COMPARATIVE STUDY ON TRANSMISSION PRICING FOR DEREGULATED SYSTEM

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Abstract- Deregulation of the power sectors has been occurring in many countries worldwide. Many reforms have been undertaken by introducing commercial incentives in generation, transmission, distribution and retailing of electricity. There are many reasons for the restructuring of the power sectors and it depends on different countries geographical situations. MVA-Mile pricing involves load flow analysis to model the power flows on the transmission network to determine transmission charge. It expands upon the MW-Mile method into MVA-Mile method that is currently subject to considerable discussion and is under analysis. North Indian real test 37 bus test system results has been reported using MW-Mile and MVA-Mile methods and useful for power market.

Keywords- Deregulation, MW-Mile, MVA-Mile, Pricing.

I. INTRODUCTION

In the mid 80s, the economic benefits were encouraged by deregulation in the airlines and communication sector, and reforms begun to take place in the electric power industry. It has been a matter of concern that monopolized and regulated systems in the past were coupled with many problems such as inefficient system management and irrational tariff system resulting in the incapability of meeting high power demand growth. The Countries like United Kingdom, United States and Norway were among the first few players to introduce various laws and policies of deregulation to take place in their electric power industry, in order to introduce more competition in the electric power industry. Other nations have followed their footsteps for either deregulating their electric power industry or considering it. Deregulation becomes a common trend in various parts of the world.

This concept brings wheeling of power. Wheeling is considered one of the important factors to be considered by the power utilities in the modern day operations. It has been well accepted that transmission utilities should be compensated by performing various wheeling services. There has been a huge debate in the justification of the various proposed methods of compensating the wheeling utilities for the costs incurred. The Indian power sector has witnessed significant changes since early 1990s. Endemic power shortages, poor operational performance and precarious financial condition of State Electricity Boards (SEBs) prompted a number of policy and regulatory changes - focusing mainly on better management and control of the power industry and for attracting investment in the sector. In India, with the enactment of the Electricity Act 2003 and implementation of open access, the market structure in the power sector changed from the old single buyer structure to a multi-buyer model. The energy producers could sell power to any buyer using the open access provision in transmission and users had the choice to choose their supplier which will provide the economic and technical benefits. Ever since the Indian Electricity Act 2003 has introduced, this increased competition among generators and suppliers, which improved the sector's performance. Currently many states, which have unbundled the SEBs, have reported improvements in their operational efficiency and are able to ensure reliable power supply to consumers. The incorporation of transmission into this competitive framework has proven more complicated and is the subject of an ongoing debate among utilities, consumers and suppliers. Different methods to determine the pricing of wheeled power have been proposed and some of them are currently in practice in different parts of the world. However, all these methods have been subjected to various debates regarding their justification and eligibility.

Wu et al. discussed MVA power-flow and loss analysis on the basis for allocating the fixed costs and power losses under electricity-market deregulation. Wheeling pricing using MVA-KM method has been explained which applies AC power flow and considers apparent power. Ya et al. reported MVA based transmission supplement cost allocation.

The components of complex power have been computed by the generalized generation distribution factors (GGDFs) and the proposed reactive power distribution factors (RPDFs).
Kumar et al. explained MVA-Mile approach for transmission cost allocation to Indian power utility. This paper presents transmission cost allocation using MW-Mile and MVA-Mile methods on practical 37 bus test system.

II. METHODOLOGIES

MW-Mile is also known as Line-by-line method. The change in the magnitude of power flow on the system caused by wheeling transaction is taken into consideration in order to assist in the allocation of the wheeling costs of each of the wheeling transaction. One distinct feature is the length of the transmission lines used in the transaction is also taken into consideration when determining thewheeling costs MVA-Mile Method, F. Li et al. explained the methodology to evaluate the transmission network capacity use for firm transmission services including wheeling transactions. MVA-Miles method is an enhanced charging methodology over MW-Miles, it considers the extensiveness of the use of the network by network users due to their active and reactive power injection/drawn while MW-Mile method consider only active power. Still, the MVA-Miles method fails to distinguish between the direction of real and reactive power flow. The methods work well for demand and generation where they either withdrawn both real and reactive power or inject both. However, in the case of wind generator injecting real power and withdrawing reactive power, the MVA-Miles method fails to distinguish the difference in the direction of the same network user, resulting in misleading network charges. The cost is calculated as:

