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Dynamic load in Transmission Cost for Electricity Markets

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***Abstract*—One of the most significant discussion in electricity market are transmission cost. It is becoming increasingly difficult to ignore the load changing's effects ,but in real electricity markets, loads are varying continuously. This paper has been focused on proposes a method that had flexibility on dynamic loads. Also determine the effect of different loads in transmission cost for electricity markets. At the first proposed method tested on 4-bus system then case study based on the IEEE 24-bus system is used to illustrate the load's effects on transmission cost for the participants. Some relevant results are finally shown.**

Keywords-Transmission cost allocation; Load's effect; Deregulation markets; Demand Response; Varing load; Electricity markets.

I. INTRODUCTION

ALL the governments in world are in developing on the power system deregulation or power marketing. However one of the aspects in deregulated power systems is transmission costs and methods that obtained. That is main, what method is fairly because in competition markets one of the main subjects is cost charging for participants [2]. Participants in power systems defined, generators and demands. So far these methods have only been applied to allocate transmission cost for usage network .loads and generators in network called usages network or participants. But all the methods are in ideal condition in other words one of the main factors in markets is load that assumed fixed. In real deregulated power systems demand is varying naturally. This paper allocates the usage costs to the buses directly. Different loads are one of the problems for electricity market and smart grids.

This paper is based on load flow equation. Next stage determined apparent load flow in lines. Then calculate the usage share of each bus to allocate active loads to the buses and in addition obtained the transmission cost in lines. We should be selecting a standard power system to execute the relations for transmission costs. At first this method tested on 4-bus power system and also to apply this relation in large dimension, IEEE-24bus RTS79 selected. Analyzing three states for this case study are: system with base load, system with increase in all the loads up to 10 percent (that signed with *ul* subscript) and decrease in all the loads to measure of 10 percent (that signed with *dl* subscript). For these states obtained transmission cost for all the buses. Then analyzing these demands changing in buses on the buses cost. Assume that power market is pool based.

II. TRANSMISSION USAGE COST

A. Power Flow Equations

For calculating of usage share for each bus should be determine power flow in all the lines. To reach to this purpose is necessary to write power flow relation. At first shown a model for transmission line in fig1 and Consider power S_{ij} calculated in bus i and the line connecting bus i to bus k then complex power flow is S_{ij} and:

$$S_{ij} = V_i I^*_{ij} \tag{1}$$

Consider line i-j shown in Fig.1 current flowing in this line written as (4)

$$I_{ij} = y_{ij}(V_i - V_j) + y_{i0}V \tag{2}$$

Voltage in node *i* yields:

$$V_i = \sum_{k=1}^{n} Z_{i,k} I_k \tag{3}$$

Current flowing between i, j bus can be written by (4):

$$I_k = \left(\frac{S_k}{V_k}\right)^* \tag{4}$$

From two relations 1and 2 can to write the apparent power as shown in (5) and (6):

$$S_{ij} = V_i(y^*_{ij}(V^*_i - V^*_j) + y^*_{i0}V^*_i) \tag{5}$$

$$S_{ij} = V_i y^*_{ij}(V^*_i - V^*_j) + y^*_{i0}V_iV^*_i \tag{6}$$

We can write the V_i with consider (4) into (3) as shown:

$$V_i = \sum_{k=1}^{n} Z_{ik} \left(\frac{S_k}{V_k} \right)^* \quad (7)$$

$$V_i = \sum_{k=1}^{n} \left(\frac{Z_{i,k}}{V_k^*} \right) S_k^* = \sum_{k=1}^{n} x_k S_k^* \quad (8)$$

We defined x_k in upper equivalent , at same work in V_j we have similar to (8) for bus j yields:

$$V_j = \sum_{k=1}^{n} \left(\frac{Z_{j,k}}{V_k^*} \right) S_k^* = \sum_{k=1}^{n} w_k S_k^* \quad (9)$$

Substituting (8) and (9) in (6) given by:

$$S_{ij} = \left[y_{ij}^* \sum_{k=1}^{n} x_k S_k^* \right] \left[\sum_{k=1}^{n} x_k^* S_k - \sum_{k=1}^{n} w_k^* S_k \right] + y_{i0}^* \left[\sum_{k=1}^{n} x_k S_k^* \right] \left[\sum_{k=1}^{n} x_k^* S_k \right] \quad (10)$$

