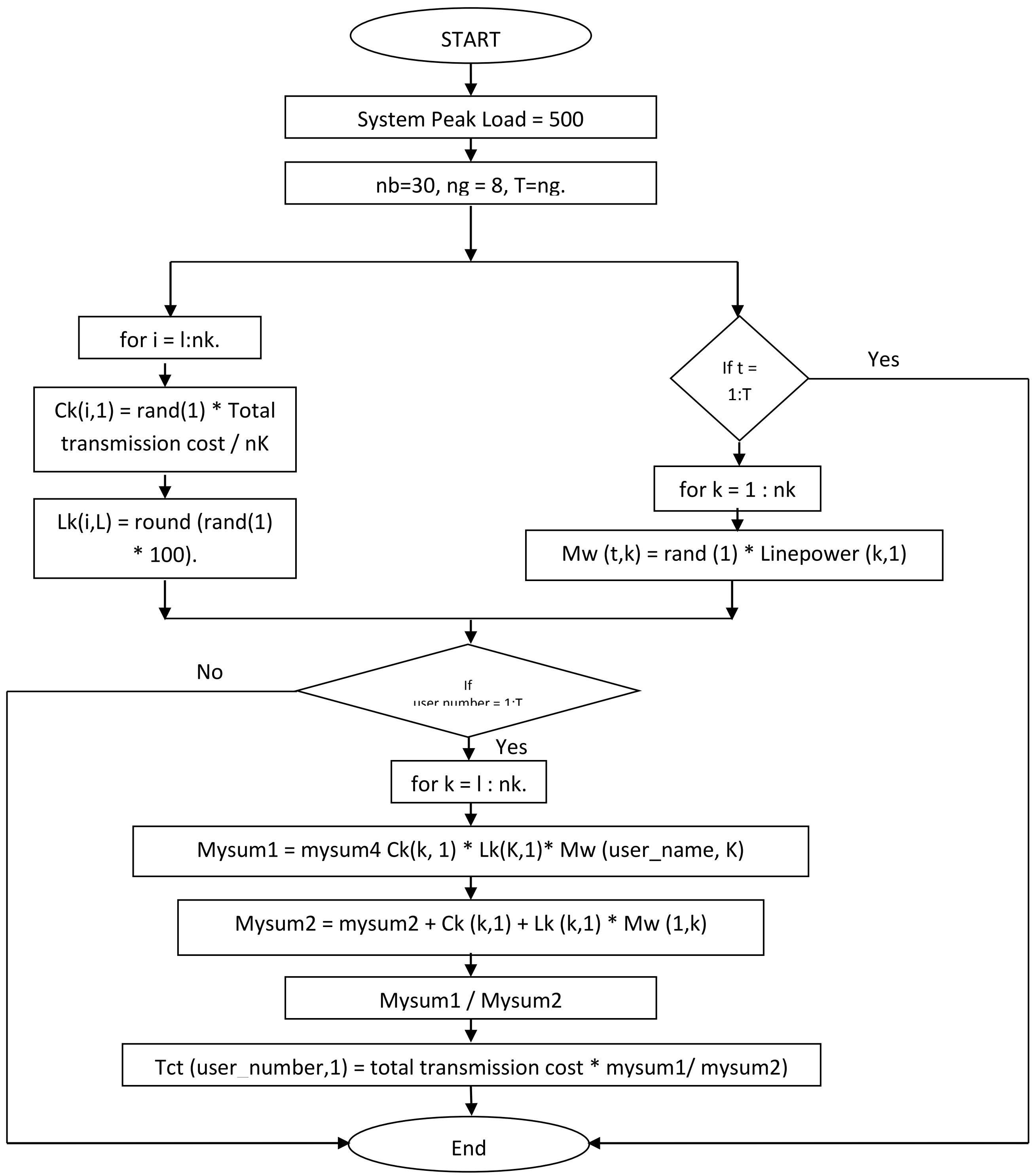

Fig.2: Flowchart for MW-Mile Method

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(*) Unused Absolute MW-Mile Method

The unused absolute MW-mile method charges users based on the power flows they cause, irrespective of the power flow direction, that is, the users who cause counter flows will pay for them, so each user k has to pay [5]:

$$TC_t = \sum_{k \in K} C_k \frac{|F_{t,k}|}{\sum_{t \in T} |F_{t,k}|} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots. [5]$$

where TCt is the cost allocated to network user t, Ck is the cost of line k,

Ft,k is the power flow on line k caused by user t,

T is the set of users, and K is the set of transmission lines.

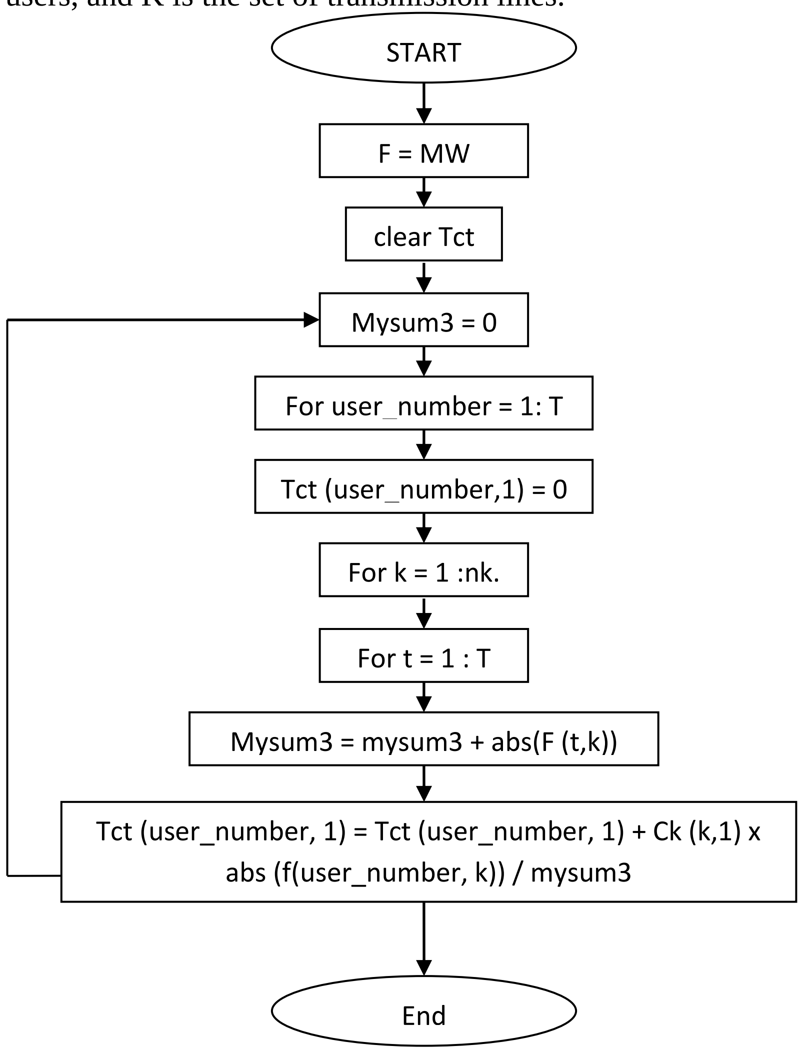

Fig.3: Flowchart for Unused Absolute MW-Mile Method

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(*) Unused Reverse MW-Mile Method

In the unused reverse MW-mile, users get credit for the counter flows they cause. More specifically, the charge for user t is [6]

$$TC_t = \sum_{k \in K} C_k \frac{F_{t,k}}{\sum_{t \in T} F_{t,k}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots [6]$$

where TCt is the cost allocated to user t, Ck is the cost of line k, Ft,k is the power flow on line k caused by user t, T is the set of users, and K is the set of transmission lines.

