Genetic Algorithm based Wheeling Prices Allocation for Indian Power Utility by using MVA-Mile and MW-Mile Approaches

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***Abstract*—In deregulated power system, assessment and analysis of wheeling prices become a challenging task. In Indian power sector various network users are based on a regional postage stamp method for wheeling prices. But due to changed scenario, postage stamp method does not satisfy Indian electricity policy. It is because of non linear power flow plays an important role to decide wheeling prices across transmission lines. So flow based MW-mile method for real power and MVA-mile method for real and reactive power wheeling price assessment is used now on national level. To increase efficiency of both flow based methods different optimization techniques are to be used. In this paper wheeling prices are allocated for Indian utility 62 bus system by using MVA-mile and MW-mile method based on genetic algorithm approach for optimum power flow calculation.**

Keywords: MW-Mile, MVA-Mile, Wheeling Prices[1]

I. INTRODUCTION

In last few decades electrical power industry is de-regularize due to privatization. Wheeling will be very useful especially for developing countries moving toward unbundling of electrical supply industry [1, 2]. Wheeling can be defined as "the use party's (or parties) transmission system(s) for the benefit of other parties [3, 4]. In India the enactment of the electricity act 2003 has recognized transmission as distinct business [5]. In 2006, ministry of power, government of India notified national tariff policy with the objective to recover and share the transmission cost through transmission tariff [6]. Due to this conventional postage stamp method for regional assessment is not sufficient and satisfactory approach.

MW mile approach may be first pricing strategy [7,8] proposed for the recovery of fixed transmission cost based on actual use of transmission network of real power flow, but due to counter flow and direction sensitive approach MW mile method is categorized in different part as absolute, dominant and reserve flow method.

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MVA mile is an extended version of MW mile method [9, 10]. The extension is proposed to include charges for reactive power flow in addition to charges for real power flow. Both MW mile and MVA mile are better approaches to measuring wheeling prices in Indian transmission sector [11].

Both Power flow based methods are more efficient and use with different optimization techniques. Genetic algorithm may be a suitable technique for above [12]. Genetic algorithms are adaptive heuristic search based on the evolutionary ideas of natural selection and genetics [13]. It's start with generation of initial population and then selection, crossover and mutation are performed until the best population is found [14].

II. WHEELING PRICE ANALYSIS

For calculate wheeling prices tracing method, optimal power flow and different methodologies are required. The discussion about calculation as follows.

A. Distribution Factor based Tracing Method

For security and contingency analysis distribution factor is used in power system [15]. The concept behind the use of distribution factors is to find out how a particular generator or load influences the power flow over particular transmission lines. There are three types of distribution factor [16, 17, 18].

Generation shift distribution factor (GSDF) is used to measure the incremental use of transmission network by generators or loads that is they provide line flow changes in generation and distribution [16]. Generalized generation distribution factor (GGDF) representing the impact of total generation change in generation buses in the total flow over any line. Generalized load distribution factor (GLDF) representing the impact of total load change in load buses in the total flow over any line.

B. Optimal Power Flow

The use of optimal power flow in power system operation and planning as well as power market is to optimize of an objective function for physical and operating constraints [19]. GA based optimal power flow is used for simple approximation of the main OPF in following points:

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- Read the input data, line length, MW and MVA limit.
- Generate randomly real, apparent power flows and population.

C. MW Mile Method

Power flow based MW-mile methodology allocates the Charges for each transmission facility to [7, 8] transmission Transactions based on the extent use of that facility by these transactions. As can be seen the dimension of power (MW) and distance (mile).

$$TC_t = TC * \frac{\sum_{k \in K} C_k L_k P_{t,k}}{\sum_{t \in T} \sum_{k \in K} C_k L_k P_{t,k}} \quad (1)$$

Where TC_t price allocation of network user t, TC is the total transmission cost, C_k is cost per mw per unit length of line k, L_k is line length, P is power flow (MW) in line k due to user t, T is user set and K is transmission line set.

D. MVA-Mile Method

MVA mile is an extended version of MW mile method [9, 10]. As can be seen the dimension of power (MVA) and distance (mile).

$$TC_t = TC * \frac{\sum_{k \in K} C_k L_k P_{t,k}}{\sum_{t \in T} \sum_{k \in K} C_k L_k P_{t,k}} \quad (2)$$

Where TC_t price allocation of network user t, TC is the total transmission cost, C_k is cost per mw per unit length of line k, L_k is line length, P is power flow (MVA) in line k due to user t, T is user set and K is transmission line set.

