A review on congestion management in the restructured power system

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***Abstract*— the power system, around the world tends to operate power capacity close to their full capacities due to the environmental and economic constraints to build new power plants and transmission lines. Therefore congestion management became a vital issue within the power system operation, under deregulated environment and can be a major hurdle to trade of electricity if not properly implemented. It ensures the non-violation of operating limits. The paper describes the recent trends in the Congestion Management mechanisms within the deregulated power Markets. A synthesis of the congestion management methods and techniques involved has been effectuated. Several operating regimes that are leading to special situations are pointed-out, followed by appropriate conclusion.**

Keywords: Congestion Management, Rescheduling, Pool-Markets, Bilateral-Markets, Load flow Studies, Allocation

I. INTRODUCTION

In the congestion management the reforming of power is made based on organizational and operational changes. The commodity cost based power market is changed into price based liberalized electric power markets. In the competitive environment the cost per unit will be decided by the number of market participants and sellers to ensure optimum pricing. Due to the overloading and congestion in the system leads to frequent voltage outages, violation of transmission capacity thermal limits, threatens the power system security and impacts the operability of the system [1] systematic overview of the providing solution by OPF methods based on the system structures. The objective of the congestion management under unbalance or congested systems would be sharing the MW schedules decided by the ISO based on the loading forecasting with system security and reliable operations to get maximum benefits to the markets participants and power markets. Providing required power to interruptible loads by assistance of ISO to relieve congested lines. The congested condition system can also be released by curtailing the power system [5].

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To ensure congestion management in the competitive environment, various methods has been investigated e.g. counter trading and re-dispatching, bidding, auctioning methods nodal or zonal pricing model [2]. The Congestion Management plays a key role in deregulated power system. The work done in the area of congestion management has demonstrated the in competitive Power Market the traditional Regulated Power System has become more popular. The Electric Power Supply System has been changed in the real time scenario. Transmission congestion does not have enough transfer capability in operating condition.

Congestion management is related with one or more operational constraints under which gird can be operated. As compared to the conventional electric power system the open competition power market constraints are more in the market because each seller needs maximum benefits unlike convectional systems. The congestion management manages both technical and financial aspects which mean congestion management provide action solution and pricing allocation mechanism [3].

The classification of congestion management methods and their techniques has been demonstrated in this paper. Also deals with the analysis of several congestion issues and the pricing are discussed. In the competitive Power world, TSO is responsible for system security risks and reliable operation of his transmission network and it plays important role in Congestion Management in deregulated environments [4]. Also TSO has to determine individual customer or user of electric power to balance the system without any congestion and changers based on the appropriate energy cost.

ISSUES GENERATED IN THE CONGESTION MANAGEMENT

The reforming of the electric supply is difficult exercise due to the national energy strategies and

policies impact the Congestion Management in the several ways.

In the conventional power sectors the issue of overloading of the lines can be easily resolved by re-distribution of the outputs of generator units either corrective/preventive measures, which result in the re-allocation of economic benefits of several generation participating commodities.

Direct impact of the congested lines is on GENCOs in aggressive environment along with optimal bidding strategies are severely affected. A new technology introduction is needed [6] for optimal bidding strategies in the competitive power market. Due to their individual marketing strategies, the Congestion Management has conflict with the objectives of several GENCOs. In the literature survey of congestion management implies that they have significantly used the tools like neuro-fuzzy price forecasting approach [4] for forecast the LMP values at a node or in an area. Every individual participant expects to maximize their own benefits by redistribution of the generated energy which in result in the manipulation of benefits of others, where as in case of bilateral transaction the needs instantaneous and equal reduction at both the sides [7].