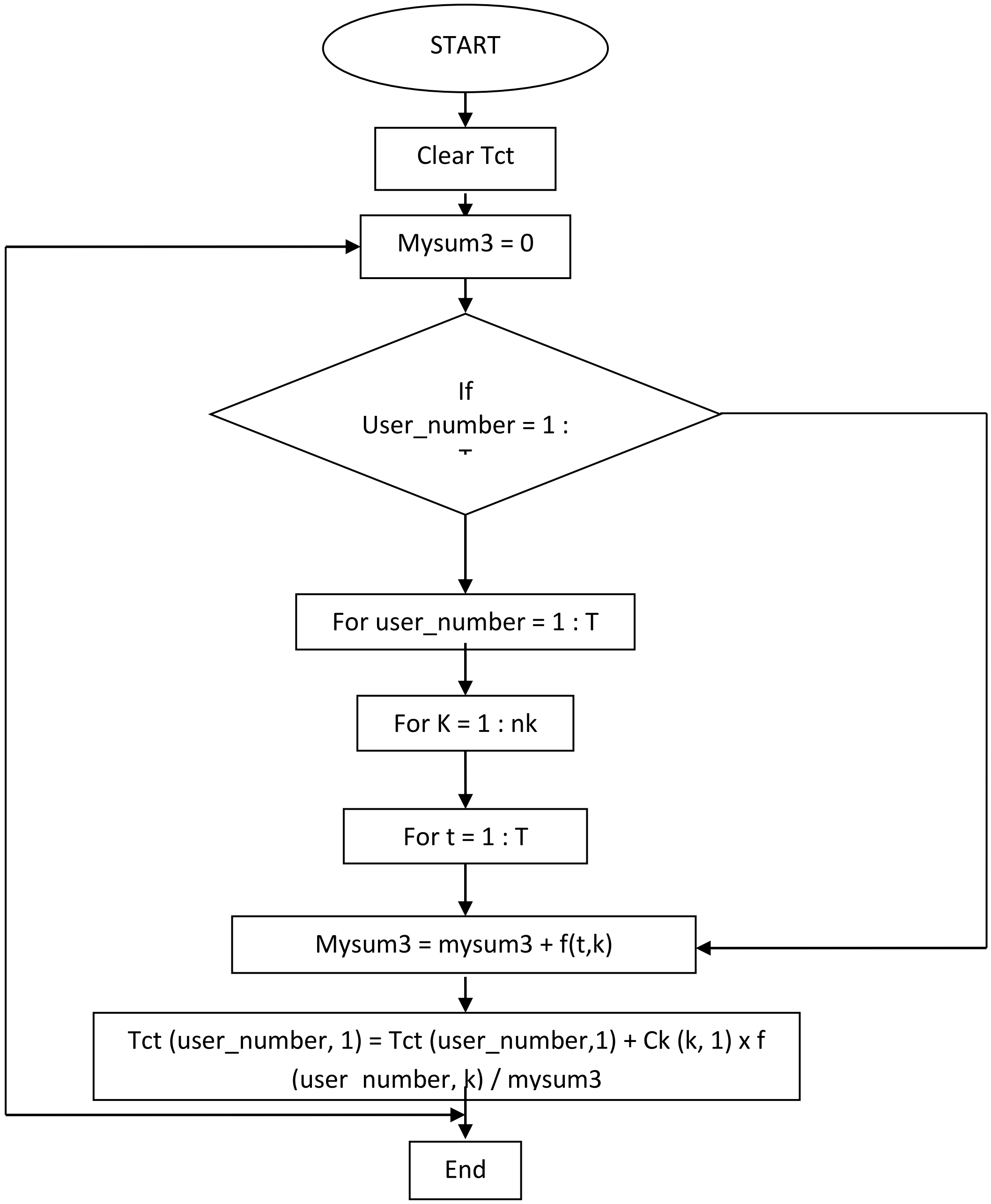

Fig.4: Flowchart for Unused Reverse MW- Mile Method

(*) Unused Zero Counter Flow MW-Mile Method

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The unused zero counter flow MW-mile method charges the users who use the network only in the same direction of the net power flow. So users responsible for the counter flows neither pay any charge nor get any credit for the counter flows. The payments are as follows [7]:

$$TC_t = \sum_{k \in K} C_k \frac{F_{t,k}}{\sum_{t \in T} F_{t,k}}, \qquad \forall F_{t,k} > 0 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..[7]$$

where TCt is the cost allocated to network user t, Ck is the cost of line k, Ft, k is the power flow on line k caused by user t, T is the set of users, and K is the set of transmission lines.

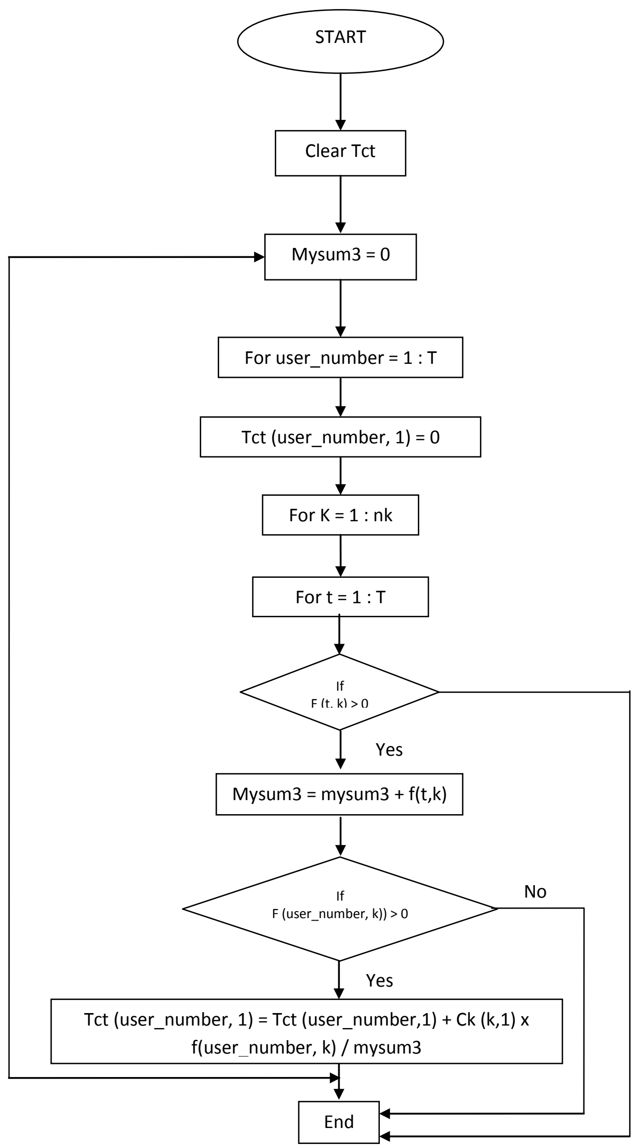

Fig.5: Flowchart for Unused Zero counter flow MW-Mile Method

(*) Used Absolute MW-Mile Method

In the used absolute MW-mile method, the charge for user t becomes [8]

$$TC_t = \sum_{k \in K} C_k \frac{|F_{t,k}|}{F_{k,max}} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots [8]$$

where TCt is the cost allocated to network user t, Ck is the cost of line k, Ft,k is the power flow on line k caused by user t, Fk,max is the capacity of line k, and K is the set of transmission lines.