III. Problem Formulation

Optimal power flow and distribution factor have to be calculate for wheeling price calculation. Descriptions of problem areas under.

A. Optimal Power Flow Calculation

Calculation of power flow may come either from results of an optimal power flow calculation or from a power flow calculation using fixed generation input data as in Genetic algorithm based OPF formulation which are as under [19]:

$$\min f = \sum_k q_k p_{gk} + G \sum_k r_k \quad (3)$$

Where q_k is generation bid of bus k, p_{gk} is generation of bus k, r_k is load not served of bus k and G is penalty term of not supplied power.

B. Generation Shift Distribution Factor (GSDF)

Generation shift distribution factor represents the sensitivity of power flow in line l-k with respect to bus I. GSDF may be computed as [18]:

$$GSDF_{lk,i} = \frac{x_{li} - x_{ki}}{x_{lk}} \quad (4)$$

Where x_{li} reactance from line l to bus i is, x_{ki} is reactance from line k to bus I, x_{lk} is reactance between line l-k.

C. Generalized Generation Distribution Factor (GGDF)

Generalized generation distribution factor (GGDF) have been formulated rescinding the need for a reactance bus and the restriction of constant total generation. GGDF may be computed as [18].

$$GGDF_{lk,br} = \frac{fl_{lk} - \sum_{\substack{i=1 \\ i \neq br}}^{N} GSDF_{lk} P_{gi}}{\sum_{i=1}^{N} p_{gi}} \quad (5)$$

Where fl_{lk} the power flow in line l-k is, br is reference bus, P_{gi} is generation of power from generator to bus i.

$$GGDF_{lk,i} = GGDF_{lk,br} + GSDF_{lk,i} \quad (6)$$

Allocation of the usage of transmission line l-k to generator i is,

$$G_f = GGDF_{lk,i} P_{gi} \quad (7)$$

In above G_f is the flow of generator in transmission line.

D. Generalized Load Distribution Factor (GLDF)

Generation load distribution factor which formulated the contribution of each load .GLDF may be computed as [18]:

$$GLDF_{lk,br} = \frac{fl_{lk} + \sum_{\substack{i=1 \\ i \neq br}}^{N} GSDF_{lk} P_{li}}{\sum_{i=1}^{N} P_{li}} \quad (8)$$

Where fl_{lk} the power flow in line l-k is, br is reference bus, P_{gi} is generation of power from generator to bus i.

$$GLDF_{lk,i} = GLDF_{lk,br} - GSDF_{lk,i} \quad (9)$$

Allocation of the usage of transmission line l-k to load i is:

$$G_l = GLDF_{lk,i} P_{gi} \quad (10)$$

In above G_l is the flow of load in transmission line.

IV. Result and Discussion

After execution of MW-mile and MVA-mile method with Indian utility 62-bus system price should be calculated across each load and generator. Total annualized cost of transmission across Indian utility 62-

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bus system is Rs. 41214 lac. After analysis, contribution of generators and loads results were found as follows.

- Graphical representation of generator and load with percentage of total cost in Rupees determined with Indian utility 62-bus system.
- Generator and load price calculation in Rupees (lac) with Indian utility 62-bus system.

Result of calculation of wheeling prices at generator and load buses is as under:

A. Generator Test

Generator test is performed with 62 buses and found non zero values only on 19 generator buses. Total peak load is 400 MVA while total installed generation capacity is 16290 MVA. Here total investment cost of transmission line in Indian utility 62-bus system is Rs. 41214 lac and assumed generators contribution as 30% of total transmission cost. Generator Charges in MW-mile method (Rs.in lac/MW) and MVA-mile method (Rs. in lac/MVA) are shown in Table 1. Fig. 1 shows the generators charges on 62-bus system using GGDF.

