**Design and Development of Available Transfer Capability Enhancement using FACTS Device in Power System**

**1.Introduction**

In the electricity market, ensuring economic operationunder power system security constraints has become anurgent problem for operators and participants. Availabletransfer capability (ATC) represents the remaining powertransfer capacity on condition that the secure and stableoperation of the power system is guaranteed [9]. In other words,ATC approximately evaluates the safety and stability margin of the current operating point. Therefore, ATC is not only animportant basis for electricity market participants to carryout transmission right transactions but alsoa boundary condition for the power system expansionplanning. In modern power systems with high penetrationof renewable energy [10] and multiple types of loads, it isof great significance to develop an ATC evaluation methodto satisfy electricity market operation [2]. The ATC calculation is a real-time problem that addsan extra huddle to its evaluationprocess. There are alot of financial and engineering benefits for real-timeATC evaluation as follows: firstly, the on-line study canbe boiled down to those cases relevant to actual operatingcircumstances [1].

The power system is a compound electrical network, which is extremely bulky and includes generation networks, transmission networks, anddistribution networks along with loads, and these networks are being stretched all over a huge geographical zone.Recently, the demand forelectric power has escalated in an exponential mode [11], and hence ceaseless efforts are being made by the power system industries in distribution,transmission, and generation of electric power.Deregulation of electric manufacturing all over the world aims at generating aggressivemarkets to buy and sellelectric power. [8].To supply the demanded power, the transmission lines are working near or at theirthermal stability limits. This creates congestion in the system. To avoid this congestion [12],the power transfer capability of the lines must be known before any transaction is made. Tomanage a safe and economical transaction, the Available Transfer Capability (ATC) of thesystem must be calculated at regular periods [4].

Developmentand implementation of renewable energy andsmart grid inject more uncertainties, which make real-timeATC determination a hard nut to crack. In earlygrowths of ATC, estimation was dependent on the powerflow [13] of the network, hence, their computational speedwas high. However, the modern large-scale power systemconsisting of the grid, distributed generators (DGs),etc., makes power flow equations complex and non-linearin nature [2]. The wind power generated by both machines is more or lessthe same. But, in SCIG, for the variable wind speed, the rotor [14] is rotated at constant speed, and if the wind speed is beyond thecutout level, there may be the possibility of fluctuation in the rotor and which causes fluctuation in voltagestability [5]. The intermittency and uncertainty of wind power make system operation complex andvariable. This tends to cause problems such as the overloading of the transmission line [15] [3].

**2.Literature Review**

Kingsuk Majumdar*et al.*[1] presented the optimization-based calculation to enhance the available transfer capability (ATC) under various conditions. Moreover, the with and without Unified Power Flow Controller (UPFC) results are exhibited to derive the enhancement of ATC, and the opposition-based learning-based algorithm to improve the convergence characteristic performance. However, the complex and non-linear power flow equations introduced complexity in the evaluation performance. Xiangfei Meng*et al.*[2] developed the stochastic scenario-based ATC assessment methodology to evaluate the security margin, which considers the renewable output and load demand of power systems. Furthermore, the generative adversarial network was adopted to choose the representative scenario, which reflects the system operating condition with high energy penetration. However, the distribution range of ATC does not provide the probability distribution or average value.

Wenli Liu*et al.*[3] presented the optimal allocation method for the thyristor-controlled series compensation (TCSC) to enhance the ATC performance. In addition, the grid side and load side demand response were determined to find the optimal allocation of TCSC, and an improved algorithm was utilized to solve the optimization model. However, the economic and network side improvement performance needs to be considered to improve the ATC performance. Anurag Gautam*et al.*[4] introduced the TCSC to enhance the ATC, which contributes to congestion mitigation and power loss reduction. Moreover, the parameter of TCSC was optimized by the developed algorithm, which was used to validate the performance of the bus system. Different contingency conditions were considered to outperform the robust results. However, the complex patterns were introduced in the demand and power generation process.