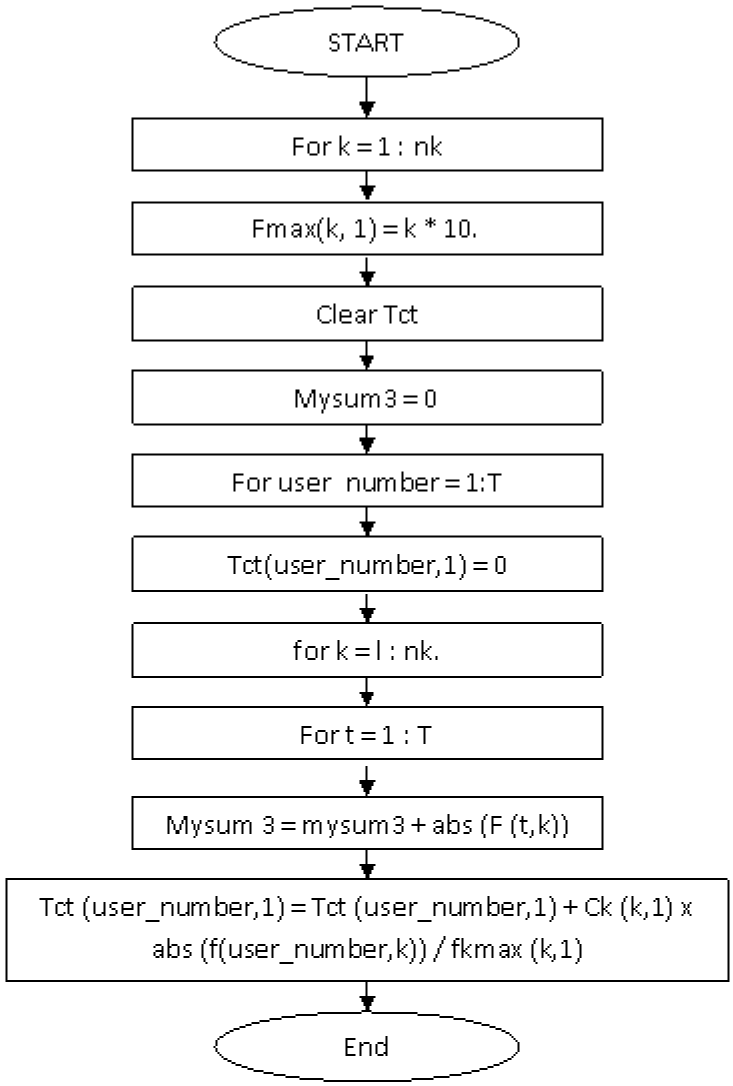

Fig.6: Flowchart for Used Absolute MW-Mile Method

(*) Used Reverse MW-Mile Method

In the used reverse MW-mile method, the charge for user t [9]

$$TC_t = \sum_{k \in K} C_k \frac{F_{t,k}}{F_{k,max}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots [9]$$

where TCt is the cost allocated to network user t, Ck is the cost of line k, Ft,k is the power flow on line k caused by user t, Fk,max is the capacity of line k, and K is the set of transmission lines.

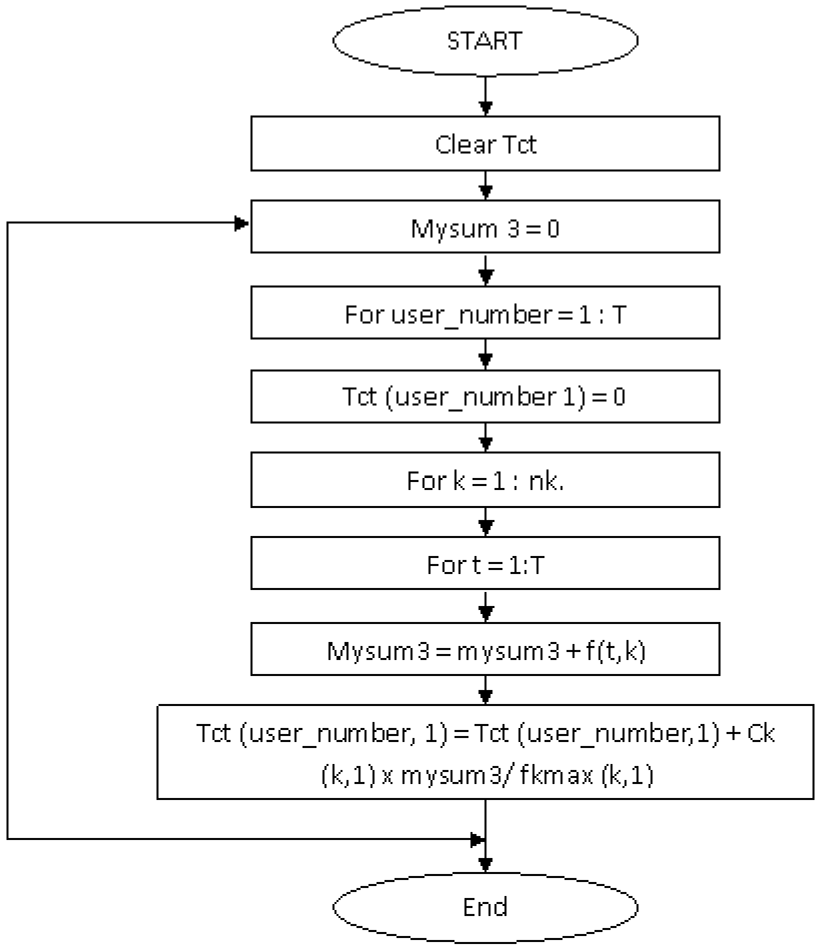

Fig.7: Flowchart for Used Reversse MW-Mile Method

(*) Used Zero Counter Flow MW-Mile Method

In the *zero counter-flow method* (zcf), reverse power flows are not counted so users responsible for the counter-flows do not pay any charge (as happens in the absolute MW-Mile approach) and do not receive any credit like (as happens in reverse MW-Mile method): The payments are as follows :

$$TC_{t,used} = \sum_{k \in K} C_k \cdot \frac{F_{t,k}}{F_{k,max}}, \qquad \forall F_{t,k} > 0 \ldots\ldots\ldots\ldots\ldots\ldots\ldots [10]$$

where TCt is the cost allocated to network user t, Ck is the cost of line k, Ft,k is the power flow on line k caused by user t, T is the set of users, and K is the set of transmission lines.

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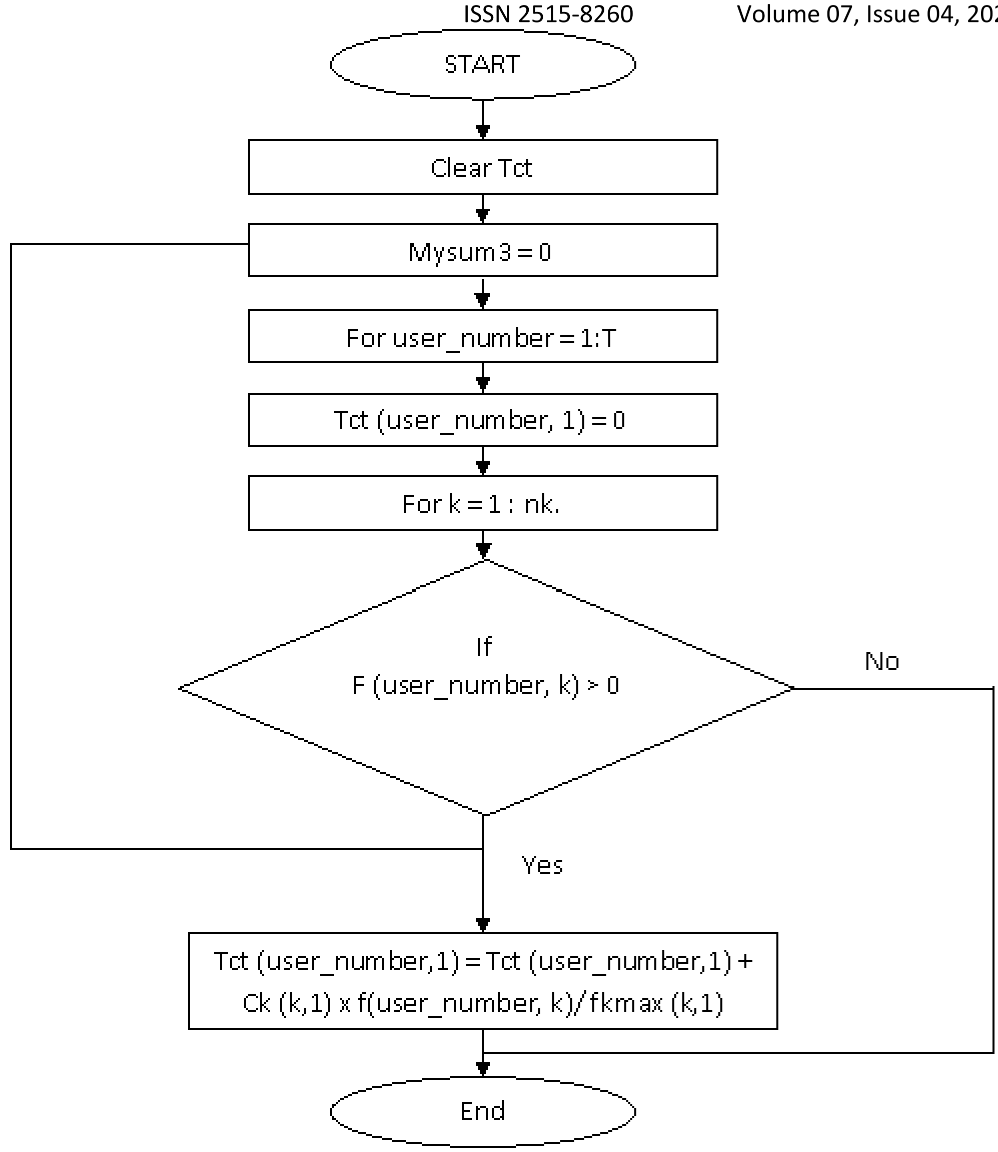