B. Transmission Allocation to Buses

After step is to determine share of usage allocated by buses i and j .is better to write equation (10) by matrix form, but before defined some of the variables as fellow:

S_l apparent power flow in line *l*
S_{bus} bus injection (generate in bus- load in same bus) with dimension [k×1]

D_l equivalent by $y_{ij}^* x_k$

C_l equivalent by $x_k^* - w_k^*$

E_l equivalent by $y_{io}^* x_k$

A_l equivalent by x_k

Where:

$$F_l = D_l C_l^T + E_l A_l^T$$

Now equation (10) is performed as follows to matrix form:

$$S_l = \left[(S_{bus}^*)^T D_l C_l^T S_{bus} \right] + \left[(S_{bus}^*)^T E_l A_l^T S_{bus} \right] \quad (11)$$

$$F_L = D_L C_L^T + E_L A_L^T \quad (12)$$

$$S_l = (S_{bus}^*)^T F_l S_{bus} \quad (13)$$

Relation 11 given the apparent power flow in each line but we considered active power, then we needed to the P (MW) in system this decomposed by:

$$S_{bus} = P_{bus} + jQ_{bus} = (1 + j\frac{Q_{bus}}{P_{bus}}) P_{bus} \quad (12)$$

$$S_{bus} = \sigma \; P_{bus}$$

Relation 13 can be written in another form:

$$S_l = P_{bus}^T (\sigma^* F_l \sigma) P_{bus} \quad (13)$$

$$S_l = P_{bus}^T \mu_l P_{bus} \quad (14)$$

Based in this method need to determine the usage of each transaction on each branch. That is main, how to determine the usage in every branch. Equation 14 can be written as:

$$P^T \mu_l P = \sum_{i=1}^{n} \sum_{j=1}^{n} \mu_{l,ij} P_i P_j = \sum_{i=1}^{n} \mu_{l,ii} P_i^2 + \sum_{i=1}^{n} \sum_{j=1}^{n} \mu_{l,ij} P_i P_j \quad (15)$$

$$S_{l,k} = \mu_{l,kk} P_k^2 + \sum_{i=1}^{n} \left(\frac{|P_k|}{|P_i| + |P_k|} \right) \times (\mu_{l,ik} + \mu_{l,ki}) P_i P_k \quad (16)$$

$S_{l,k}$ is share of usage measure for bus K in line L. but in this paper we focused on active power . Then can be written as fellow:

$$P_{l,k} = \mathrm{Re}\,al\{S_{l,k}\} \quad (17)$$

C. Transmission Cost Allocation to Buses

After this step should be determine cost usage in each line separated. Charging cost is calculated different but is usage based that take a factor from line reactance (X_L)

Where:

$C_{P_{l,k}}$ Cost of active power usage from line *l* in bus k

$$C_{P_{l,k}} = (1000 * X_L) * P_{l,k} \quad (\$/h) \quad (18)$$

III. Illustration of the Application of the Method

For the purpose of illustration 4-bus system is used to show the result of this method. The single diagram of the 4-bus system is shown Fig.2 with 2 loads and 2 generators [1].

This method applied in this system, describes in tables and compared with other methods.

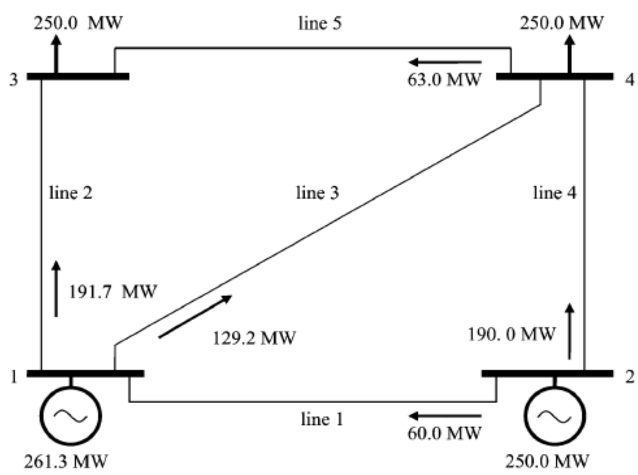

Figure2. 4-bus test system

Consider that all buses are similar in terms of generations and loads. For lines, the five lines in the system have similar condition as follows:

Series resistance : 0.01275 pu

Series reactance : 0.097 pu

Susceptance (shunt admittance): 0.4611 pu

We assume that loads are fixing and without changing. For this system ignore the lines loss and also assume that all the generating can be consumed in this system.