$$C_K = \sum_{i=1}^{N} \frac{L_i . F_i . P_i^K}{P_i} \qquad (1)$$

Where Li= length of circuit i, Fi= pre-determined unit cost reflecting the cost/mile of circuit i, (here Rs./km),N= total number of circuits in the circuit, Pik =power flow imposed on the circuit i by user k, Pi=capacity rating of circuit i. The advantage about MVA-Mile method is that it overcomes some of the limitations of rolled-in-embedded methods. It seeks to allocate the cost of wheeling based on the actual operating system usages as close as possible. However, there have been some concerns raised regarding the insufficient recovery of its embedded capital costs. This is because the total circuit power flows are usually smaller than the full system capacities. Hence, MVA-Mile method is only charging for a base case network and not taking the system reserve into consideration. In the MVA-Mile method, there are three different approaches:
a. Absolute MVA-Mile b. Reverse MVA-Mile c. Dominant MVA-Mile which is used to allocate the cost to the various users of a circuit.

Absolute approach, charge is calculated by the absolute value of the power flow whether it is positive or negative power flow .Power flow imposed on the circuit i by the user k, Pik is considered based on the following condition,

$$P_i^k = \left| P_i^k \right|$$ r direct and reverse power flows ·

Reverse approach calculates the charge for each line based on power flows. It considers the positive and negative power flows. Power flow imposed on the circuit i by the user k, Pik is treated based on the following condition,

$$P_i^k = \text{+ve for direct power flows, or}$$
$$\text{-ve for reverse power flows}$$

In the dominant MVA-Mile approach, network users are only charged on the basis of direct power flow impose on each line and power flow imposed on the circuit i by the user k, Pik is calculated based on the following condition,

$$P_i^k = \begin{cases} \left| P_i^k \right| & \text{for direct power flows,or} \\ 0 & \text{for reverse power flows} \end{cases}$$

III. CASE STUDY

MW-Mile and MVA-Mile methods have been tested on practical 37-bus test network which are shown in Fig.1. A Mat lab program has been developed to analyze the MW-Mile and MVA-Mile approaches. Test network of 37-bus (Fig.1) has 37 buses, 2 generators and 49 transmission lines at 220 kV and 132 kV voltage level. The names of the buses are given in Appendix I. The generation capacity of 1300 MW is assumed as base load condition and total load connected on the system is 911 MW. Annual revenue requirement of transmission facility is equal to 843.56 Rs-Crs. It is assumed in this analysis 100% of the transmission cost of services to the transmission utility is paid by the load customer.

Table I and Table II show the tariffs of transmission cost using MVA-Mile, MW-Mile approaches. Table III and Table IX present the tariffs to be charged to every load customer using MW-Mile and MVA-Mile methods. Obtained results show that the tariffs for the bus no. 1,2,3,4,5,6,28,29 and 31 are found zero as load is not connected to these buses and no charges are being paid.

It is obvious that the locational transmission price is different for methods of MVA-Mile and MW-Mile approaches The reverse approach has the minimum tariff while absolute approach, it is the maximum tariff. Results shown that MVA-Mile method recover higher cost.

TABLE I. WHEELING CHARGE USING MW-MILE (RS-CRS/MW/YEAR)

Bus No	Reverse	Absolute	Dominant
1	0	0	0
2	0	0	0
3	0	0	0
4	0	0	0
5	0	0	0
6	0	0	0
7	0.078	0.15	0.114
8	0.096	0.294	0.192
9	0.096	0.3	0.198
10	0.138	0.342	0.24
11	0.204	0.414	0.306
12	0.156	0.384	0.27
13	0.114	0.33	0.222
14	0.222	0.456	0.342
15	0.078	0.084	0.084
16	0.132	0.132	0.132
17	0.066	0.234	0.15
18	0.096	0.204	0.15
19	0.102	0.27	0.186
20	0.144	0.252	0.198
21	0.132	0.168	0.15
22	0.042	0.06	0.054
23	0.06	0.072	0.066
24	0.18	0.234	0.204
25	0.156	0.306	0.234
26	0.168	0.366	0.27
27	0.156	0.378	0.27
28	0	0	0
29	0	0	0
30	0.21	0.258	0.234
31	0	0	0
32	0.294	0.348	0.324
33	0.186	0.342	0.264
34	0.054	0.27	0.162
35	0.042	0.204	0.12
36	0.006	0.012	0.006
37	0.084	0.144	0.114

