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Evaluating Available Transmission Capability using PTDF and Generator Participation Factor

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Abstract: ***Congestion management in restructured power system is a major technical challenge for the power system engineers. For a congestion free power market , Available transfer capability(ATC) is to be enhanced. ATC is a measure of remaining MW transaction that can be carried out without violating the transmission limits. In deregulated market , change in load can be met by more than one generator of the system generator participation factor is a measure of amount of power contributed by the generator to satisfy the load.This paper proposes that in simultaneous power transaction generator participation factor can decide the ATC of the network and can also change the maximum amount of load sustained by the bus before causing congestion of the network For this coding is done in MATLB and results are verified on Power world Simulator software.***

Index terms— Deregulation, congestion, power transfer distribution factor, Available transfer capability, Generator participation factor

I.INTRODUCTION

Electric power utilities, throughout the world, are currently undergoing major restructuring process and are adopting the deregulated market operation[1]. The restructured markets normally employ either pool trading that involves bidding in the open market or bilateral/multilateral trading directly between seller(s) and buyer(s) or a combination of the both Managing dispatch in an open access environment is a new challenge facing independent transmission system operators who are mandated to provide a level playing field for all transmission uses. Two issues are especially important viz, use of transmission system charges and congestion management[2-3].

objective of deregulation of power system is to provide electrical power to consumers, which will be qualitative, quantitative and economic. However this objective could be encountered by the network congestion.

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Effective design and controlling of power system network can avoid it. This requires determining the sensitivity of power flow for the changes in power at a bus [4] Enhancing the transfer capability of existing transmission system under steady state as well as improving system security under dynamic contingencies has become need of a new era[5]

IIAvailable transfer capability(ATC)

Definition- According to NERC Report [6] Available Transfer capability (ATC) is a measure of transfer capability remaining in the physical transmission network for further commercial activity over and above already committed uses

ATC = TTC-TRM-{ETC + CBM} (1)

Where TTC- Total Transfer Capability

TRM-Transmission Reliability Margin

ETC-Existing Transmission Commitments

CBM-Capacity Benefit Margin

The versatile nature of load needs ATC to be updated continuously.ATC gives a measure how far the system is from the congestion [7].The main constraints for transaction of power are the thermal limit , the voltage limit and steady state limit.[8]The minimum out of these three i.e the thermal limit is considered for ATC calculation.Controlling,further planning and future planning of transmission infrastructure is dependent on ATC. Many researchers has come forward with various mathematical models to evaluate ATC of network.

II. POWER TRANSFER DISTRIBUTION FACTOR FOR ATC CALCULATION

Power transfer distribution factor (PTDF) method is used by many utilities for determination of ATC [9-10] .The change in load is met by various generators of the system.As the system is interconnected all transmission lines are sensitive to load change. The coefficient of the linear relationship between the amount of a transaction and the flow on a line is called the PTDF. When DC power flow is considered and ATC is calculated using PTDF method [11],it provides fast calculation but with less accuracy The change in line flow associated with a new transaction is then ,

$$\Delta P_{ij}^{New} = PTDF_{ij,mn} P_{mn}^{New} \quad (2)$$

Where i and j are buses at the ends of the line being monitored,

m and n are “from” and “to” zone numbers for the proposed new transaction,

P_{mn}^{New} is new transaction in MW amount.

$$P_{mn,ij}^{Max} \leq \frac{P_{ij}^{Max} - P_{ij}^{0}}{PTDF_{ij,mn}} \qquad (3)$$

$p_{mn,ij}^{Max}$ is the maximum allowable transaction amount from zone m to zone n.

ATC of the network is constrained by the minimum of the allowable transaction over all lines.

$$ATC_{mn} = \min_{ij} P_{mn,ij}^{Max} \qquad (4)$$

In deregulated system consumer can demand power from any particular source. This makes it difficult to trace the power flow in such a vast and interconnected system. J.Bialek[12] has proposed proportional sharing principle for tracing electricity flow from sourse to sink. This is helpful is finding the actual usage of a particular transmission line in a system.For ATC computation change in power flow before and after the transaction is to be known . To find this change sensitivity analysis is used[G]

III.ATC BASED ON PARTICIPATION FACTOR

Participation factor of a generator is the ratio of change in generator power of that generator to the change in load [4]. It is given as

$$x_i = \frac{\Delta T_{ik}}{\Delta P_k} \qquad (4)$$

Where x_i is Generator participation factor,

ΔT_{ik} is change in generator power at i^{th} bus due to change in load at k^{th} bus,

ΔP_k Change in load at k^{th} bus.