We shown the result of transmission cost allocation to each bus in Fig2. The numerical obtained from proposed method compared with those obtained using method in pervious methods, those are EBE, proportional sharing (PS), pro data (PR),Z_{bus} and Z_{bus}^{ave} .[1,2]

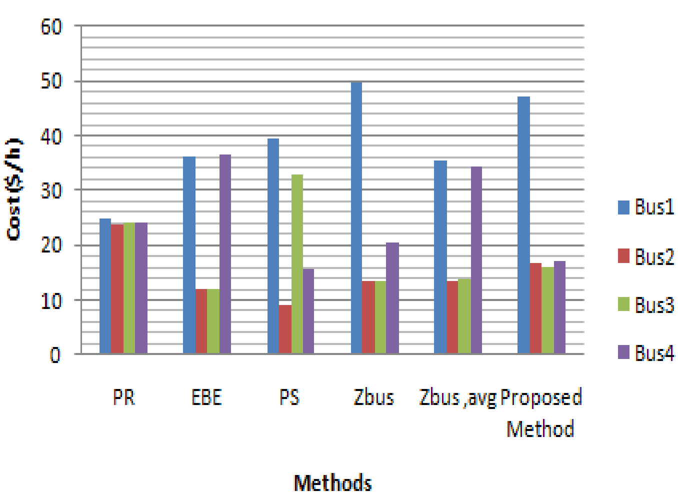

Fig2.Difference of cost between six methods

Fig2. For illustration was shown the transmission cost for each bus in line3 and is define that Z_{bus}^{avg} and proposed method in this paper are fairly, because in line 3 there is buses1and 4 have direct role in this line and we have expect that allocated maximum cost to another buses. Now should be take sum cost share of all the lines for each bus that was shown in table1.sumation cost of all the line is 495$ where obtained from:

$X_l \times 1000 \times 5 = 495$ $

Highest cost is relation to the bus 1 and 2 and is define that this proposed method have slowly trend to the generation to ratio of load.

TABLE 1
Transmission cost allocation to bus

Bus	Cost($/h)					
----	Proposed Method	Z_{bus}	Z_{bus}^{avg}	EBE	PS	PR
1	134.79	128.3	114.06	115.6	94.9	123.9
2	163.23	183.4	129.09	126.9	147.6	118.5
3	87.47	78.3	131.44	126.9	105.9	121.3
4	99.51	95.0	110.41	115.6	136.6	121.3
Total	485.0	485.0	485.0	485.0	485.0	485.0

IV. EFFECT OF VARITY LOAD ON BUSES COST IN CASE STUDY

This paper after present of method and his application in 4-bus system and test of relations in transmission cost allocation and compare with other methods wants to be changing the loads in all the including load buses in standard system. For this purpose is necessary to increase all the load in buses up to 10 percent(%10) then decrease load similar before down to 10 percent(-%10) and analyzing obtained the results .

In this study we present the case study results for the applications of the proposed method which has been applied to the IEEE 24 bus test system. That is usage-based which cost in each line calculated as follow:

$$C_l = 1000 \times X_l \qquad (17)$$

X_l : Reactance of every line in power system

Obtained results written in table .3.

First time select a base loads and share of each bus from cost in electricity market, calculated.

In each bus that every both participants are exist, usage ratio, become divide between usages of participants. Participants are including of demands and generators [9, 10]. In 11, 12 buses transmission cost is zero because of absence of participants. These usages cost for demands and generators that shown in table s 2, 3and 4. We know that operations method in power electricity have two models, are called: pool market and bilateral market. This paper has emphases on pool market. This method have depend on to the injection real power .We expect that in every power system where haven't nor load and generation, transmission cost will be obtained zero. This is destination in buses number 11, 12,17and24.