Fig.8: Flowchart for Used zero counter flow MW-Mile Method

3. 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.

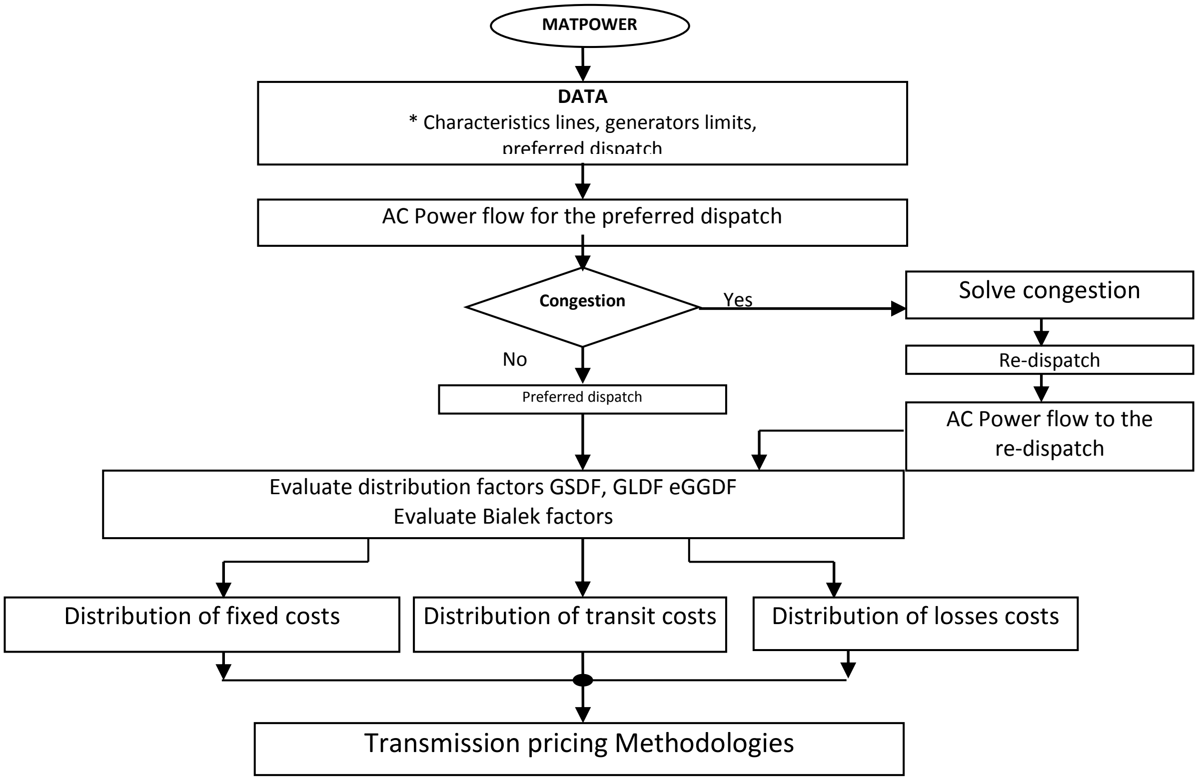

Fig.9: Flowchart for re-dispatch based congestion management.

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

4. Results of Transmission Pricing Parameters for IEEE 14 bus Case Study

The single line diagram of IEEE-14 bus test system is shown in Fig.10. The system consists of 5 synchronous generators. Associated flow results along with Transmission Pricing are given in Figures and Table as shown below. Table 1 and 2 gives the idea about initial dispatch and re-dispatch value. which is given in Fig.11 it also gives their differences. Result indicates that the difference in load demands at generator bus , whereas difference at other buses are zero. Table 3 provide the contribution of each generator and each load to the line flows under all methods. It illustrate the different results and characteristics between the pricing schemes for each pricing method. The obtained results are shown in Fig 12.This figure gives the solution for the minimum power transaction problems. Unused reverse Mw-mile method gives the minimum price. Fig.12, Fig.13 and Fig.14givesTransmission Pricing based on different pricing methods at Generator Buses tested under three conditions like on actual load, 5% increase in load and 10 %

increase in load. Tabular representation is given in table 3,table 4 and table 5 Analysis is that Unused reverse Mw-mile method gives the minimum price under three different load conditions. The results indicates that the unused MW-mile method will be the preferred for calculating the transmission pricing. Numerical examples are provided to compare the results using different pricing methodology. At the End of the paper, a case study is carried out to access the effectiveness of the methodology developed.

