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A Review on Congestion Management Approaches in Deregulated Power System

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ABSTRACT:
Since last two decades, Indian electricity markets are deregulated. With which generation and consumption of electricity are increasing unexpectedly. At the same time transmission sectors are not growing satisfactory due to many limitations like existing grid aging, very high cost of building new lines, permitting delays etc. Which has led to difficulties in accommodating all power transactions as transmission system are operated near to their full capacity in deregulated environment to satisfy the demand. Optimal utilization of transmission network without congestion is the main focus of ISO now days. This paper focuses on reviewing publications of transmission congestion management methods which can be an anther solution to building newer lines.

Keywords : congestion management, Deregulation, OPF, FACT, AI

INTRODUCTION:

Restructuring has brought organizational and operational changes by the virtue of Which Electricity has now became a commodity and regulated cost based electric power system is converted into price based liberalized power market. Under this competitive power market environment, number of market participants has increased and all of them try to get benefits of cheaper sources [1]. The tendency of getting more profit margins may cause overloading and congestion in certain transmission corridors. Thus congestion may lead to violation of voltage or transmission capacity limits and threatens the power system security and reliability. Moreover, open access in transmission system and competition in generation and distribution, has introduced a more intensified and frequently occurring problem of congestion. Also the growing congestion may lead to unanticipated divergent electricity pricing [2, 3]. Owing to these facts congestion management has become a crucial issue in the deregulated power system scenario [4]. Transmission Congestion Management is to alleviate the amount of power flow in the congested transmission lines by changing the flow pattern. Principally, this process of redispatch can be done by modifying generation or modifying load, or both, without compromising the system security and service quality. In a deregulated environment, all the GENCOs (Generation Cos.) and DISCOs (Distribution Cos.) plan their transactions ahead of time. But by the time of implementation of transactions, there may be congestion in some of the transmission lines. Hence, Independent system operator (ISO) in a competitive electricity market is responsible for determining the necessary actions to ensure that no violations of the grid constraints occur [5].

CONGESTION MANAGEMENT PERSPECTIVE:

Congestion management approaches are based on issuing orders by the ISO to various parties to reschedule their contracts, re-dispatch generators, use various control devices, or to shed loads in the extreme conditions when these measures are not able to mitigate congestion. Basic approach is based on centralized optimization with some form of optimal power flow program or depending upon the control measures executed by the SO for congestion relief [6].

Congestion management based on power market:

All the congestion management techniques are strongly coupled with the overall market design. Based on the literature review, to relieve the congestion, ISO uses mainly two approaches [7-9]:

1. Market-based congestion management methods

Market-based pricing methods:

Explicit auctioning: In this method ISO of the system sell their interconnector capacity to the highest bidders. In an explicit auction only transmission capacity is traded.

Implicit auctioning: In an implicit auction energy and capacity are traded at the same time. The main drawback of implicit auctions is that they require an organized power exchange at the high-priced end of each congested interconnection.

Market splitting: Market splitting is the most sophisticated of the congestion pricing methods. The market operator buys electricity from the power exchange with the lower price and sells it in the exchange with the higher price. It is most convenient method and can be applied quite flexibly and quickly. These methods are also called Allocation methods: methods used to allocate capacity up to the capacity limit.

B. Market-based remedial methods

Re dispatching*:* When Re dispatching is used to manage congestion, the market trades as if there are no physical constraints in the transmission system. Without signalling this problem to the market players, the ISO re dispatch generation to the point that the net flow of electricity matches the available capacity on the link, by dispatching more generators downstream of the link and reducing generation upstream.

Counter trading*:* counter trading is based upon the same principle as Re dispatching, which is to adjust the generation pattern in such a manner that physical overloading of the interconnector is avoided; it requires the involved ISOs to enter the market to do so. These methods are called Alleviation methods: methods used to alleviate the transmission network down to the capacity limit [9].

2. Nonmarket-based congestion management methods:

These methods have in common that they introduce a certain measure of arbitrariness and that they do not contribute to an economically efficient use of the congested line. Generation Rescheduling, Reactive power support & Load curtailment

Brief reviews regarding the CM schemes and the associated pricing mechanism used by the five ISO's of England and Wales, Norway, Sweden, PJM, and California are discussed [10] and a formulation is presented for comparison of various schemes. They have remarked that use of particular method depends on network configuration, load conditions and it varies from system to system of other country. Bibliographical survey for various congestion management schemes [11] and the list of general websites that dealing with the issue of congestion management is reported.

