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A Review on Techniques of Power Transmission Lines Congestion Management in Deregulated Electricity Market

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Abstract

The idea of market power has gained its significance after the electric power industry started a practice of transition and restructuring since early Nineteen ninety. In this competitive electricity market, the physical and operational the constraints of the network hold key intimidation to the market by the generation companies. The growth of deregulated power systems has an outcome in terms of overloading transmission networks or network congestion. Congestion has severe effects on power systems, which includes rigorous system damage. Congestion take place when transmission systems fail to deliver power based on the load demand. These problems can be managed by implementing congestion management methods, which has a significant role in current deregulated power systems. Congestion has created the risk to reliability and power system security through defiance of transmission ability limits of line. This paper reviews some of important techniques and meticulous used by various researcher for management of congestion of lines. The exertion of various publications is used to review the implication of each anticipated technique in relieving congestion and optimizing system operating costs.

Keywords: *Artificial Intelligence, Congestion Management.*

1.0 Introduction

At present, the power industry in numerous countries is going through reformation and deregulation with the substitute of earlier colossal regulated public utilities with competitive power markets[1]. To meet growing demands for electricity around the world at optimized cost results congestion in the transmission lines of deregulated electric power systems, endangering transmission system reliability and security[2]. Action taken against Congestion management desires to be instant performed so that congested systems are avoided. Due to violations of the system operating limits transmission networks are sometimes unable to accommodate all desired transactions in deregulated market which causes congestion in power system networks[3]. The transmission network has some system and physical limitation which are one of the factors and phenomena cause congestion on transmission lines. System limitations are referring to reliability of transmission network, transient stability, Voltage limitation in a node, dynamic stability, which contributed to congestion of the network. Violated in addition with that when power flows in the transmission line are exceeding the flow limit by operating reliability limits[5] the conges-

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tion occurs. The transmission network has some system and physical limitation which are one of the factors and phenomena cause congestion on transmission lines[6]. Due to mismatch between power generation and demand, sudden generation outages, unexpected growth of load demand, and equipment failure causes congestion[4]. To ensure the power system reliability, security Congestion Management (CM) system should operate immediately after detection of system congestion. The significance of CM is to identify any congestion, failure, outage of power transmission lines and to maintain security and reliability of transmission networks. For the last two decades many studies have been carried out to determine the finest CM approaches for preventing congested transmission lines. In this paper a comprehensive review has been carried out on CM techniques[5,6].

2.0 Techniques for Congestion Management

Congestion Management (CM) can be broadly classified into two conventional categories namely: Technical Method mainly includes the line outages and failure which does not have any overall economic effect on system. In the Non-Technical Method, Cost is the most important factor for designing any power system. The conventional non cost free methods are nodal pricing scheme, generator rescheduling, distributed generation, load shedding, and demand response.

3.0 Conventional Methods of Congestion Management

3.1 Nodal Pricing Method

Nodal prices vary throughout the network according to the location, it is known here as "Location Marginal Price" (LMP). The nodal price stimulates the additional generation of power. Then the surpluses power is offered to pay for "contract rights." In this scheme Contract holders get rights to take power from a node and take output from another node.

3.2 Price Area Congestion Management (PACM)

PACM is mainly performed in performed Nordic countries like Norway, Sweden, Denmark and Finland, likewise it also practiced in India. It is aggravated in decentralized, day ahead and markets of bilateral type. Each and every power sector has their own generators as well as loads, contributing in different bids. Considering all the bids and offers primarily, the system price P_S is calculated. When over power flows between auctioning areas the area price P_O is calculated. The idea about additional unit installation can be find out from the differences between P_S and P_O. There are some areas where the power surplus and power deficit occurs, in those area price is regulated in such way so that power flow remains maintained according to the capacity of line between these areas.

3.3 Congestion Management Based on ATC

ATC stand for "available transfer capability." which refers to extra amount of power that can be transferred on the transmission line. Available Transfer Capability = Total Transfer Capability (TTC) – Total Required Margin (TRM) – (Existing Transfer Commitments (ETC) + CBM), where, CBM is the reserved margin by load serving units for reliability of generation requirements. One of the major characteristics calculated in transmission line is ATC. The ATC data of a line is recorded and store by ISO, at OASIS website it is uploaded which is handled by the ISO[7]. OASIS webpage is open to all to get the information about the transaction that would board or not, and implementation of electronic scheduling takes place by OASIS. Calculation of ATC can be done on the base of following four methods: Optimum Power Flow (OPF), Active Power Transmission Congestion Factor (PTCDF), Continuation method and Line Outage Distribution Factor (LODF). In Transmission Line Congestion Management ATC is one of the basic methods. These days in many areas it is most practically used method.