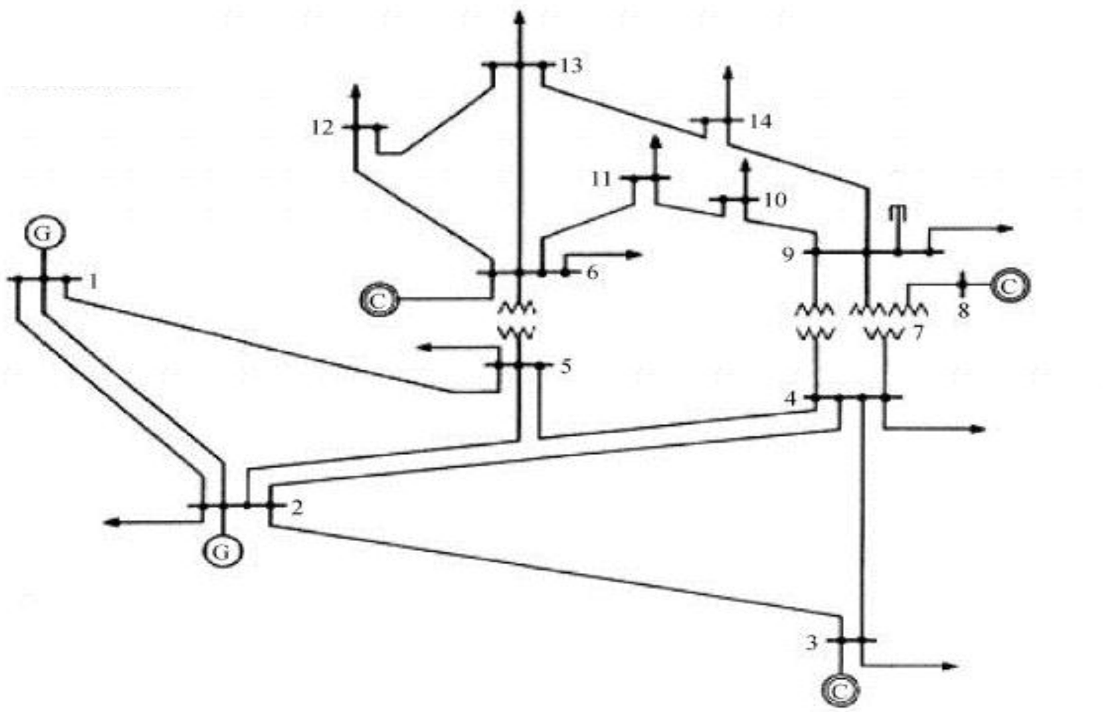

Fig 10. Single Line Diagram of IEEE 14 bus test system

Table 1 : Congested lines for Initial Dispatch

Line	Maximum Capacity	Expected line flow capacity	Actual Line flow
1	90	81	84.1196
2	50	45	45.0642

Table 2 : Re-Dispatch (MW)

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Line	1	2
OPF	112.5	62.5

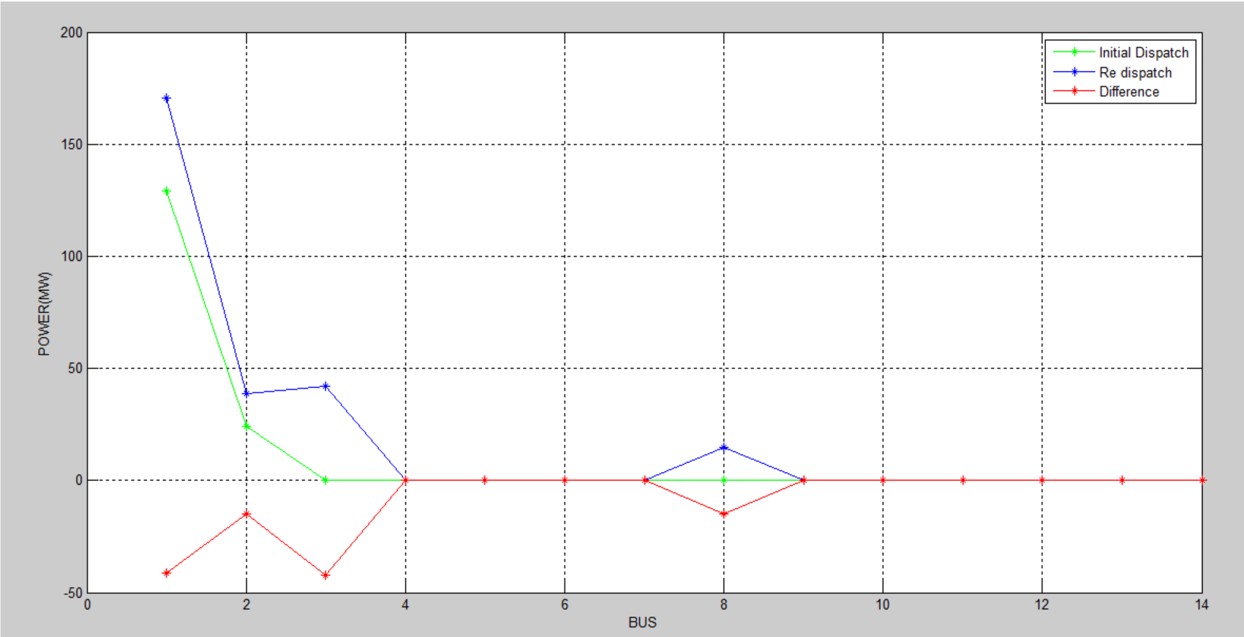

Fig 11. Difference in Initial power flow and Re-Dispatched Power at All Buses in Power System.

Table 3 : Tabulated Transmission Pricing based on different methods when load demand is actual

	G1	G2	G3	G4	G5
Postage Stamp	40970	9279	10118	10000	3559
MW-Mile (original)	39595	35331	31248	26098	24000
Unused absolute MW-Mile	2383	2918.7	1761.3	999.2	1116.8
Unused reverse MW-Mile	2252.7	2546.8	1574.7	813.8	1011.8
Unused ZCF MW-Mile	2325.7	2754.1	1678.8	917.5	1071
Used absolute MW-Mile	29682	35987	21614	10307	11661
Used reverse MW-Mile	28380	32898	20065	8582	10477
Used ZCF MW-Mile.MW	29031	34443	20840	9444	11069

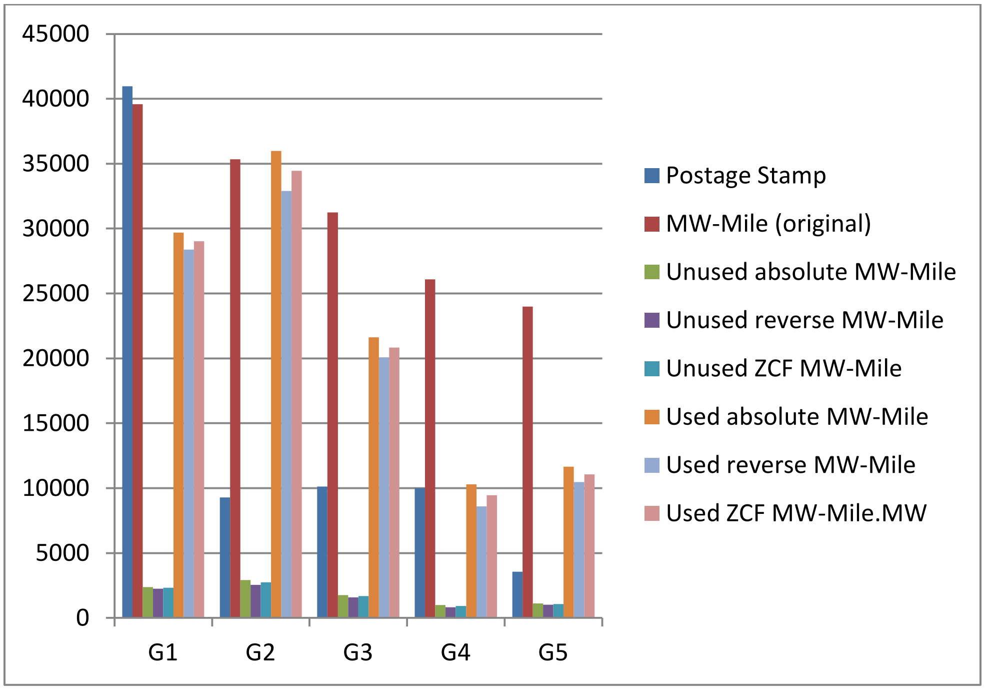

Fig 12. Transmission Pricing based on different pricing methods at Generator Buses when load demand is actual

Table 4 : Tabulated Transmission Pricing based on different methods when load demand increased by 5%

	G1	G2	G3	G4	G5
Postage Stamp	35031	9774	13524	38	5150
MW-Mile (original)	24617	27234	26431	24104	24000
Unused absolute MW-Mile	2159.8	2992.7	2178.6	1226	1156.2
Unused reverse MW-Mile	2018	2778.9	1891.6	1161.2	1165.8
Unused ZCF MW-Mile	2095.4	2895.2	2047.7	1196.8	1161.1
Used absolute MW-Mile	27494	40258	26630	14402	13246
Used reverse MW-Mile	25824	38209	23793	13404	12922
Used ZCF MW-Mile.MW	26659	39233	25212	13903	13084