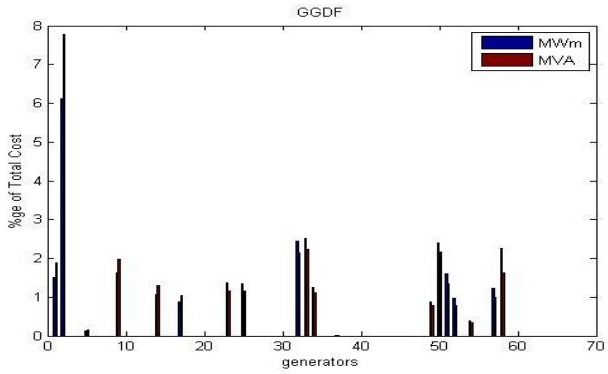

Fig. 1: Generator Charges using GGDF Tracing Method

TABLE 1: GENERATOR CHAREGES FOR INDIAN UTILITY 62-BUS SYSTEM

S. No.	Tracing Method	Generator	Wheeling Price Assessment Approaches	
			MW-mile (Rs. in lac/MW)	MVA-mile (Rs. in lac/MVA)
1	GGDF	G1	623.02	773.29
2		G2	2522.22	3209
3		G5	55.11	66.46
4		G9	668.53	818.13
5		G14	437.94	539.22
6		G17	363.61	428.62
7		G23	564.25	479.47
8		G25	551.97	475.2
9		G32	1006.19	886.46
10		G33	1036.88	920.62
11		G34	518.81	460.47
12		G37	8.32	7.09
13		G49	358.83	320.29
14		G50	989.51	891.18
15		G51	659.38	553.41
16		G52	399.04	319.58
17		G54	161.39	138.22
18		G57	507.77	405.74
19		G58	931.42	671.75
Total			12364.2	12364.2

B. Load Test

Load test was performed with 20 load buses among 62 buses. Contribution of load assumed 70% of total transmission cost. Charges across each load in MW-mile (Rs. in lac/MW) and MVA-mile (Rs. in lac/MVA) are shown in Table 2. Fig. 2 shows the load charges on 62-bus system using GLDF.

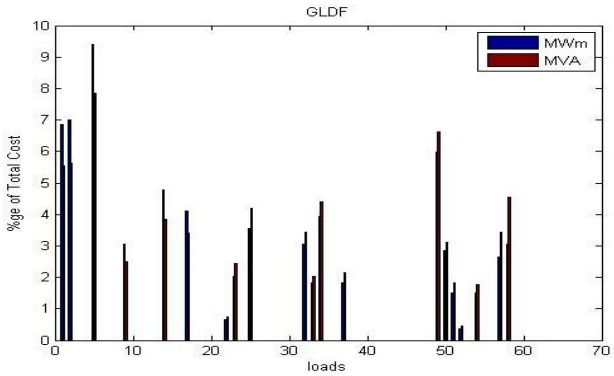

Fig. 2: Load Charges using GLDF Tracing Method

TABLE 2: LOAD CHARGES FOR INDIAN UTILITY 62-BUS SYSTEM

S. No.	Tracing Method	Load	Wheeling Price Assessment Approaches	
			MW-Mile (Rs. in lac/MW)	MVA-Mile (Rs. in lac/MVA)
1	GLDF	L1	2823.02	2281.21
2		L2	2889.89	2325.17
3		L5	3870.74	3237.91
4		L9	1257.51	1030.25
5		L14	1974.18	1586.14
6		L17	1688.34	1401.33
7		L22	265.36	311.62
8		L23	835.11	1007.46
9		L25	1463.57	1733.94
10		L32	1262.84	1417.22
11		L33	754.58	841.7
12		L34	1624.27	1812.74
13		L37	750.68	885.2
14		L49	2468.81	2733.16
15		L50	1169.58	1279.68
16		L51	623.78	753.52
17		L52	146.18	187.31
18		L54	626.23	734.57
19		L57	1096.43	1415.45
20		L58	1258.7	1874.21
Total			28849.8	28849.8

V. CONCLUSION

Wheeling price allocation has become a challenging task due to deregulation in electric Power sector. Optimization of power flow has been carried out using GA

in the present paper. Allocation of wheeling prices among all the network users is very necessary for fair and straightforward competition. MW-mile for real power and MVA-mile for real and reactive power has found very helpful for efficient wheeling price calculation. Both these original methods are useful to recover fixed transmission cost across transmission line and are proved as satisfactory approaches especially for developing countries like India. The approach presented in this paper can be extended with different categorization to calculate running expenses of transmission line also.

ACKNOWLEDGMENT

The authors sincerely acknowledge the Director, MITS, Gwalior, India, for providing facilities to carry out research work.

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