© 2017 IJSRST | Volume 3 | Issue 2 | Print ISSN: 2395-6011 | Online ISSN: 2395-602X

National Conference on Advances in Engineering and Applied Science (NCAEAS)
16th February 2017
In association with
International Journal of Scientific Research in Science and Technology

Evaluation of Transmission Charges by Relative Electrical Distance Concept

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ABSTRACT

The electrical power industry has over the years been ruling by large utilities that had an overall authority over all actions in generation, transmission, distribution of power within its field of operation. Such system is also referred to as vertically integrated utilities. The first stage in the unbundling process of power industry has been the detachment of the transmission activities from the electricity generation activities. By the development of deregulated power system has been evolved many problems such as capacity storage, crowding of lines, allotment of transmission charges. In an open access electricity market, crowding occurs when the transmission network is impotent to accommodate all the needed transactions due to a violation of system working limits. In this restructured environment it is also very difficult to assign transmission charges. In this paper Relative electrical distance concept is use to check the transmission charges and used to improve rescheduling of generators to reduce congestion in lines. Relative electrical distance method gives relative position of load junction with respect to generator junction. This method gives the relative electrical distance between two points. In this paper a simple 4 bus network is taken to show the evaluation of transmission charges by this method.

Keywords : - Vertically Integrated Utility, Restructured Environment, Deregulated Power, Crowding of Lines, Relative Electrical Distance, Unbundled Operation

I. INTRODUCTION

The power plant is undergo a total change in its trade where the vertically integrated utility are being break or unlatch for competition with private and individual participants. In the deregulated power system, transmission charges have become a prime duty because it necessary to grow a well-planned, practical and dependable charging scheme that can evolve the useful economic signals to network users. In recent years, because of restructuring, the Electric Supply Industries (ESIs) had to face crucial reforms in its firm and operation. Deregulations have introduced functional independence and flexibility but in other hand it has also introduced complications in operational and economic decision building. The pricing of the transmission system comprise the charges of designing, working and maintenance of the transmission corridor. It is the duty of the transmission users (generators and loads) to pay the transmission utilization cost. In an open access market, it is very difficult to find an authentic and efficient method for assign the utilization and cost of the transmission system to its users. In [1] author discussed about Transmission charge allotment which is one of the key issue in transmission open access. In this paper [1] author introduces a novel process of transmission charge distribution base on relative electrical distance (RED) concept. Transmission prices are assigning based on the relative electrical distance and the power agreements. This suggested procedure allot better transmission charges for maintaining network stability margins, least transmission losses and alleviate crowding on lines. In [2] author presents a process for transmission loss charge allotment in deregulated power system based on Relative Electrical Distance (RED) method. This paper [2] presents the drawbacks of pro-rata method; ITL method and the proportional sharing method are overcome as this process takes into account the network configuration which is independent of the location of swing bus. In this paper [3] the author is examine both the outcomes of power factor and loss cost constituents in the traditional MW-Mile method for giving superior profitable signal to the consumer. In [4] author presents an approach for alleviation of system in restructured environment. The offering of every generator for a specific over loaded line is first recognize, then based on RED method the required amount of generations for the required overload alleviate is obtained, so that the network will have least transmission losses and greater stability margins with respect to Voltage profiles, bus angles and preferable transmission tariff. In [5] author talks about liberalisation of electricity market. In this paper [5] relative electrical distance (RED) method is used to calculate reactive power offering from different sources such as generators, switchable volt-amperes reactive (VAR) sources and line charging susceptances that are spread in overall system, to encounter the network demands. The transmission line charge susceptances allowance to the network reactive flows and its aid enlarge in minimizing the reactive generation at the generator buses are examine in this paper. In this paper [6] the basis on which the mutual contract are to be made so that the arrangement is together best possible and economical is discussed. If the bilateral agreement are prepared using the conceptualization of Relative Electrical Distance (RED), such an agreement will confirm enhanced network safety such as a good voltage profile and will also diminish the losses occupied in the mutual contract. In this paper the prices attain in meeting loads like generation charge, transmission prices and prices due to losses are estimate [6].