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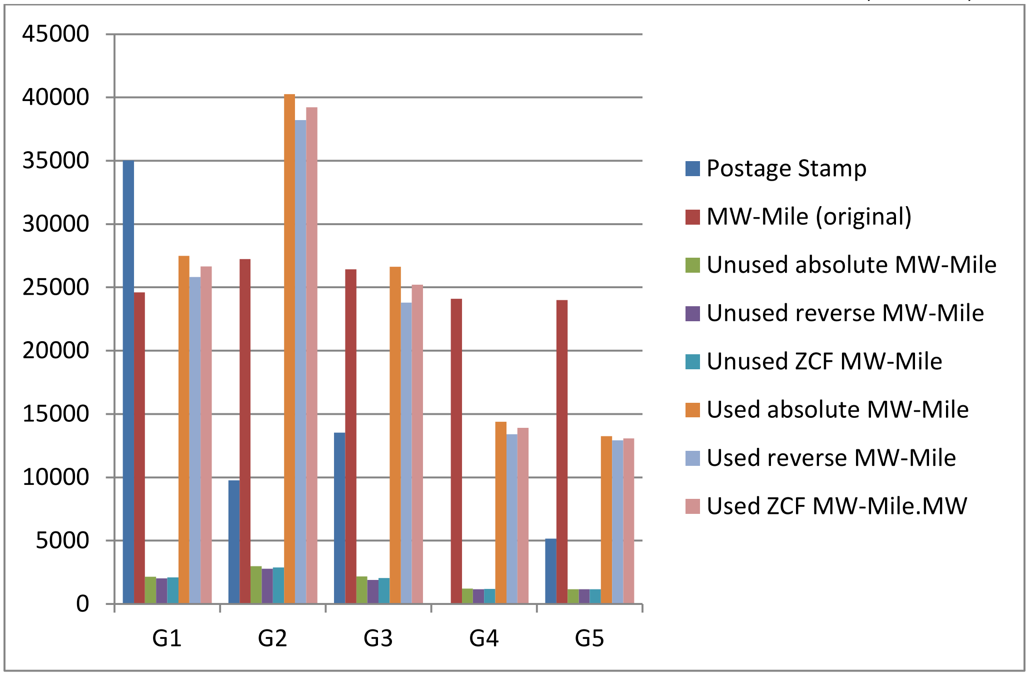

Fig 13. Transmission Pricing based on different pricing methods at Generator Buses when load demand is increased by 5 percent

Table 5 : Tabulated Transmission Pricing based on different methods when load demand is increased by 10 %

	G1	G2	G3	G4	G5
Postage Stamp	36521	9650	12676	8	4758
MW-Mile (original)	25130	26014	26047	24904	24000
Unused absolute MW-Mile	1221.7	1528.8	1405	1214.9	1060.3
Unused reverse MW-Mile	1025.3	1363.3	1259.5	914.1	785
Unused ZCF MW-Mile	1137.3	1458.6	1343	1085	941.4
Used absolute MW-Mile	1233.8	1576.9	1407.2	1165.4	1008
Used reverse MW-Mile	10489	13857	12449	9088	7830
Used ZCF MW-Mile.MW	11414	14813	13260	10371	8955

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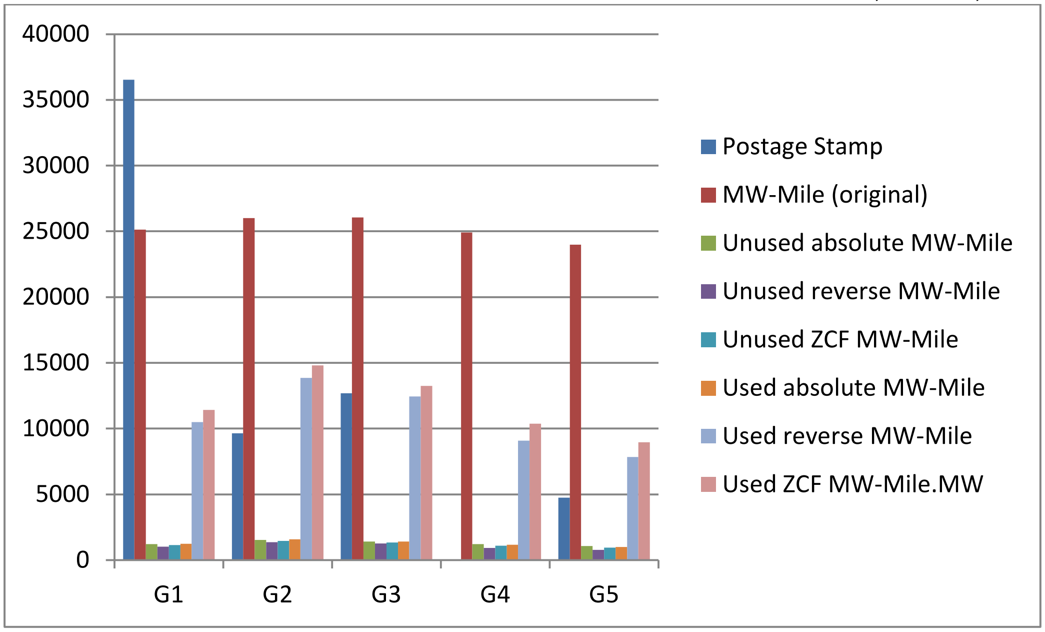

Fig 14. Transmission Pricing based on different pricing methods at Generator Buses when load demand increased by 10 percent

5. Results of Transmission Pricing Parameters for IEEE 30 bus Case Study

The single line diagram of IEEE-30 bus test system is shown in Fig. 15. The system consists of 8 synchronous generators and the system has 21 load points. Associated flow results along with Transmission Pricing are given in Figures and Table as shown below. Table 6 and 7 gives the idea about initial dispatch and re-dispatch value which is given in Fig.16 it also gives their differences. Table 8 provide the contribution of each generator and each load to the line flows under all methods. It illustrate the different results and characteristics between the pricing schemes for each pricing method. The obtained results are shown in Fig 17 This figure gives the solution for the minimum power transaction problems. Unused reverse Mw-mile method gives the minimum price. Fig.17, Fig.18 and Fig.19 gives Transmission Pricing based on different pricing methods at Generator Buses tested under three conditions like on actual load, 5% increase in load and 10 % increase in load.. Tabular representation is given in table 8,table9 and table10. Analysis is that Unused reverse Mw-mile method gives the minimum price even if the load changes. Numerical examples are provided to compare the results using different pricing methodology. The both the case study, result indicates that unused reversed MW-mile method for transmission pricing is most suitable method.