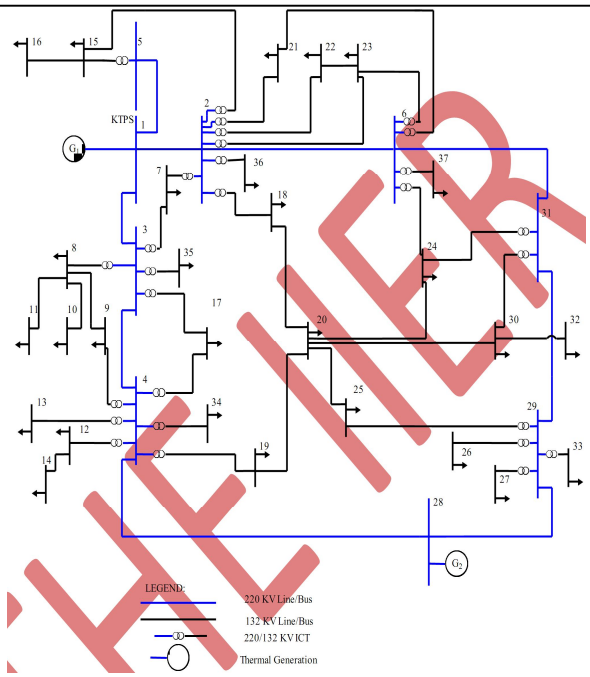


Fig.1 37 -Bus Test Network

TABLE 6.20 WHEELING CHARGE USING MVA-MILE (RS-CRS/MVA/YEAR)

Bus No	Reverse	Absolute	Dominant
1	0.000	0.000	0.000
2	0.000	0.000	0.000
3	0.000	0.000	0.000
4	0.000	0.000	0.000
5	0.000	0.000	0.000
6	0.000	0.000	0.000
7	0.061	0.139	0.100
8	0.216	0.285	0.250
9	0.190	0.279	0.235
10	0.265	0.335	0.300
11	0.341	0.413	0.377
12	0.284	0.374	0.329
13	0.227	0.314	0.270
14	0.362	0.455	0.408
15	0.079	0.080	0.079
16	0.128	0.129	0.128
17	0.149	0.215	0.182
18	0.111	0.187	0.149
19	0.229	0.250	0.239
20	0.168	0.229	0.199
21	0.027	0.076	0.051
22	0.033	0.055	0.044

23	0.050	0.069	0.059
24	0.145	0.215	0.180
25	0.135	0.273	0.204
26	0.058	0.331	0.195
27	0.071	0.346	0.209
28	0.000	0.000	0.000
29	0.000	0.000	0.000
30	0.152	0.233	0.193
31	0.000	0.000	0.000
32	0.242	0.328	0.285
33	0.039	0.309	0.174
34	0.164	0.249	0.206
35	0.115	0.190	0.153
36	0.004	0.009	0.007
37	0.070	0.128	0.099