FACTS Devices for Congestion management:

Flexible AC Transmission system (FACTS) can be utilized to enhance the loading capability of existing transmission lines by compensating reactive power which reduces power flow in line; this also contributes in reducing power losses and maintaining stability of a system broadly it can be classified in to three categories: series controllers, shunt controllers and combined series and shunt controllers. Series controllers like TCSC,SSSC etc are used to enhance transfer capability by controlling power flow and by lightening the line load [12].Despite of pricing tools and other methods, FACTS devices can provide very promising solution for transmission congestion management [13,14].Various FACTS devices can be incorporated at the sensitive locations to manage the congestion problem. Major issues related to this method are FACTS device location, size and cost. Various methods are available for determining optimal location of these devices. Several Methods to find out optimal location for FACTS controller has been presented [15-19]. Multiple and multi type FACTS devices are used to improve the power flow control of line [20].

Zonal based approach for Congestion Management:

Zonal model based on ac load flow was proposed [21]. Partitioning the grid into zones is a key step in removing congestion. A zone is defined as a subset of buses of a grid. Zones are interconnected by tie lines, whose end buses are in the different zones. Zones has been identified based on the combined effect of real and reactive line power flow sensitivity indexes Viz. real and reactive transmission congestion distribution factors [22]. Comparison of the zone based approach and relative electrical distance approach is carried out [23] with the analysis of transmission congestion distribution factors to minimize rescheduling cost.

Sensitivity factor based approach for Congestion Management:

Several sensitivity factors Viz. Generalized generation distribution factor, generalized load distribution factor, Congestion relief index and Transmission congestion distribution factors are used to find congestion in a particular line. Sensitivity based approach has been used [24] for finding suitable location of UPFC for optimal power flow control in open power market. After selecting the suitable locations a comprehensive economic objective has been considered to decide the control parameters. Location of UPFC was decided by using sensitivity factors. Sensitivity of line is analyzed by considering changes in line susceptance to manage the congestion [25]. Line outage distribution factor is utilized [26] to find out the appropriate placement of FACTS device.

Generation Rescheduling for Congestion Management:

Rescheduling the power outputs of generators is the most used technique of congestion management. Author has proposed [27] a technique for optimum selection of participating generators using generator sensitivities to the power flow on congested lines. A novel approach of Dynamic congestion management using generation rescheduling is presented [28]. Sequential quadratic programming is used to validate generation rescheduling pattern and to minimize objective function. Multi objective based congestion management approach is proposed [29] using generation rescheduling and load shedding.

OPF based Congestion Management:

The aim of an optimal power flow algorithm is to determine the steady state operation point of generation transmission system so as to minimize predefined objective functions and to achieve set of constraints [30]. Concept of Distributed generation is utilized to manage the congestion and OPF is performed to optimize location marginal prices with the assumption of load uncertainty [31]. A hybrid model has been proposed to manage the congestion for both real and reactive power transaction [32].classical gradient descent optimal power flow algorithm has been used to determine set of feasible curtailment strategies for real and reactive power transactions.

ATC for Congestion Management:

Available transfer capability is important to track the remaining power transfer capacity of transmission line. Mathematically, it defines as Total Transfer Capability (TTC) less than Transmission Reliability Margin (TRM), less than the sum of existing transmission commitments and the Capacity Benefit Margin (CBM). Information of ATC is made available day ahead on Open Access Same Time Information system (OASIS) by ISO. Concerns can access OASIS and can assure feasibility of power transactions [33]. Author has presented a probabilistic approach for analysing contingency risk and ATC to manage the congestion [34].

CONCLUSION

In a restructured-competitive market, there is a prime need of an approach utilizing existing transmission system in optimal way so that congestion in transmission lines can be alleviated smoothly. In this paper, a survey on transmission congestion management approaches has been reported. The usual approaches for congestion management are Pricing based, optimal power flow based, using FACTs device Sensitivity indices based zonal management and generation rescheduling. However, the congestion management problem cannot be solved with unique approach but requires combination of approaches to be integrated so that desired objective can be achieved.

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