With all this conditions the Congestion Management becomes an crucial task. Under the system congested the cost increases significantly. The regulating bids for providers and consumers of electric power are increased due to increase in congestion prices. The main issue of the Congestion Management is the lack of alignment between regulatory body (owner) and market participants (customer). Under this situation the deregulated power system becomes more stable then regulated conventional system. Therefore it is difficult to handle the system without congestion management. Hence to make system congestion free different techniques has been applied to preventive congestion management measures. Then by applying generation rescheduling using corrective congestion management measures which is economically high. In this situation the congestion management comes into picture to put constraints on the energy market and competitive environment, thus reduces the theme of deregulation

CASES STUDY IN CONGESTION MANAGEMENT

The Congestion Management cases in countries like Australia, Thailand, Switzerland (Entras), Nordic and Japan Countries are studied and reviewed in this paper. Congestion management one of the case like Switzerland Due to recent increase loading in the line results in the congestion [8], the Swiss TSOs have decided to take call on the power management by congestion management concept [9]. In this concept includes three processes namely, congestion forecasting, determination of congestion system elimination, system methodology and implementation. Congestion elimination can be determined by the Optimal power Flow methods by combining topological measures comprise of variation of operational status in the network elements, transformer tapping adjustments and substation reconfiguration management, while re-dispatch congested lines by using globally optimal power flow solutions.

Real Time Scenario in Congested Power System Operation Environment

A Congestion management in Power System Operation Environment comprises of different players such as generator owners, transmission networks owners and load supplier. Individual market has its own independent grid operator known as the independent system operator responsible for the hour based (time to time), day based, and weekly based load ability forecasting calculations and sometimes long life operation of the system [10].

Based on the above discussion the power systems issues can be evaluated by the congestion management players. Other than this there are multiple internal players which also have key roles in the power system operation within the restructured industry. They are

- ➢ Increasing power demand and unbalances in operation and control of power systems.
- ➢ Increasing power market companies to be accountable for decisions.
- ➢ Increased need of power exchanges data different multiple market players.
- ➢ Increasing issues in the area of renewable energy.
- ➢ Different Generating Sources and environmental impact on economics.
- ➢ Requirement analysis to meet the value of energy sources among multiple players.
- ➢ Software technologies introduction and numerical methods analysis for the power industry resolutions.

The electric energy can be stored in the energy storage device called batteries. As you know it is uneconomical to store large amount of energy hence it can be generated and consumed instantly. The power demand varies significantly in daily basis [11], weekly basis and seasonal basis and random component basis. Energy plays a key role in bought and sold in an electricity market however other services like reactive power, automatic generator control, reverse power in order to provide reliable power. The ancillary power service can be structured and used to facilitate trading of these services.

The supplier and consumer are well distributed power according to the Kirchhoff's laws which determine the routes taken by the ISO on the network. This in turn results in the congestion in this system and altering generator outputs and customers' consumption. The adjustment are made to among the Energy units[12], ancillary power services and transmission network line which operates interconnected and this are coupled with the real time systems demand makes efficient electricity market.

Role of ISO in Power System Operability and Control strategies

ISO are responsible for setting up rules for different transactions between generator outputs and demand scheduling, loads capacity, network services, maintenance of system security and reliability, congestion management, service quality assurance. Also the ISO procures various ancillary power services from ancillary providers. The responsibility of ISO is to collect hour based, daily based and weekly based of energy transactions which provides load forecasting of next day [13]. These transactions can be decided by the congestion players like independent market operator bidding mechanism.

By use of bilateral contract between supplier and consumer based on consumer individual negotiations. The ISO does not involve in the pool market where power can brought and sold by individual owner to the individual customer. Once the transactions are determined by the ISO carries out the power flow studies for determining the congested lines, overloading etc., based on load forecasting for next day, availability of transmission capacity determines the level of system security.

If requires it can provide additional transmission capacity or power curtailment based on consumer needs. After finding different trade units, ISO calculates voltage stability, frequency variations and power flows in the real time systems to interact with the multiple networks and controllability of utilities for providing adequate frequency regulation services, reactive power compensation and voltage controllability service [14].