V. CONCLUSION

The purpose of the current study was to determine a method in transmission cost allocation and it's cost response to the different demand. Now all the result has been necessary to analyzing that in different load was shown in tables 2,3and 4 has same cost (2908.93 $/h) and this have 2 means, first we use from all of the grid in another word we use from all the lines for transmission of real power, second, transmission company in deregulated power system is independent and we pay the constant fee for lines rent. In tables I , II and III was notice that in each bus in up load we had increasing in cost in that in same bus we had decrease cost but in down load, and this trend for all the buses is true. In addition measure of increasing in load is not linear ratio with cost for increasing or decrease .Fig3 has been shown transmission cost for 24 buses in power system in three states (in base load, up load and down load) and this figure is a nonlinear relation between load growth and cost .Transmission cost for all of the system in every state is constant. This method because if use from load flow and true result in verity load can be use in smart grids and electricity market.

TABLE II. LOADS AND COSTS FOR BUSES IN IEEE 24-BUS RTS 79 IN BASE LOAD

Bus No.	Base load				
	Load P_1(MW)	*cost C_1($/h)*	*Bus No.*	*Load P_1(MW)*	*cost C_1($/h)*
1	100	83.55	13	250	12.01
2	100	108.74	14	200	197.61
3	180	206.91	15	300	72.11
4	75	54.17	16	100	12.68
5	75	94.03	17	0	0.00
6	100	89.00	18	350	37.35
7	120	255.51	19	200	115.12
8	150	183.5	20	150	63.84
9	150	163.42	21	0	295.3
10	200	80.33	22	0	370.29
11	0	0.00	23	0	413.46
12	0	0.00	24	0	0.00
			Total	2800	2908.93

FIG3.COST AXIS FOR ALL THE BUSES FOR VERITY LOADS

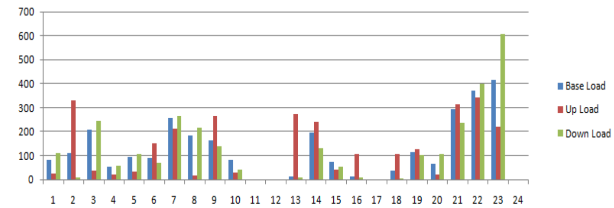

TABLE III. LOADS AND COSTS FOR BUSES IN IEEE 24-BUS RTS 79 IN UP LOAD

Bus No.	Up load				
	Load P_{u1}(MW)	*cost C_{u1}($/h)*	*Bus No.*	*Load P_{u1}(MW)*	*cost C_{u1}($/h)*
1	110	24.37	13	275	273.14
2	110	331.65	14	220	241.06
3	198	35.04	15	230	40.07
4	82.5	19.64	16	110	107.04
5	82.5	32.73	17	0	0.00
6	110	150.30	18	385	106.09
7	132	213.28	19	220	127.34
8	165	17.81	20	165	20.62
9	165	265.87	21	0	312.40
10	220	30.22	22	0	342.08
11	0	0.00	23	0	218.18
12	0	0.00	24	0	0.00
			Total	3080	2908.93

TABLE IV. LOADS AND COSTS FOR BUSES IN IEEE 24-BUS RTS 79 IN DOWN LOAD

Bus No.	Down load				
	Load P_{d1}(MW)	*cost C_{d1}($/h)*	*Bus No.*	*Load P_{d1}(MW)*	*cost C_{d1}($/h)*
1	90	108.66	13	225	8.37
2	90	7.31	14	180	131.63
3	162	245.8	15	270	51.28
4	67.5	57.01	16	90	4.71
5	67.5	106.3	17	0	0.00
6	90	70.28	18	315	2.04
7	108	263.05	19	180	102.9
8	135	216.87	20	135	107.06
9	135	140.21	21	0	238.2

Bus No.	Down load				
	Load P_{d1}(MW)	*cost C_{d1}(\$/h)*	*Bus No.*	*Load P_{d1}(MW)*	*cost C_{d1}(\$/h)*
10	180	39.92	22	0	398.5
11	0	0.00	23	0	608.83
12	0	0.00	24	0	0.00
			Total	2520	2908.93

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