Generators are ranked based on their active power generating capacity Higher ranking is given to the generator with higher active power [15]. Generator participation factor (GPF) is used to determine how the real power output of the generator changes in response to demand when the generator is available for Automatic Generation Control.Enhancing ATC of network using GPF is one of the novel methods.

IV.AN ALGORITHM FOR ATC CALCULATION USING PTDF IS GIVEN BELOW

i) Run the base case for bus voltage and initial power flow in each transmission line

ii) Apply power transaction between the seller and buyer bus

iii)Again power flow analysis to find changes in MW in each transmission line

iv) Compute PTDF and ATC of the network

v) Now set the generator participation factor and and find ATC for simulataneous transaction

vi) Apply second power transaction and repeat steps from ii to iv

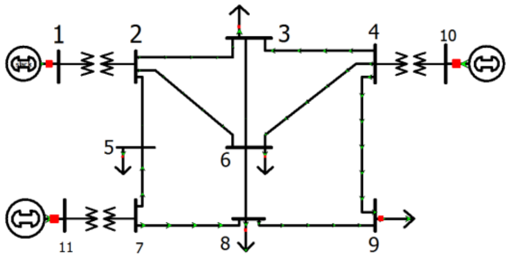

Fig1: 11 bus system

Figure 1 shows a 11 bus test system . It has three generators buses and five load buses. The load at bus 3 is continuously increades and ATC is computed for bilateral transaction . then GPF are set and simultaneous transaction is carried out andATC of network is computed . The computational results are given in following table 1 and 2

Table 1: ATC for individual and bilateral transaction when GPF are 0.4,0.3 and 0.3

Sr. No	Applied Change in Load at bus 3 (MW)	Generator and Load Bus Pair	Transacting power MW x1=0.4 x2=0.3 x3=0.3	N/W ATC when Individual Transactions are of concern (MW)	N/W ATC (MW) for Simultaneous Power Transaction from all Generators to Bus 3
1	5	1---3	2	95.59	238.98
		10---3	1.5	108.34	
		11---3	1.5	87.04	
2	10	1---3	4	93.48	233.71
		10---3	3	119.48	
		11---3	3	98.92	
3	15	1---3	6	92.72	221.36
		10---3	4.5	115.15	
		11---3	4.5	92.77	
4	20	1---3	8	74.24	185.61
		10---3	6	116.44	
		11---3	6	99.08	
5	25	1---3	10	60.05	150.14
		10---3	7.5	107.23	
		11---3	7.5	81.03	
6	30	1---3	12	43.94	109.86
		10---3	9	91.45	
		11---3	9	61.93	
7	35	1---3	14	22.68	56.7

		10---3	10.5	88.42	
		11---3	10.5	54.36	
8	40	1---3	16	5.3	13.26
		10---3	12	66.78	
		11---3	12	43.21	

Table 2: ATC for individual and bilateral transaction when GPF are 0.5,0.3 and 0.2

Sr. No	Applied Change in Load at bus 3 (MW)	Generator and Load Bus Pair	Transacting power MW x1=0.5 x2=0.3 x3=0.2	N/W ATC when Individual Transactions are of concern (MW)	N/W ATC (MW) for Simultaneous Power Transaction from all Generators to Bus 3
1	5	1---3	2.5	96.08	192.16
		10---3	1.5	94.8	
		11---3	1	107	
2	10	1---3	5	93.9	187.8
		10---3	3	112.81	
		11---3	2	106.52	
3	15	1---3	7.5	88.99	177.98
		10---3	4.5	113.24	
		11---3	3	104.67	
4	20	1---3	10	64.05	160.14
		10---3	6	116.6	
		11---3	4	98.78	
5	25	1---3	12.5	58.94	117.88
		10---3	7.5	107.8	
		11---3	5	94.64	
6	30	1---3	15	42.64	85.28
		10---3	9	92.44	
		11---3	6	58.5	
7	35	1---3	17.5	19.66	39.33
		10---3	10.5	74.74	
		11---3	7	26.95	
8	40	1---3	20	5.73	11.47
		10---3	12	22.8	
		11---3	8	8.06	