3.4 Facts Devices

FACTS devices categories are series controllers, shunt controllers, and combined series shunt controllers. SSSC, TCSC and TCPAR are the series controllers which are used to minimize the overloading and by controlling the transmission line power flow the line capacity can be improved. By direct or indirect injection of reactive power on the low voltage bus, the voltage can be controlled using Shunt controller i.e. SVC, STATCOM. To overcome power flow congestion in power transmission line UPFC is used which is a combination of series and

shunt controller and which improve the voltage profile[8]. The leading technologies in current power system are the combination of optimization methods and FACTS devices which can successfully reduce congestion. To increase transmission capacity, voltage stability and safety limits the FACTS devices are effectively used. Song *et al.*[9] Implemented a congestion management scheme which combines Genetic Algorithm (GA) with FACT devices, which shows that in TL where FACTS devices can be installed for CM. For power flow control currently IFSC is used widely. Author[10] has introduced a new method combining OPF and IFSC which shows an effective CM scheme.

4.0 Artificial Intelligence Applications for Congestion Management

Congestion Management is a non-linear program which includes numerous variables. Using optimization algorithm, the solution of this program can be achieved. Computer based algorithm and programming are used to solve CM in power system networks. Some latest algorithms are reviewed over here such as the Genetic Algorithm (GA), Particle Swarm Optimization (PSO), Grey Wolf Optimizer (GWO), Atom Search Algorithm (ASO), Flower Pollination Algorithm (FLA), Teaching Learning Based Optimization (TLBO), High-Performance Computing (HPC) algorithm.

4.1 Genetic Algorithm (GA)

To solve many problems of non-linear programming GA is one of the influential optimization techniques, more distinctively in counters trading. For providing optimal configuration in power transmission system, Granelli G. *et al.* recommend a method which is a GA approach with CM. This GA tool is appropriate for CM issues. The 33 bus CIGRE example system has been used by the author and moreover on the Italian 432 bus EHV network this methodology is tested and verified. Primarily, for modeling reconfigurations problem as linear program they use deterministic methods along with variable. Secondly, for maintaining M and M-1 security limits In MO optimization problems GA is also applicable. For MO optimization SPEA is used but it not the single way out to the MO function consequently the purpose is to find all the possible solutions. Moreover, FACTS devices or GR methods along with GA has been used for congestion management. For minimizing the system cost and obviously to manage the congestion projected method are useful optimization tools.

4.2 Particle Swarm Optimization (PSO)

M. Saravanan *et al.*[11] proposed a CM scheme based on PSO (Particle Swarm Optimization) for finding the optimal location of FACTS devices. In this proposed method two main constraints are minimum installation cost and system Load-ability improvements. If we consider the installation cost function of FACT devices, then UPFC with high installation cost gives utmost system load ability while TCSC with low installation cost gives better load ability. In power pool based electricity market for managing congestion with minimum shifts in generators. To minimize generator rescheduling costs and relieve congestion, PSO based algorithm which is an effective technique to manage congestion in power markets. Considering the Security constraints from both load bus voltage and line loading PSO based CM technique is successfully implemented on IEEE 30-bus system and hence at the end proved that PSO is an advanced method for congestion management.

4.3 Grey Wolf Optimizer (GWO)

With the rise of load demand, the occurrence of outage of any component in power system has been increased. In generator section, transmission line or in transformer section any unpredicted breakdown in any equipment of the power system network may lead to congestion on power system and also overloading causes congestion so there should be some proper supervision or control action for that. The reference [12] proposed a congestion management which aim to mitigate or eliminate overloading and violation in transmission power system. This paper presents CM with GWO based on optimal load for mitigation of load shedding, active power losses and voltage profile, voltage stability are improved. For congestion management optimal load shedding is a robust control action which is very clearly presented by the authors. Considering (N - 1) contingency the developed algorithm has applied to IEEE 30 bus system.

4.4 Atom Search Optimization (ASO)

Nowadays due to load escalation, the power transfer through transmission lines reaches beyond of its ther-

mal limit which results in transmission line congestion. Consequently, a essential step desires to be taken by Independent System Operator (ISO) in order to stay away from transmission line congestion. In this reference[13], to manage transmission line congestion the method Generator Rescheduling (GR) is considered over here by author. Initially, all the generators in the system are selected to reschedule real power outputs. Secondly, an Atom Search Optimization (ASO) is used which is urbanized population based heuristic algorithm method which is applicable to manage transmission line congestion by formulating suggested optimization problem. The purpose is to reduce the rescheduling cost while organization congestion in the transmission lines.

5.0 Conclusions

In this paper over congestion management a meticulous and critical reviews and comments has been done. The initial review part focused on conventional methods of CM. The In this paper over congestion management a meticulous and critical reviews and comments has been done. The initial review part focused on conventional methods of CM. The essential and significant discussions held in each and every section. In the next part Artificial Intelligence based CM techniques has been discussed. In that section it has been also proved that optimization tools are useful in mitigating congestion in power system. Almost all latest optimization tools have been discussed and the author tries for including congestion in power system.

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