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Total Transfer Capability Calculation Using Repeated Power flow Method

[1]M.Sheshagiri, [2]Dr.B.V.Sanker ram
[1]Divisional Engineer,[2] Professor
[1]Transmission Corporation of Telangana Limited(TSTRANSCO),Hyderabad, India
[2]College of Engineering, Kukatpally, JNTUH, Hyderabad, India

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Abstract—**The aim of this paper is to develop an approach to analyze the electricity transfer capability among different electricity markets using repeated power flow technique. Instead of minimizing the total cost in the conventional problem, the transfer capability between two markets or two electricity supplies or generation areas is maximized. The optimization shall be subjected to the operational constraints, however as the time taken by these traditional optimization methods are quite significant, but these methods may not be suitable for online application. To reduce the time required computing transfer capabilities and also in order to take advantage of the superior speed of other power flow methods are referred to implement the transfer capability calculations. The results have been simulated by using MATLAB. And the results have been presented and compared with the conventional methods.**

***IndexTerms*—Day-Ahead market, Competitive bidding, Available Transfer Capability (ATC), Repeated Power Flow (RPF).**

I. INTRODUCTION

The role of Independent System Operator (ISO) in a competitive market environment would be to facilitate the complete dispatch of the power that gets contracted among the market players. The trading of large amount of energy and the increasing load levels day-by-day result overloading of the transmission system. The market driven schedule dispatchable problems due to overloading create many challenging issues to be addressed by the researchers. Based upon the NERC's definition [1], Available Transfer Capability (ATC) is a measure of the transfer capability remaining in the physical transmission network for further commercial activity over and above already committed uses.

Total Transfer Capability (TTC) is the maximum of power that can be transferred in a reliable manner between a pair of defined source and sink locations in the interconnected system while meeting all of a specific set of defined pre- and post contingency system conditions. TTC is the most important and first term to be determined in the ATC determination. Due to nonlinear nature of the interconnected electric power systems, TTC between two locations and their associated binding constraints depend on the set of operating conditions.

The operating conditions represent a single snapshot of the operation of the interconnected network based on the consideration of a number of factors. Generation dispatch, system configuration, base schedule transfers, system contingencies, projected customer demand etc. are the major ones. And similarly, the computation method of ATC should consider limits imposed on the system components such as thermal, voltage and stability limits. However, these limits in the system are mainly dependent on the power injections/ withdrawals, position of load flow controlling devices like transformer tap/phase shifters setting and major disturbances in the system. Whatever the disturbances considered, the ATC value will decrease significantly. The transaction power must be limited to available transfer capability (ATC), if bottlenecks prevent a reliable system operation under consideration of uncertainties. In general, the uncertainties like generator/line outages, uncertainties in load forecast, system operating constraints and simultaneous transactions are major limiting factors to the ATC between specified seller buses to buyer buses.

In addition, the competitive environment in day-ahead energy market auction changes the level of power injections/ withdrawals for every trading hour in the system. Under this scenario, the MW flow in a line may increase or decrease. The incremental flow i.e. stress which can also causes to congestion. Since ATC is a network capability signal for commercial activities over the network, it is worthwhile to incorporate stress with market participants' strategies in addition to common disturbances while computing ATC to increase the efficient use of the transmission system. In this paper, our aim is to impose unstable market schedule with bids change and load forecast errors while determining the ATC value at every trading hour hence ATC value that reflects the strategic market activities in addition to major contingencies. In this paper, first we have schedule the generations as per the single sided day-ahead energy auction. Repeated Power Flow (RPF) [2] method is adapted to calculated TTC value between any pair of source and sinks. The (N-1) contingency incident is imposed for the account of TRM, CBM and finally ATC is determined.

This paper is organized as follows: Following the introduction, day–ahead market settlement is explained briefly. Evaluation of Available Transmission Capability (ATC) is explained briefly. The case study with different bilateral transactions between various sources/sink is carried out and simulation results.

II. EVALUATION OF ATC

Total Transfer Capability (TTC): It is defined as the quantity of electric power that can be transferred over the interconnected transmission path reliably without violating the predefined set of conditions of the system.
Available Transfer Capability (ATC): It is a measure of the transfer capability remaining in the physical transmission network for further commercial activity over and above already committed uses.
Mathematically, ATC is defined as the Total Transfer Capability (TTC) less the Transmission Reliability Margin (TRM), less the sum of existing transmission commitments (which includes retail customer service) and the Capacity Benefit Margin (CBM).

