Available Transfer Capability (ATC) based Nodal Pricing

V.G.Umale, S.Wadhankar, A.A.Deosant, M.Ahmed

Abstract—The transmission pricing depends on generator, load levels and transmission line constraints. The transmission system places an importance on the intensive use interconnected network reliably, which requires knowledge of the complex capability. Available Transfer Capability (ATC) is a compute of the remaining power transfer capability of the transmission network for further transactions. Available transfer capability in the transmission system has become essential quantity to be declared well in advance for its commercial use in a competitive electricity marketplace. The proposed approach of ATC using AC Power transfer distribution factors (AC PTDFs) based approach has been used for single and concurrent transactions using power transfer distribution factor and ATC based Locational Marginal Pricing methodology is used to decide the energy price for transacted power and to handle the network congestion and marginal losses. Simulation is carried out on IEEE30 bus system.

Keywords—Locational Marginal Pricing, Optimal Power Flow, transmission pricing, Available Transfer Capability (ATC), AC Power Transfer Distribution Factor (ACPTDF)

I. INTRODUCTION

The LMP at a location is defined as the marginal cost to supply an additional MW increment of power at the location without violating any system security limits [1]. LMP can vary appreciably from one location to another. If the lowest priced electricity is allocated for all Location LMP values at all nodes will be same. If congestion present in the system lowest cost energy cannot attain all location, more costly generators will billed to reach out the demand. Thus LMP is the outline of the costs of marginal energy, marginal loss and congestion. LMP can be stated as follows:

LMP = generation marginal cost + congestion cost +marginal loss cost

Available transfer capability in the transmission network has become essential quantity to be confirmed well in advance for its commercial use in a aggressive electricity market. In open access to the transmission system places an import on the intensive use of the interconnected network reliably, which requires knowledge of the network capability.

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V.G.Umale, Department of Electrical Engineering, Priyadarshini Indira Gandhi College of Engineering, G.H.R.I.E.T

S.Wadhankar, Department of Electrical Engineering, Priyadarshini Indira Gandhi College of Engineering, G.H.R.I.E.T

A.A.Deosant, Department of Electrical Engineering, Priyadarshini Indira Gandhi College of Engineering, G.H.R.I.E.T

M.Ahmed, Department of Electrical Engineering, Priyadarshini Indira Gandhi College of Engineering, G.H.R.I.E.T

Available Transfer Capability (ATC) is a determine of the remaining power transfer capability of the transmission network for further transactions.

Power transfer distribution and optimal power flow based methods can be implemented for any number of transactions occurring simultaneously. The ac power transfer distribution factors, computed at a base case, have been used to find various transmission system quantities for a change in MW dealings at different operating conditions. ATC based LMP is obtained from the result of Optimal Power Flow (OPF).To reduce the complexity in the calculation in this paper AC-DC OPF is used. Different types of optimization models are used for LMP calculations like LP and Lagrangian. Amongst these in this paper quadrating programming is used to explain the optimization problem.

II. ATC PRINCIPLES

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 dedicated uses. Mathematically, ATC is defined as the Total Transfer Capability (TTC) less the Transmission Reliability Margin (TRM), less the sum of accessible transmission commitments (which includes retail customer service) and the Capacity Benefit Margin (CBM). ATC defined as measure of the transfer capability [3] other in the physical transmission network for additional commercial motion 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 obtainable transmission commitments and the Capacity Benefit Margin (CBM) [8].

ATC = TTC- TRM- Presented Transmission Commitments

III. Mathematical Model Formulation for ATC

Congestion do occur in both vertically bundled and unbundled systems but the management in the bundled system is relatively simple as generation, transmission and, in some cases, distribution systems are managed by one utility.[4] The management of congestion is somewhat more complex in competitive power markets and leads to numerous disputes. To manage the congestion in real time process, normally following methods are adopted:

Methods for ATC Calculation

i) DC Load Flow Based Approach (DC Method)