II. NETWORK EQUATION

To finding out [***F***LG] matrix we have to consider a network in which n is the overall unit of buses with 1, 2, g, g *is* unit of generator buses, and g +1, n, remaining ($n - g$) buses. For a given network we can write,

$$\begin{bmatrix} I_G \\ I_L \end{bmatrix} = \begin{bmatrix} Y_{GG} & Y_{GL} \\ Y_{LG} & Y_{LL} \end{bmatrix} \begin{bmatrix} V_G \\ V_L \end{bmatrix}$$

Where ***I***G, ***I***L and ***V***G, ***V***L illustrate complex current and voltage vectors at the generator and load junction.

[***Y***GG], [***Y***GL], [***Y***LL] and [***Y***LG] are relative partitioned portions of system ***Y***-bus matrix:

$$[I_G] = [Y_{GG}][V_G] + [Y_{GL}][V_L] \quad (2)$$

$$[I_L] = [Y_{LG}][V_G] + [Y_{LL}][V_L] \quad (3)$$

From eq (3);

$$[Y_{LL}]^{-1}[I_L] = [Y_{LL}]^{-1}[Y_{LG}][V_G] + [V_L],$$
$$[V_L] = [Y_{LL}]^{-1}[I_L] - [Y_{LL}]^{-1}[Y_{LG}][V_G] \quad (4)$$

Substituting $[V_L]$ in eq. (2), we get,

$$[I_G] = [Y_{GG}][V_G] + [Y_{GL}]\{[Y_{LL}]^{-1}[I_L] - [Y_{LL}]^{-1}[Y_{LG}][V_G]\}$$

Representing eq (4) and (5) in matrix form we get,

$$\begin{bmatrix} V_L \\ I_G \end{bmatrix} = \begin{bmatrix} Z_{LL} & F_{LG} \\ K_{GL} & Y_{GG} \end{bmatrix} \begin{bmatrix} I_L \\ V_G \end{bmatrix}$$

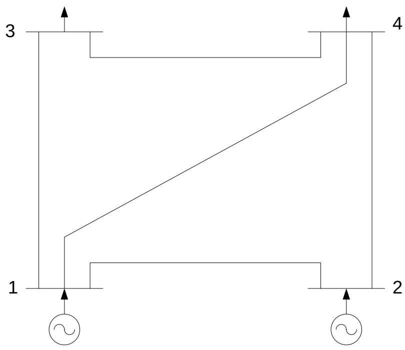
Where,

$$[F_{LG}] = -[Y_{LL}]^{-1}[Y_{LG}].$$

The components of [***F***LG] matrix are complex and its columns relative to the generator bus numbers and rows relative to the load bus numbers. This matrix provides the relationship between load bus voltages and source bus voltages. It also provides information about the location of load junction with respect to generator junction that is designate as relative electrical distance between load nodes and generator nodes.

III. SAMPLE SYSTEM

The sample bus system is shown below



The line specifications (in ohms) of sample four bus system:-

From bus	To bus	Line resistance	Line reactance
1	2	12.75	97
1	3	6	69.5
1	4	11.7	96
2	4	3.5	30.8
3	4	5.75	5.8

1. Calculations of [FLG], [RLG], and [DLG]:-

The [FLG] matrix which gives the association between load bus voltages and source bus voltages and also gives the statistics about the position of load junction with respect to the generator junction. Its columns relative to the generator bus numbers and rows relative to the load bus numbers. The elements of the [FLG] matrix are complex in nature and the matrix relative to the load/generator buses for the above system is given by;

$$[F_{LG}] = \begin{bmatrix} 0.6500 + 0.0000i & 0.3500 + 0.0000i \\ 0.3600 + 0.0000i & 0.6400 + 0.0000i \end{bmatrix}$$