Transmission Reliability Margin (TRM): It is defined as that amount of transmission transfer capability necessary to ensure that the interconnected transmission network is secure under a reasonable range of uncertainties in system conditions.

Capacity Benefit Margin (CBM) is defined as that amount of transmission transfer capability reserved by load serving entities to ensure access to generation from interconnected systems to meet generation reliability requirements.

Total Transfer Capability (TTC) is defined as the amount of electric power that can be transferred over the interconnected transmission network in a reliable manner while meeting all of a specific set of defined pre- and post-contingency system conditions.

TTC = Minimum of {Thermal Limit, Voltage Limit, Stability Limit}

TTC is an important parameter that indicates how much power transfer can take place without compromising the system security. It provides vital information for the planners, operators and marketers. The accurate TTC calculation is essential to ensure that power system can operate without reliability risks. A number of methods exist for calculation of TTC and excessive conservative transfer capability may limit the transfer unnecessarily and also lead to inefficient operation of power system.

In other words TTC is the maximum value of power transfer between the paths without any limit violations, with or without contingency. The objective can be defined as the determination of maximum real power transfer between the utilities.

III. PURPOSE OF TRANSFER CAPABILITY COMPUTATIONS

The need for transfer capability computations: Estimation of TTC can be used as a rough indicator of relative

- System indicator. It can be used for comparing the relative merits of planned
- Transmission betterments. To improve reliability and economic efficiency of the power
- Markets. For providing a quantitative basis for assessing transmission
- Reservations to facilitate energy markets.

Methods of Transfer Capability Calculation:
A number of methods have been proposed in the literature. These methods are classified as:

- Continuation power flow (CP FLOW) based methods
- Optimal power flow (OPF) based methods
- Linear approximation methods(Repeated Power Flow method)

Various methods of calculating transfer capability are explained below:

Continuation methods in which the transfer capability is computed using a software model called continuation. This process requires a series of load flow solutions to be solved and tested for limits.

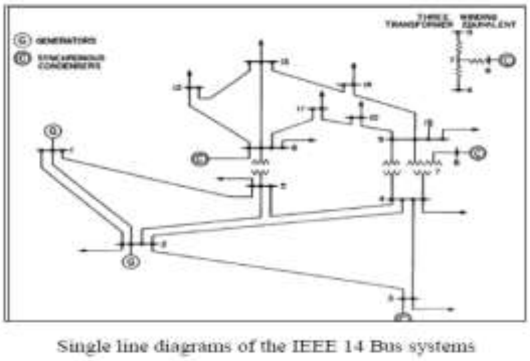
Optimization problem: Equality constraints obtained from power flow are used in this approach. Linear methods use PTDFs (power flow distribution factors) to express the percentage of power transfer that occurs on a transmission path.

Repeated Power Flow method: At a specified hour with congestion free market schedule, the maximum value of ATC can be obtained using RPF method, as the name implies, finds TTC by successively solving a set of power flow problems. The demand at buyer bus, and the generation at the seller bus are increased in an increment step until any of the operating constraints' violation. In this paper, the voltage limit, thermal limit and generation capacity limits are considered. Finally the ATC will be equal to TTC minus base load at sink bus which can be further useful to bilateral transaction.
The computational procedure of this approach is as follows:

i. Establish and solve for a base case
ii. Select a transfer case
iii. Solve for the transfer case
iv. Increase step size if transfer is successful
v. Decrease step size if transfer is unsuccessful
vi. Repeat the procedure until minimum step size reached.

IV. CASE STUDY AND RESULTS

Selection of IEEE 14-bus system



Single line diagrams of the IEEE 14 Bus systems

Fig 1: Single Line diagram of IEEE 14 Bus system

Analysis: Our test system is the IEEE 14 BUS system is a case study, which has 22 lines and 14 buses. Bus 1 is Slack Bus and Buses 2,3,6,8 are the generator buses. All the buses except bus 1 contain loads also. So it is important to decide that which bus is the most critical bus. A single line diagram of the IEEE 14-bus standard system taken from [9]. It consists of five synchronous machines with IEEE type-1 exciters, three of which are Synchronous compensators used only for reactive power support. There are 11 loads in the system. The dynamic data for the generators exciters was selected from [9]. The system consists of 17 transmission lines and 11 loads.