So system imbalance can be corrected by making different parties which are responsible and costing the same for existing parties. After real-time power calculations of allocation of transmission losses for generator output and consumer demand. The ISO compensates the losses by allocating other suppliers.ISO coordinates with different parties for settlements and payments of ancillary service providers.

Types of ISOs

There are two different types of networks for ISOs. They are pool based model and bilateral / multilateral based Model.

i) Pool Model (centralized)

In the pool type model ISO setup operational decisions which are made centrally and developed by each end user. In turn which results electric output from generating units is pooled and rescheduled to meet the electricity demand. In this reconstruction it is a needed for continues power supply with respect to the variation the demand and power consumed by the particular customer. For large utilities decisions are made in another level of hierarchy for further distributed to the geographical areas of same utility. For doing all this required communication protocols and engineering computation with in a utility and between the utilities. The use of computerized power system modeling makes this possible by ensuring heart of system operation and control in the utility of energy control center [15].

ii) Bilateral (Decentralized)

In the Bilateral systems, the ISO does not have authority to control the energy market. In the activity like free markets allows supplier cost and the consumer demand to negotiate each other to determine the economical scheduled cost as compare to other market cost. The role of ISO in bilateral model networks is to accommodate preferred schedules which manages the transmission market values and involves in the energy market only when the system gets congested. Unlike the pool type markets, ISO in the bilateral markets does not coordinate with energy markets and transmission costs. For making these ISO uses adjustment bids provided by market participants [16]. These markets provides the amounts participated which increases or decreases, below or above the preferred schedules and provides the cost saving accordingly between the supplier and consumer.

ii) Multilateral Markets (Power Exchange)

In the multilateral markets the energy brought and sold by increased number of private players. This can be achieved by creating very dynamic market places and variable pricing scheme. The main role of the multilateral is application of pricing in relation to the power sector by optimization and equilibrium for trading of energy. The equilibrium pricing method helps in bidding of electrical energy economically and efficiently. The management of short term supply and demand of electrical energy can be made by centrally coordinated dispatch process called power exchangers. The power exchangers play a key role in bought and sold of electrical power according to the stock exchange

[17]. The power exchange is an organization that provides the wholesale power buyer and seller participants in auction bidding. In the power markets, the power exchange can be formed in addition to the bilateral model. Clearing the energy markets results in exceeding the power flow capacity in the transmission networks.

The schedules in the power exchange are similar to that of schedules in the centralized ISO except for network constraints for consideration. The power exchanges receive the request from several ISO and bilateral transactions for use of transmission lines. The power exchangers adjust bids provided by market participants to eliminate congestion like bilateral contract. In congestion lines in the power exchangers involves in the energy markets but does not force any participants in the power traders.

Importance of Ancillary Services in Power System Operation

The scheduling and dispatching of power, frequency and voltage etc are referred as ancillary components which are required by the transmission system other than basic energy transmission and power delivered by the generator. Ancillary components are mainly defined by the fulfillment of active power demand of consumer. They generally control the active power, reactive power, voltage regulation, maintain the system frequency. They are important for ensuring reliable operation and control of interconnected power system [18]. The ancillary services in the Congestion management are classified as follows:

i) Energy imbalances

V/F control plays key role in power system operation and control. Frequency is an indication of energy balance between generation units and load demand in the power system. A frequency variation beyond the limits results in asynchronous operation in generator which requires immediate action in balancing supply power and the load demand. The control area operator controls the generation versus load demand curve.

ii) Scheduling and Dispatching

Scheduling and Distribution of power in power system coordinates transaction with different power markets and ensure the power exchange in the control area.

iii) Reduction of Power Loss

Every individual trader is needed to take care of the power losses and ensure reduction of the power losses.

iv) Voltage control

Voltage control means maintaining the required voltage in range of injection and drawing of reactive power from generating units.

v) Spinning Reserve (reliability)

Making unbalanced system into balanced system by synchronizing the grid frequency and voltage for generation and load imbalances caused by plant units and line outages.

vi) Load forecasting

Load forecasting for next day can be determined by calculating hourly based, daily based and weekly based load variation. These are ancillary component needed in the power system operation and control when the lines are congested.