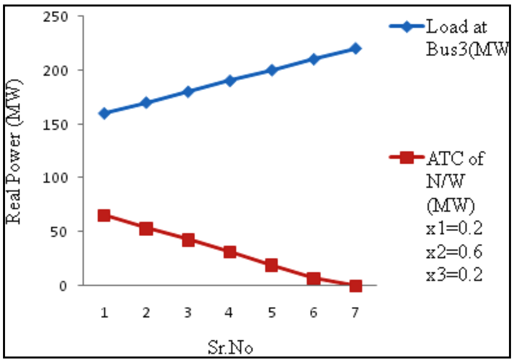

Fig3: ATC and load variation for GPF 0.2,0.6 and 0.2

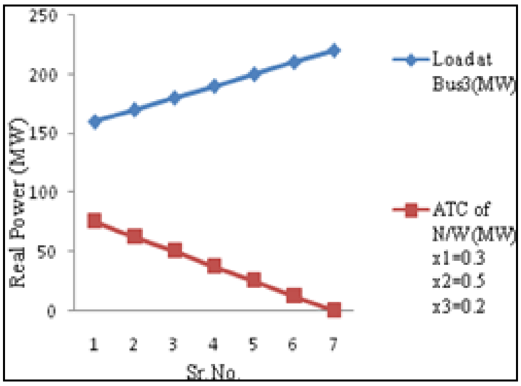

Fig5: ATC and load variation for GPF 0.3,0.5 and 0.2

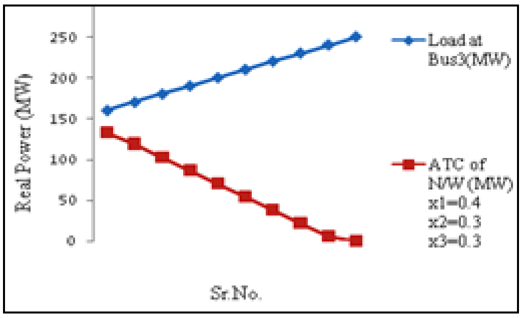

Fig4: ATC and load variation for GPF 0.4,0.3 and 0.3

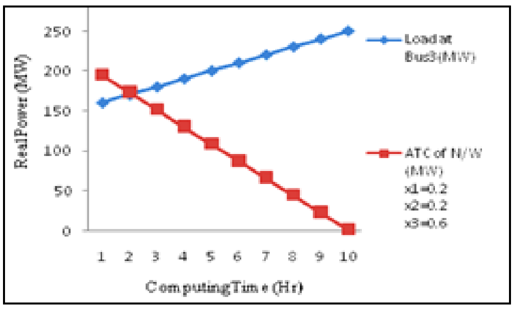

Fig6: ATC and load variation for GPF 0.2,0.2 and 0.6

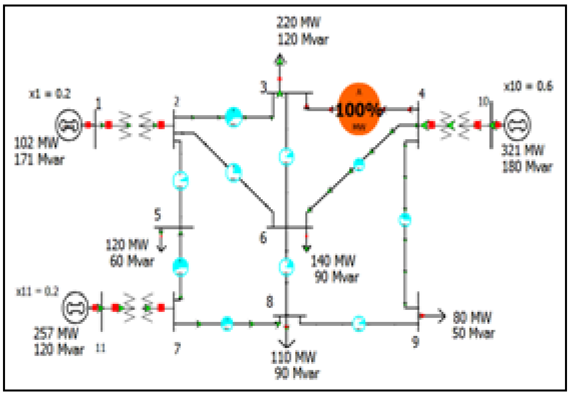

Fig7:Congestion in network at GPF 0.2,0.6 and 0.2

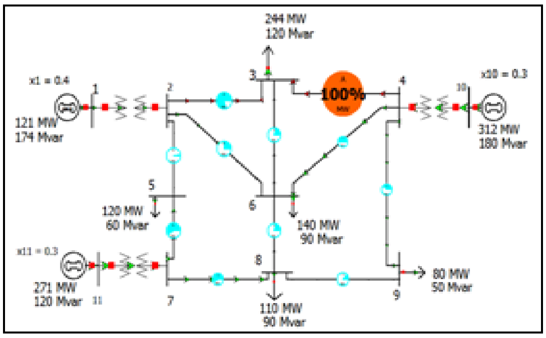

Fig8:Congestion in network at GPF 0.4,0.3 and 0.3

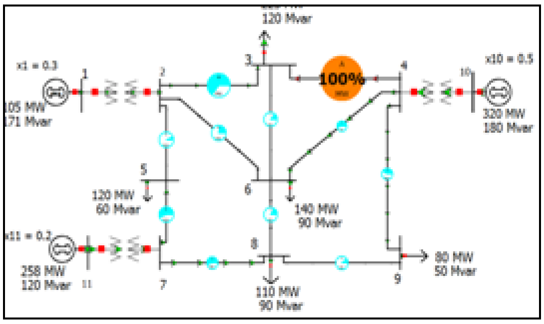

Fig9: Congestion in network at GPF 0.3,0.5 and 0.2

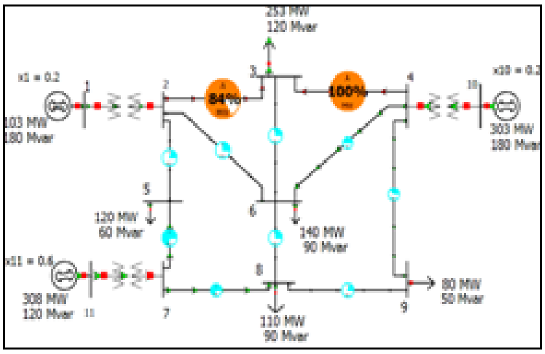

Fig10: Congestion in network at GPF 0.2,0.2 and 0.6

V. RESULT:

For the change in load, the generators will contribute the real power to meet the load depending on their generator participation factors. First the ATC of network is calculated for the bilateral transaction where all the generators contribute to satisfy the load as mentioned in column 5 of table 1 and 2 .When bilateral transaction is considered, the transaction is in between load and individual generator depending upon the participation factor. Value ATC of network for simultaneous transaction are given in column 6 of table 5 and 6.This value is the amount of MW power that can be further transacted to increasing load of bus 3. ATC is also calculated and verified on Power World Simulator 20 software. The Value of ATC in terms of transacting real power and computing time based on GPF are graphically represented in fig 3 to 6. The congestion of network along with GPF and load sustained by bus 3 are pictorially given in fig 7 to 10 on Power World Simulator Software. For different sets of generator participation factor, maximum load sustained by bus3 before leading to congestion is found to be different as follows

i. 220 MW for GPF 0.2, 0.6 and 0.2
ii. 244 MW for GPF 0.4, 0.3 and 0.3
iii. 233 MW for GPF 0.3, 0.5 and 0.2
iv. 244 MW for GPF 0.2, 0.2 and 0.6

VI.CONCLUSION:

ATC is an indication of how much additional power transaction can be carried out maintaining the security of the system. ATC of network is inversely proportional to the load and vice versa. The amount of real power supplied by the generator can be decided by Generator participation factor. Generator with more generating capacity has a more impact on deciding the transmission capability of the line. Change in GPF changes the ATC of the network. The maximum amount of load sustained by a bus without violating the security limits can be changed by changing the generator participation factor .Thus Generator participation factor can serve as a tool to change the maximum sustainable load at a bus