The IEEE 30 Bus system is considered in estimation of TTC using different power flow methods. The 11 kV and 1.0 kV base voltages are considered as initial conditions. The model actually has these buses at either 132 or 33 kV.

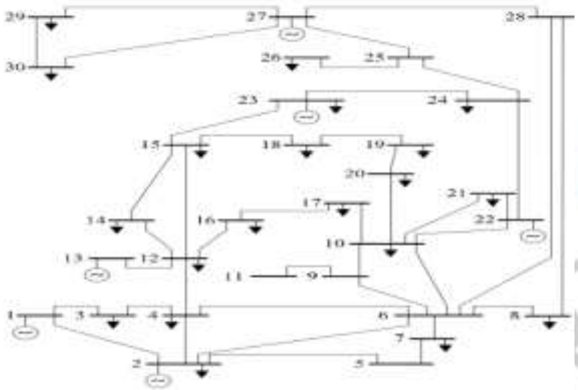
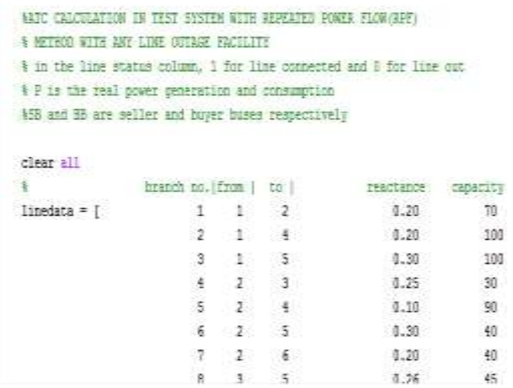


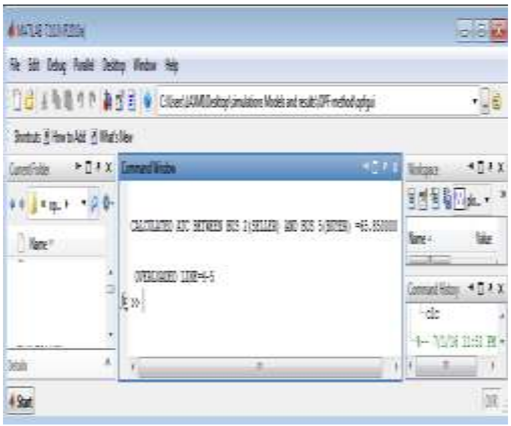
Fig 2: Single line diagram



```
%ATC CALCULATION IN TEST SYSTEM WITH REPEATED POWER FLOW(RPF)
% METHOD WITH ANY LINE OUTAGE FACILITY
% in the line status column, 1 for line connected and 0 for line out
% P is the real power generation and consumption
%SB and BB are seller and buyer buses respectively

clear all
%                branch no.|from |  to |          reactance   capacity
linedata = [             1     1     2              0.20        70
                         2     1     4              0.20       100
                         3     1     5              0.30       100
                         4     2     3              0.25        30
                         5     2     4              0.10        90
                         6     2     5              0.30        40
                         7     2     6              0.20        40
                         8     3     5              0.26        45
```

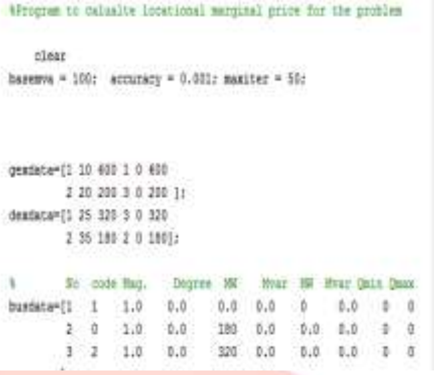
Fig 3: M-file program for 14-Bus system (weak buses considered from OPF and CPF methods)by using RPF method



```
CALCULATED ATC BETWEEN BUS 2(SELLER) AND BUS 5(BUYER) =65.850000

OVERLOADED LINE=4-5
>>
```

Result: Overloaded Line ATC= 65.85 MW



```
%Program to calualte locational marginal price for the problem

   clear
basemva = 100;  accuracy = 0.001; maxiter = 50;



gendata=[1 10 400 1 0 400
         2 20 200 3 0 200 ];
demdata=[1 25 320 3 0 320
         2 35 180 2 0 180];

%        No  code Mag.   Degree  MW    Mvar  MW  Mvar Qmin Qmax
busdata=[1   1    1.0    0.0     0.0   0.0   0     0.0   0   0
         2   0    1.0    0.0     180   0.0   0.0   0.0   0   0
         3   2    1.0    0.0     320   0.0   0.0   0.0   0   0
```