TABLE III. PAYMENT (MW-MILE METHOD) RS-CRS

Bus No.	Load (MW)	MW-Mile		
		Reverse	Absolute	Dominant
1	0	0	0	0
2	0	0	0	0
3	0	0	0	0
4	0	0	0	0
5	0	0	0	0
6	0	0	0	0
7	18	1.404	2.7	2.052
8	28	2.688	8.232	5.376
9	10	0.96	3	1.98
10	20	2.76	6.84	4.8
11	20	4.08	8.28	6.12
12	26	4.056	9.984	7.02
13	20	2.28	6.6	4.44
14	14	3.108	6.384	4.788
15	40	3.12	3.36	3.36
16	20	2.64	2.64	2.64
17	35	2.31	8.19	5.25
18	25	2.4	5.1	3.75
19	30	3.06	8.1	5.58
20	40	5.76	10.08	7.92
21	42	5.544	7.056	6.3
22	80	3.36	4.8	4.32
23	85	5.1	6.12	5.61
24	29	5.22	6.786	5.916
25	20	3.12	6.12	4.68
26	35	5.88	12.81	9.45
27	30	4.68	11.34	8.1
28	0	0	0	0
29	0	0	0	0
30	35	7.35	9.03	8.19
31	0	0	0	0
32	25	7.35	8.7	8.1
33	35	6.51	11.97	9.24
34	42	2.268	11.34	6.804
35	25	1.05	5.1	3
36	50	0.3	0.6	0.3
37	32	2.688	4.608	3.648
Total	911	101.046	195.87	148.734

TABLE IV. PAYMENT (MVA-MILE METHOD) RS-CRS

Bus No.	Load (MVA)	MVA-Mile		
		Reverse	Absolute	Dominant
1	0	0	0	0
2	0	0	0	0
3	0	0	0	0
4	0	0	0	0
5	0	0	0	0
6	0	0	0	0
7	19.350	1.177	2.688	1.932
8	29.790	6.438	8.482	7.460
9	10.530	2.006	2.939	2.473
10	21.280	5.640	7.133	6.386
11	21.270	7.244	8.785	8.018
12	27.360	7.763	10.242	9.003
13	21.051	4.775	6.601	5.688
14	14.739	5.333	6.704	6.019
15	41.670	3.272	3.334	3.303
16	20.830	2.656	2.689	2.672
17	37.230	5.549	7.998	6.773
18	26.878	2.994	5.021	4.008
19	30.931	7.069	7.741	7.405
20	41.241	6.948	9.433	8.190
21	45.161	1.217	3.419	2.318
22	86.030	2.824	4.771	3.798
23	91.400	4.533	6.272	5.402
24	29.900	4.334	6.417	5.375
25	20.611	2.792	5.620	4.206
26	36.080	2.106	11.959	7.032
27	30.931	2.207	10.705	6.456
28	0.000	0.000	0.000	0.000
29	0.000	0.000	0.000	0.000
30	36.080	5.497	8.400	6.948
31	0.000	0.000	0.000	0.000
32	25.769	6.245	8.441	7.343
33	36.080	1.415	11.151	6.283
34	44.209	7.236	10.986	9.111
35	26.601	3.069	5.067	4.068
36	53.759	0.223	0.493	0.358
37	32.990	2.300	4.233	3.266
Total	959.750	114.860	187.723	151.295

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CONCLUSION

In this paper, a case study is presented to estimate the transmission pricing of deregulated North Indian power system. Amongst three approaches of MW-Mile and MVA-Mile methods, absolute MVA-Mile approach has been found economically efficient in order to provide sufficient revenue to the transmission owner. However, this approach has been found to recover more revenue than MW-Mile methods. In this approach both active and reactive power has been considered. Therefore this pricing scheme would be beneficial to deregulated power market.

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APPENDIX

TABLE I. NAMES OF BUSES-INDIAN UTILITY-37 BUS SYSTEM

Bus No.	Bus Name	Bus No.	Bus Name
1	KTPS (Generator)	20	Sangod
2	Sakatpura (220 kV)	21	Gopal Mill
3	Morak (220 kV)	22	Mahveer Nagar
4	Jhalawar (220 kV)	23	Industrial Area
5	Bundi (220 kV)	24	Anta
6	Dahra (220 kV)	25	Bapawar
7	MadanaTown	26	Atru
8	BhawaniMandi	27	ChhipaBarod
9	Kanwari	28	Chhabra(Generator)
10	Hemda	29	Kawai (220 kV)
11	Dug	30	Baran (132 kV)
12	Akelera	31	Baran (220 kV)
13	Bakani	32	Kelwara
14	Manoharthane	33	Kawai (132 kV)
15	Bundi (132 kV)	34	Jhalawar (132 kV)
16	Hindoli	35	Morak (132 kV)
17	Mayla Ramganj Mandi	36	Sakatpura (132 kV)
18	Deoli Manji	37	Dahara (132 kV)

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