M. Karuppasamypandiyan*et al.*[5] developed the Artificial Neural Network (ANN) model to predict the future wind speed, which contributes to determining the day-ahead ATC performance in the deregulated power system. Moreover, the dynamic ATC evaluation occurred based on the constant wind speed and dynamic voltage stability. However, the inability of reactive power support is caused due to the constant speed wind generator. Hala W.Reyad*et al.*[6]introduced the ATC assessment method to maximize the transactions between the different zones. Moreover,the most severe contingencies ranked by the linear sensitivity technique and the ATC estimation provide the complexity in analyzing the complexity of contingencies. IN addition, the developed method contributes to the reliability performance of the IEEE33 bus system. However, the prediction of high variability wind speed was considered as a difficult task.

Divya Gupta and Sanjay Kumar Jain [7] presented the power loss-based congestion reduction method to increase the power flow and relieve the system congestion. Moreover, the optimization technique was adopted for the ATC calculation, which controls the reactance of the power transmission line. However, the system does not maintain accuracy due to the significant changes. Joginder Singh*et al.*[8]developed the hybrid method to resolve the chos in the ATC of the power system. Moreover, the enhancement of ATC occurred due to implementing the TCSC, and the corresponding lines were selected by the optimization algorithm. However, the accuracy of ATC was low due to handling the symmetrical operational problems.

**3.Challenges**

* Interval optimization only provides the distribution range of the ATC, which does not provide the probability distribution and average value. In the electricity market, an accurate boundary is lacking by the transaction right trading, which performs the inaccurate classification due to the computation workload [2].
* Determination of ATC was complex due to the grid uncertainties, which depend on the network power flow, and it increased the convergence speed. Moreover, the grid and distributed generators make the non-linear and complex power flow equations [1].
* When calculating the dynamic ATC, fluctuation and voltage instability were caused, which also limit the dynamic stability [5]. Moreover, the accuracy of ATC computation is low, while handling the operational problems by the power flow method [8].
* Complex patterns of power generation and demands introduced the overloading on the transmission lines. Moreover, the severe issue of congestion degrades the power transfer capability at regular periods [4].

**4.Objectives**

* To consider the IEEE14 and IEEE30 bus system and conduct the power flow analysis to calculate the ATC, which reveals the amount of power transmission through the grid.
* To determine the optimal location of FACTS devices by hybridizing the horned lizard optimization and chameleon swarm optimization, which contributes to the ATC enhancement and minimizes the uncommitted active power transfer of the prescribed interface.
* To compare the developed method with existing methods to prove the proposed model as an efficient model.

**5.Proposed Methodology**

In transmission lines, the realand reactive power as the base for electrical power transfer. Inreal power, ATC is the limit margin that is transferred from the supply tothe load margin.For certain transmission lines, the maximum ATC limit is fixed, and it is insufficient to caterto the needs of customer demand.Such that, ATC enhancement with FACTS devices is essentialto enrich the ATC transferring limit. Hence, the research work will adopt the IEEE14 and IEEE30 bus system for power system analysis and enhancement purposes. Afterward, the power flow analysis will be conducted to calculate the ATC, which identifies the thermal limits, voltage limits, and congestion to reveal how much power can be safely transferred through a transmission grid. Moreover, the optimal location of FACTS devices will be considered to make the correct placement of FACTS devices, which contributes to power transfer, congestion reduction on transmission lines, system stability improvement, and overall efficiency enhancement in the deregulated markets with limited transmission expansion. Optimal placement of FACTS devices helps with effective power flow control. Moreover, the horned lizard optimization and chameleon swarm optimization will be hybridized for the optimal placement of FACTS devices. Moreover, the ATC will be determined at various contingencies, and then the system will conduct the power flow analysis to calculate the ATC after finding the optimal location of the FACTS device. Here, FACTS device of Unified Power Flow Conditioner (UPFC) will be considered for the better ATC enhancement. MATLAB is utilized as an implementation platform. Figure 1 illustrates schematic diagram of proposed methodology.

IEEE 14 IEEE 30bus system

Perform power flow analysis

Calculate ATC

Optimal location of UPFC device

Horned Lizard optimization

Chameleon Swarm optimization

Calculate ATC at various contingencies

System after optimal location

**Figure 1.** Schematic Diagram of proposed methodology

**6.References**

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