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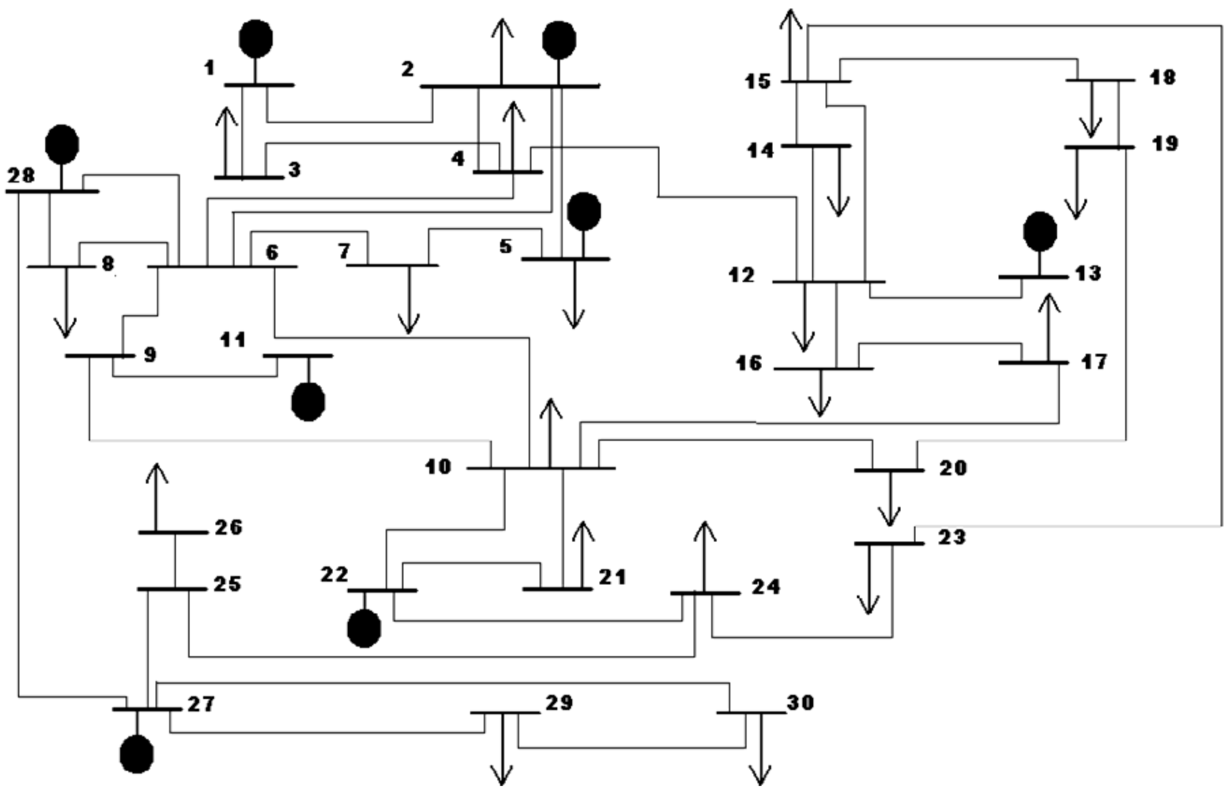

Fig 15. Single Line Diagram of IEEE 30 bus test system

Table 6 : Congested lines for Initial Dispatch

Line	Maximum Capacity	Expected line flow capacity	Actual Line flow
1	50	45	46..5290
2	20	18	19.9822
5	30	27	29.9942
9	30	27	29.9986
13	30	27	29.9867
16	30	27	29.9937

Table 7 : Re-Dispatch (MW)

Line	1	2	5	9	13	16
OPF	62.5	25	37.5	37.5	37.5	37.5

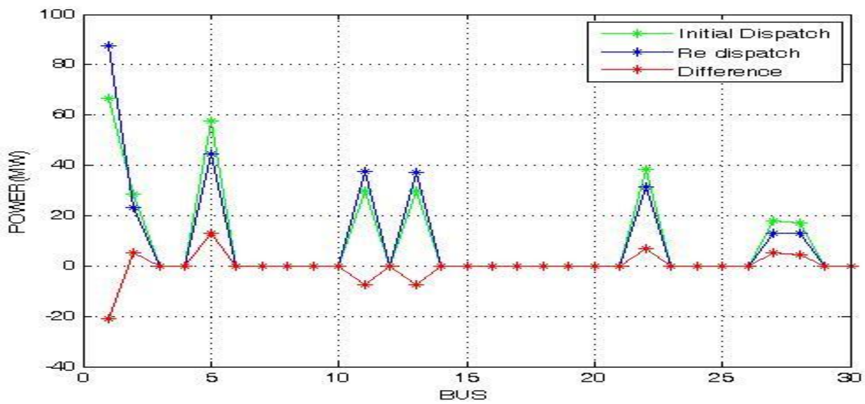

Fig 16. Difference in Initial power flow and Re-Dispatched Power at All Buses in Power System.

Table 8 : Tabulated Transmission Pricing based on different methods when load demand is actual

	G1	G2	G3	G4	G5	G6	G7	G8
Postage Stamp	20997	5604	10734	8994	8950.3	7523.3	3075.7	3099.8
MW-Mile (original)	21331	15188	16821	16530	13748	15726	15281	15000
Unused absolute MW-Mile	589.5813	412.3119	620.2634	648.5309	505.0881	497.0704	583.4231	617.1611
Unused reverse MW-Mile	383.8171	232.9476	462.0951	437.2383	207.2587	405.2488	372.4666	431.5599
Unused ZCF MW-Mile	509.6929	346.8107	558.7132	571.6908	391.3002	464.1904	500.2527	544.28
Used absolute MW-Mile	7390.8	4227.4	8604.3	8376.5	5988.5	5880.5	7871.4	7995.3
Used reverse MW-Mile	5761.1	2859.9	7357.9	6865.3	3921.3	5066.8	6296.8	6541
Used ZCF MW-Mile.MW	6775.9	3543.6	7981.1	7620.9	4954.9	5473.7	7084.1	7268.1

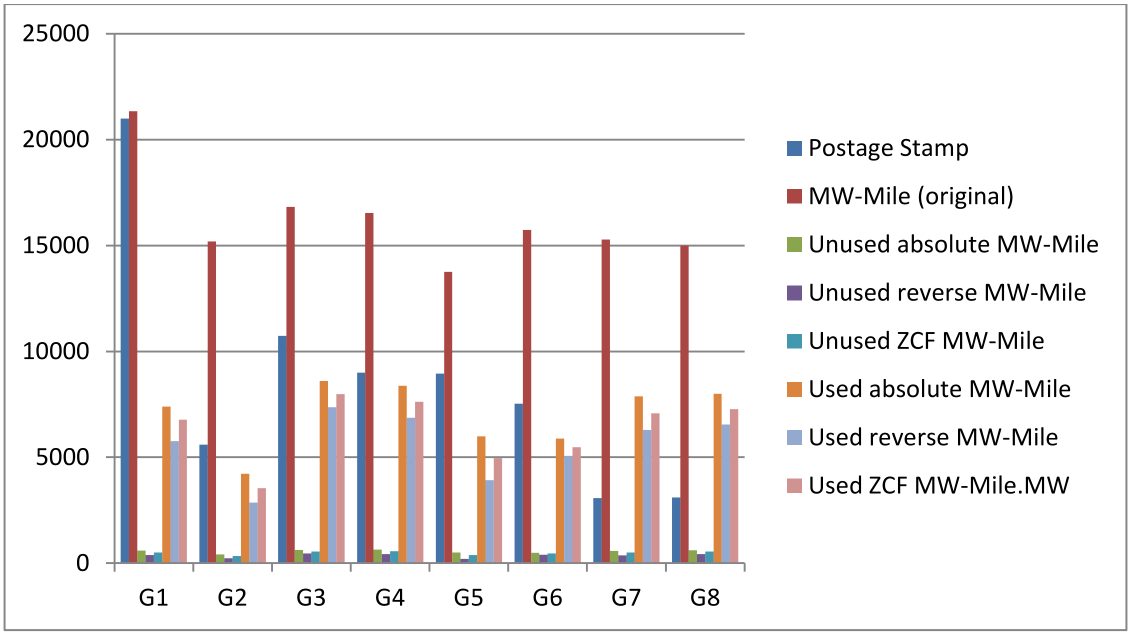

Fig 17. Transmission Pricing based on different pricing methods at Generator Buses when load demand is actual

Table 9 : Tabulated Transmission Pricing based on different methods when load demand is increased by 5 percent