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ii) AC Load Flow Based Approach (AC Method)
PTCDF and LODF (Line Outage Distribution Factor) method is extensively used in ATC calculation. Here, this method is explained thoroughly. Other two methods are not considered as they are rarely used for calculation of ATC [3],[4]. The most sensitive zones have been identified as the union of real and reactive line flow sensitivity indices [10]. The PTCDFs have been derived utilizing the sensitivity properties of the Newton-Raphson load flow (NRLF) Jacobian as given below.

$$PTCDF_n^k = \frac{\Delta P_{ij}}{\Delta P_n} \quad (1)$$

$$QTCDF_n^k = \frac{\Delta Q_{ij}}{\Delta Q_n} \quad (2)$$

$$PTCDF_n^k = a_{ij} m_{in} + b_{ij} m_{jn} \quad (3)$$

$$QTCDF_n^k = c'_{ij} n_{in} + d'_{ij} n_{jn} \quad (4)$$

$$P_{new\,ij} = P^0_{ij} + \Delta P_{ij}$$

$$P_{new\,ij} = P^0_{ij} + PTCDF_k^n \,\Delta P_n \quad (5)$$

$$\Delta P_n^{ij\max} = {P_{ij}^{\max} - P_{ij}^0} \Big/ {PTCDF_n^{ij}} \quad (6)$$

ATC is given by equation as under

$$ATC_n^{ij\max} = \min(\Delta P_n^{ij\max}) \quad (7)$$

If proposed transaction ΔPkn is less then ATCn then transaction is allowed, if not then procedure must be rejected or limited to ATC. Thus ATC can be used as a rough indicator of comparative system security [8]. ATC information can help ISO to determine the validity of behest results in an open access deregulated [2] Electric advertises when timely.ATC in order is very significant. It can also help the power market participants to place bid deliberately when congestion happens. ISO when the ISO [9] posts the ATC value for exacting transaction.

IV. STEPS FOR STATIC ATC DETERMINATION

The steps for computing the ATC for each applied transaction are given below:
Step 1: Take particular system details.
Step 2: Run a base case load flow.
Step 3: Assume the transactions (*m-n*) .
Step 4: Calculate the PTDF using (3).
Step 5: Determine the transfer capability (TC) for each branch (*i, j*) using (7)
Step 6: Do the possible transactions and determine the ATC using (1).
Step 7: If any line or generator is out, simulate the contingency and then go on; otherwise
Step 8: Determine the ATC for line outage contingency condition
Step 9: If any of the generator is out, then calculate ATC for the generator.
Step 10: After completing one transaction, proceed with another transactions.
Step 11: Display the value of ATC computed.

VI. TEST SYSTEM AND RESULTS

Available Transfer Capability has been calculated for various bilateral transactions for normal as well as with contingency conditions for IEEE 30 bus system. IEEE 30 bus system contains 6 generators, 41 transmission lines.
The various transactions considered here are,
T1 (30): transaction between 2 (seller bus) to 28 (buyer bus)
T2 (30): transaction between 5 (seller bus) to 30 (buyer bus)
T3 (30): transaction between 6 (seller bus) to 28 (buyer bus)

ATC FOR IEEE 30 BUS SYSTEM FOR NORMAL CONDITION (MW)			
Transaction	Normal Mode (DCPTDF) Method	Normal Mode (ACPTDF) Method	Limiting Area
T1(2-28)	22.67	23.79	6-28
T2(5-30)	12.20	14.87	24-25
T3(6-28)	21.98	23.45	8-28

Table No.1 ATC for IEE 30 Bus system

ATC Calculated by MATLAB	Limiting Area
16.65	2-6
22.73	5-7
41.52	6-8
10.42	9-10
43.69	12-15

VI. CONCLUSION

ATC development is the probable issue in deregulated electric power market. This paper has analyzed conventional PTDF methods including ACPTDF, for ATC assessment. This work would help to get enhanced the ATC results based on various joint transactions under normal and contingency conditions. This will help to reduce extra transmission lines for the structural investments and expansion development issues. The main application for ATC is to provide users an directory for finalizing better generation locations and for marketing transactions which will increases the economic benefits in the competitive power markets. The solutions obtained are appropriate and linear understanding factors applied here is of fast and less computation burden.

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