Fig 4: M-file program for LMP

Result of Locational Marginal Price in Command Prompt

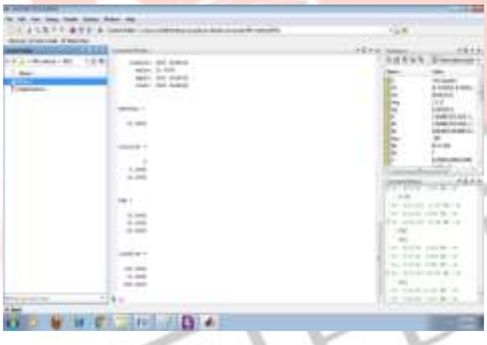


Table 1: Enhancement of power transfer capability for IEEE 14-Bus system

From Area	To Area	TTC in MW	Constraint
		RPF	
1	2	**42**	Violating reactive power limit of generator at bus: 1;
3	2	**53**	Voltages at all buses are within permissible limits
1	5	**50.2**	Violating reactive power limit of generator at bus: 1;

Table 2: Enhancement of power transfer capability for IEEE 30-Bus system

From Area	To Area	TTC in MW	Constraint
		RPF	
25	26	**168.1**	Violating reactive power limit of generator at bus: 26;
29	30	**168.4**	Violating reactive power limit of generator at bus: 30;

V. CONCLUSION

This paper reviews the influence of different uncertainties on the ATC value. In addition to the general contingencies, the stress due to strategic bidding or trading schemes in the competitive market is also studied for modeling. The ATC value between a specified seller bus and buyer bus can vary significantly with the change in bid since it causes to alter the schedule as a result system operating state. The higher value of bidding parameter from the case study , causes to allocate lower schedule at that generator and ATC value to any bus from that source is increased. The results have been improved by using Repeated Power Flow (RPF) for the computation of transfer capabilities between system areas. A significant reduction in computational time, thus making it a potential candidate for online application. The work proposed in this paper can also be used to calculate available transfer capabilities (ATC) under the open access environment.

REFERENCES

[1] B. Gao, G. K. Morison, and P. Kundur, ―Voltage stability evaluation using modal analysis,‖ IEEE Trans. on Power Systems, vol. 7, no. 4,pp. 1529–1542, Nov. 1992.

[2] P. A. Lof, T. Smed, G. Anderson, and D. J. Hill, ―Fast calculation of a voltage stability index,‖ IEEE Trans. on Power Systems, vol. 7, no. 1,pp. 54–64, Feb.1992.

[3] L. Bao, Z. Huang, and W. Xu, ―On-line voltage stability monitoring using var reserves,‖ IEEE Trans. Power Syst., vol. 18, no. 4, pp.1461 –1469, Nov. 2003.

[4] “S. Kamel, M. Kodsi and C. A. Canizares, “Modeling and simulation of IEEE 14 bus system with facts controllers”, Technical Report, (2003), p. 3.”

[5] Venkataramana Ajjarapu ―Computational Techniques for Voltage Stability Assessment and Control‖ E-Book— Library of Congress Control Number: 2006926216 , Iowa State University ,Department of Electrical and Computer Engineering . 1122 Coover Hall ,Ames Iowa 50011, U.S.A.

[6] Varun Togiti ―Pattern Recognition of Power System Voltage Stability using Statistical and Algorithmic Methods‖ University of New Orleans ScholarWorks@UNO University of New Orleans . 5-18-2012.

[7] Satish Joshi , ―A Thesis on Voltage stability and contingency selection studies in electrical power system‖, Department of electrical engineering. Indian institute of technology Kanpur . December 1995.

[8] P. Kundur, ―Power System Stability and Control‖ McGraw-Hilll, 1994.

[9] J. Paserba, V. Ajjarapu, G. Andersson, A. Bose, C. Canizares, N. Hatziargyriou, D. Hill, A. Stankovic, C. Taylor, T. Van Cutsem, V. Vittal, P.Kundur, "Definition and Classification of Power System Stability," IEEE Trans. on Power Syst., vol. 19, no. 2, pp. 1387-1401, May 2004.