	G1	G2	G3	G4	G5	G6	G7	G8
Postage Stamp	12449	4897	4581	10041	8551	6442	2772	4000
MW-Mile (original)	16605	13673	15297	13342	14134	13814	14098	15000
Unused absolute MW-Mile	636.76 14	436.23 61	556.22 23	448.54 56	549.52 77	452.96 73	402.92 93	608.56 64
Unused reverse MW-Mile	459.13 29	345.56 92	357.14 28	214.45 53	438.84 3	232.46 98	240.50 95	438.52 3
Unused ZCF MW-Mile	574.80 72	404.96 8	491.18 64	359.20 46	505.10 05	371.44 57	345.42 04	548.31 59
Used absolute MW-Mile	80054	55514	53600	55208	66210	48018	35194	63597
Used reverse MW-Mile	6793.6	4740.3	4166.7	3928.1	5641.5	3199.7	2452.4	5212.6
Used ZCF MW-Mile.MW	7399.5	5145.8	4763.4	4724.4	6131.2	4000.7	2985.9	5786.1

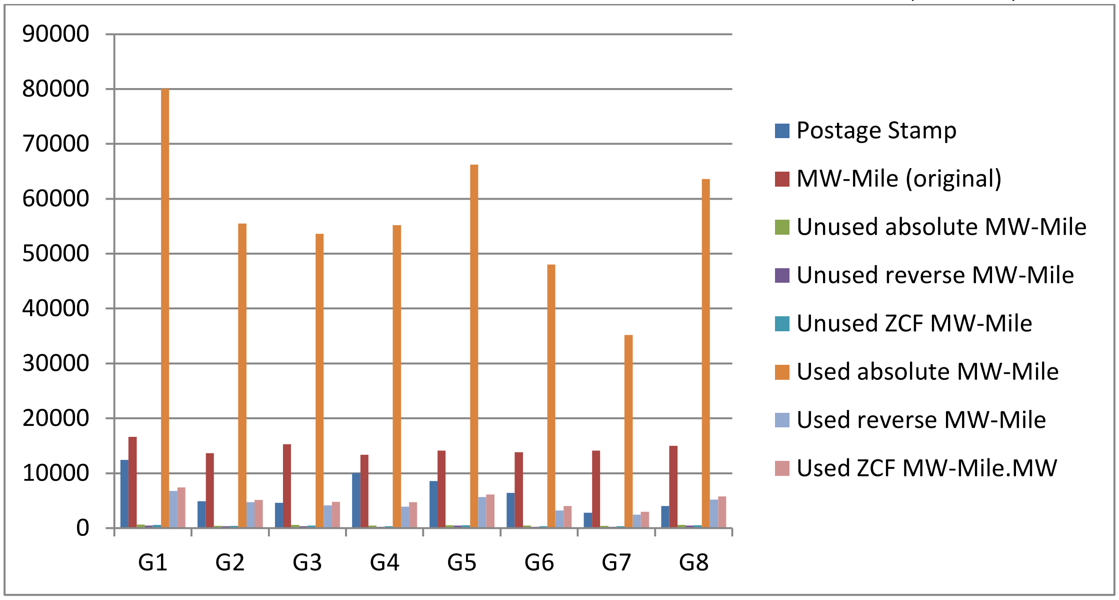

Fig 18. Transmission Pricing based on different pricing methods at Generator Buses when load demand is increased by 5 percent

Table 10 : Tabulated Transmission Pricing based on different methods when load demand is increased by 10 percent

	G1	G2	G3	G4	G5	G6	G7	G8
Postage Stamp	22215	18925	17966	14988	15213	14613	15249	15000
MW-Mile (original)	20615	15541	15059	14373	14474	14511	14678	15000
Unused absolute MW-Mile	10022	4690	5842	6844	6364	8202	8641	7210
Unused reverse MW-Mile	912.4293	402.0945	487.3463	551.7121	554.7381	715.7953	718.1917	595.8288
Unused ZCF MW-Mile	975.9226	448.5462	554.5674	640.3852	613.3504	785.6229	815.6329	678.3815
Used absolute MW-Mile	13617	4580	6340	8238	7656	10330	11837	8993
Used reverse MW-Mile	12969	4008	5579	7368	6944	9603	10848	8039
Used ZCF MW-Mile.MW	13293	4294	5960	7803	7300	9966	11343	8516

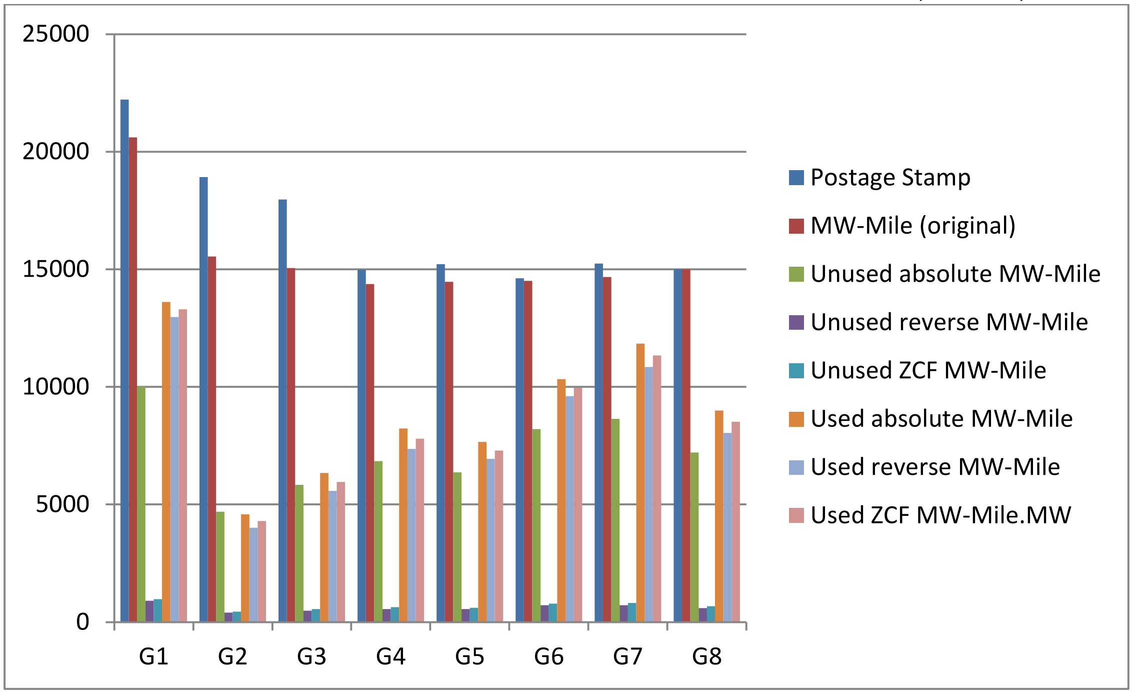

Fig 19. Transmission Pricing based on different pricing methods at Generator Buses when load demand increased by 10 percent

6. Conclusion

This paper presents computation of different transmission pricing for a case study of standard IEEE 14 bus and IEEE 30 bus system as an integral part of simulator built for deregulated power trading. Features of simulator include in depth analysis of various pricing schemes, management scheme and effect of Re-dispatch with optimal power flow constraint to relieve congestion. The programmed simulator offers a set of methods to calculate the allocation of these costs by the loads and generators and re-dispatch criteria. The trading philosophy with contracts based on different pricing can be negotiated in techno-economical way. In this paper we presented a case study based on the IEEE 14 and IEEE 30 bus network. Several congestion situations and transactions along with pricing both in the pool and bilateral contracts were analyzed and pricing based re-dispatch congestion management with economics as integral part proved to be effective as a temporary solution. MATPOWER calculation gets economical boost with such strategy. All the methods have been tested for all the pricing methods on IEEE 14 bus and IEEE 30 bus system. The methods were implemented in MATLAB, while optimal power flow was also used for the purpose of the method's evaluation. In this paper eight transmission pricing methodologies have been evaluated. Moreover, it is clear that Unused reverse MW-Mile method

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gives minimum pricing method even when the load changes. However, this pricing method are able to fulfill transmission pricing objectives: economic efficiency non-discrimination, transparency and cost coverage and can be also applied to large power system.

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