The sample system shown above has two generators and two sinks at bus 1,2and 3, 4 respectively. The components of [FLG] matrix are complex and its rows represent the load bus number 3 and 4 and the column represents the generator bus number 1 and 2. The [RLG] matrix which gives the relative electrical distances, i.e., the relative locations of load Junction with respect to the generator junction is obtained from the [FLG] matrix and is given by;

$$[R_{LG}] = 1 - \text{abs}\{[F_{LG}]\}$$

The solution of [RLG] matrix is given by;

$$[R_{LG}] = \begin{bmatrix} 0.35 & 0.65 \\ 0.64 & 0.36 \end{bmatrix}$$

The desired quantity of generation for the required load sharing/generation arrangement is also acquiring from the [FLG] matrix and is given by;

$$[D_{LG}] = \text{abs}\{[F_{LG}]\}$$

The solution for the desired quantity of generation, for the required load sharing/generation scheduling is given by;

$$[D_{LG}] = \begin{bmatrix} 0.65 & 0.35 \\ 0.36 & 0.64 \end{bmatrix}$$

For example, if the load at bus 3 is 60 mw then it compute $0.65\times 60 =$ 39 mw from above matrix of load from generator 1and partial remaining load $0.35\times 60 =$ 21 mw from generator 2. Likewise the load at other buses also has to obtain according to the corresponding components of the [DLG] matrix. If the load sharing/generation arrangement is according to the [**D**LG] matrix, then the network will have smallest amount of transmission losses and greater stability margins with respect to voltage profile, bus angles and *L*-indices.

Required load sharing/generationarrangement in mw

Load bus no.	Power taken from generator		load at the bus
	G1	G2	
3	195	105	300
4	72	128	200
SUM	267	233	500

The contract matrix used in this paper is basically the transaction matrix. In this paper, it is supposed that there is no action by the dealing utility. All the transaction is therefore restricted to consumers and the suppliers.

Ignoring transmission losses, the transaction matrix is given by;

A. Calculation of [PLG]:-

$$[\boldsymbol{P}_{\mathrm{LG}}] = \begin{bmatrix} p_{g+1,1} & \cdots & p_{g+1,g} \\ \vdots & \cdots & \vdots \\ p_{n,1} & \cdots & p_{n,g} \end{bmatrix}$$

Where 1, g are generator buses, g + 1, n are load buses. Each constituent of [PLG] presents a transaction between consumer and a supplier. Additionally, the sum of row represents the overall power consumed at load and the sum of column represents the entire power given by a generator.

2. Evaluation of Basic Charges

The required power contracts/transactions the contract/transaction matrix is;

$$[\boldsymbol{P}_{\mathrm{LG}}] = \begin{bmatrix} 195 & 105 \\ 72 & 128 \end{bmatrix}$$

3. Calculation of [CLG] matrix:-

$$[\boldsymbol{C}_{\mathrm{LG}}] = \{1000 + ([\boldsymbol{R}_{\mathrm{LG}}]500)\} = \begin{bmatrix} 1175 & 1325 \\ 1320 & 1180 \end{bmatrix}$$

For the study of transmission charges, it is assumed that the transmission charge (in Indian Rupees) for 1MW of power transaction from load at bus 3 to generator 1 is Rs. 1175 and to generator 2 are Rs. 1325. Likewise, the rate for 1MW of power contract from load at bus 4 to generator 1 is Rs. 1320 and to generator 2 is 1180 Rs. It means that the transmission charges are comparable to the relative electrical distances and they are restricted to maximum of Rs. 1000 for very long way situated users and minimum of Rs. 500 for very closely situated consumer. If the relative electrical distance of a load bus is fewer then the transmission charge is low and if the electrical distance is highest then the transmission charge is more. The transmission charges are estimate by multiplying each component of the transmission cost matrix [CLG] by the corresponding elements of the contract/transaction matrix [PLG]. The entire transmission basic charge (in Indian Rupees) for the above power contracts is;