REFERENCES

1. S.C. Srivastava,"Transmission System Management In Restuctured Electricity Markets".Power Transmission Research Interest and Challenges.
2. A. K. David, "Dispatch methodologies for open access transmission Systems," *IEEE Trans. Power Syst.*, vol. 13, pp. 46–53, Feb. 1998.
3. R. D. Christie, B. F. Wollenberg and I. Wangensteen, "Transmission Management in the Deregulated Environment", *Proceedings of The IEEE*, Vol. 88, No. 2, Feb 2000, pp 170-195.
4. N.D.Ghawghawe, and K. L. Thakre, "Power Flow Sensitivity Analysis in Deregulated Environment" Proceedings of IEEE International Conference on Power Electronic Drives and Energy Systems (PEDES-06) Organized by PES IES PEIS at IIT New Delhi, *India*. Dec. 2006
5. Prabha Kundur, Power System Stability and Control, EPRI, Power system Engineering Series, Tata McGraw-Hill, 3 Reprint 2007
6. North American Electric Reliability Council (NERC), 'Available Transfer Capability Definitions and Determination', NERC Report, June 1996.
7. Sauer P.W , 'Technical Challenges of Computing Available Transfer Capability (ATC) in Electric Power Systems" Proceedings, 3tf[th] Annual Hawai International Conference on System Sciences Jan 7-10, 1997 pp. 1-5
8. Ruiz-Vega D., and Pavella M.,"A Comprehensive Approach to Transient Stability Control. Part II: Open Loop Emergency Control," *IEEE Transactions on Power Systems,* Vol.18, No. 4, pp. 1454-1460, 2003.
9. Srivastava,et al 'ATC determination in a competitive electricity market using AC distribution factors', Electric Power Components and Systems 32 (2004) 927-939 Vol.10 No.2, May 95.

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10. Venkatesh et al'Available Transfer Capability Determination Using Power Distribution Factors' Journa of Emerging Electric Power Systems Vol.1(2) 2004,Article1009.
11. Konrad Purchala,, Daniel Van Dommelen, and Ronnie Belmans," Usefulness of DC Power Flow for Active Power Flow Analysis" IEEE Power Engineering Society General Meeting, vol. 1, pp. 454 – 459, June 2005.
12. Bialek J.'Tracing the Flow of Electricity' IEE Proceedings of Generation Transmission and Distribution, Vol.143 No.4, pp.313-320. July 1996

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