(195×1175)+ (105×1325) + (72+1320) + (128×1180) = 6, 14,330 RS

It is supposed that the transmission power charge to be enhanced for a transmission line is equal to the line resistance of the line. Then the total charge to be recuperated for a given network is equal to the sum of resistances of all the lines. The sum of the resistances of all the lines for the four-bus system is 39.7. A multiplication factor (*w*) is used to obtain the related transmission charges in Indian Rupees for each line and is given by;

$$w = \frac{6,14,330}{39.7} = \text{Rs. } 15474.307/\text{ohm}$$

4. Calculation of Transmission supplementary charges:-

The benefit of the suggest method is that knowing the electrical distance matrix of a network the transmission charges can be assess for another possible associations of power contracts with small calculations. If any contract changes from the desired contract supplementary transmission charges will be allocate for the deviated power contract. If the sum of real generation at a generating bus is greater than the expected generation, the power contracts, which are larger than the expected, are allocate supplementary charges. Likewise, if the entire generation at a generating bus is small than the desired generation, the power contracts, which are small than the expected, are allocate supplementary charges. Consider a real power contract/transaction matrix:

$$\text{Actual}\,[\boldsymbol{P}_{\mathrm{LG}}] = \begin{bmatrix} 190 & 110 \\ 140 & 60 \end{bmatrix}$$

From the above contracts matrix it is seen that the total generation at bus 1 is 190 + 140 = 330MW which is more than the desired generation of 267MW and the total generation at Generator bus 2 is 110 + 60 = 170MW that is less than the desired generation of 233MW. That means for the above contract matrix the new generation values are deviating from the desired generation scheduling. To calculate the transmission supplementary charges, first which contract is causing to deviate from the desired generation scheduling and the amount of MW deviations are identified. The amounts of power contract (MW) deviations are

$$\begin{bmatrix} -5 & +5 \\ +68 & -68 \end{bmatrix}$$

And the deviations of generation values (MW) are given by;

$$[+63 \quad -63]$$

Since the total generation at bus 1 is more than the desired generation by (+63 MW), the deviated power contract (+68 MW), which is more than the desired, is allocated supplementary charges. Similarly, the total real generation at the generating bus 2 is less than the desired generation by (−63 MW), the deviated power contract (−68 MW), which is less than the desired, is assigned supplementary charges. The load sharing scheduling (mw) and deviation of power contract and supplementary charges are shown in below tables.

5. Load contribution scheduling (MW):

Case no.	Load bus no.	Power taken from generator		Total load	Total generation	
		1	2		1	2
1	3	195	105	300	267	233
	4	72	128	200		
2	3	190	110	300	330	170
	4	140	60	200		
3	3	240	60	300	400	100
	4	160	40	200		

6. Variation of power transactions and supplementary charges

Case no.	Load bus no.	Deviation of Power contracts		Deviation of Generations		Transmission Supply. Charges of load
		G1	G2	G1	G2	
1	3	0	0	0	0	0
	4	0	0			0
2	3	-5	+5	+63	-63	0
	4	+68	-68			17000
3	3	+45	-45	+133	-133	11250
	4	+88	-88			22000

IV. CONCLUSION

A new approach, called relative electrical distance, is used for evaluation of transmission prices. The suggest method assign the transmission charges based on the relative location of load junction with respect to the generator junction. The suggest method gives a preferable transmission tariff for verify system stability and reduce crowding on trnsmission lines. To have an effective operation in deregulated power network, it is mandatory to understand the possible ways of congestion and its comfort. In this paper a method of generation rearranging for congestion management has been suggest under restructured environment. The presented concepts are better adapt for finding the utilization of resource generation/load and system by various utilities involved in the day-to-day working of the system under regular and contingency situations. This will support in finding the contribution by various players involved in the congestion management and the deviations can be used for proper tariff purposes. This process is authentic and fast to determine congested lines. The main benefit of this process lies in its applicability to examine various contracts/transactions together.

V. REFERENCES

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