DISCUSSION IN CONGESTION MANAGEMENT METHODOLOGIES

Congestion management can be broadly classified into two systems. They are price-free measures and not-price-free measures. In the price-free measures TSO would be setting the new topology for transformer tabs by generic compensation devices e.g. phase modifiers and FACTS - Flexible AC Transmission System devices.

These are price-free devices which evolves one-third of total cost in their nominal use. The non cost-free measures include generating energy rescheduling and load curtailment transactions. An algorithm is proposed for screening and ranking of contingencies in generation rescheduling and load-shedding. Different systems tackle the congestion in different ways. Examples as followed.

Application FACTS devices in Congestion management

The main constraint in the congestion management is deregulation of power markets i.e. to supply power with economical and efficiently. Congestion in the line increases the cost of supply unit in addition to the surplus congestion costs. The main task of the FACTS devices is to increase the transfer capability of transmission line. Also reduces the congestion cost by performing voltage control, stability limit of power system and reactive power compensation. Some FACTS devices like SSSC, UPFC are suggested as best reactive power compensating device. A closed loop controller with DC-link and UPFC in combination gives advocate pricing for operating system in their limits under challenging task.

Congestion Management Price Control theme

In this topology system is divided into multiple pricing units. The system with excessive generating unit

cost will have lower pricing and with excessive power demand will have more pricing. In this theme the spot market tenders must have to provide separate bids for respective areas. Also provides the network for area price calculation and combine market congestion management.

Congestion Management on ATC

In the available transfer capability the report of hour to hour, day to day is uploaded in the website called as Open Access Same time Information System (OASIS). For allocating any transaction one has to OASIS web page to have report about his transaction details. OASIS develops the computerized scheduling which as future scope to facilitate for data sharing in energy market towards controlling congestion.

Congestion Management on OPF

The role of optimal power flow technique is to reduce the generation pricing and provide benefit to consumer with respect to power system parameters. The OPF can be utilized effectively when the system is congested helps in analyzing overloading issues. A complete matrix for congestion management comprises in pool markets environment, bilateral markets and multilateral markets for power balance conditions and curtailment strategies. The basic objective of curtailment policies is to minimize deviations from scheduled transactions. In the multilateral transactions reliability of the system assessed by congestion management which in turn results in reduced curtailments and congestion charges comparatively bilateral transactions.

An optimization resolution is known as decentralized risk based congestion management which can be used determining the thermal overloads. An soft technique called optimal power flow control is used widely in scheduling and reducing congestion charges in the most of the congested system.

Application of Genetic Algorithm in congestion management

In the congestion management usually we face optimization problem having overloading issues. The algorithm is written as a powerful tool in achieving optimal power flow under specific operating conditions as compared to other computational techniques. Hence, genetic algorithm is proved as a smart definition in resolving optimal power flow in the congested system. A differential technique is evaluated for congestion problems called large scale mixed integer algorithm for determining optimal power flow in the congested network.

Application of Fuzzy logic connection approach

The definition of fuzzy logic in the electrical system points the use of hybrid technique in connection with FLC controller. The decisions are made in fuzzification is opinion matrix approach to select best strategy. A similar method called symbolic systems MATLAB simulation based approach with regressive testing technique is adopted in resolving congestion issues.

Congestion management techniques are rapidly used in inter-regional trading and development in new markets for gaining popularity in the congestion management system. In the literature survey of congestion management many of the references like inter-area electricity. The cross border congestion management system splits into market coupling, splitting etc.. These market based techniques allows optimal use of ATC without any system security risks. The combination of counter trading and market splitting arises correctiveness of optimization in the centralized control. Finally by applying the new concept called unit commitment, traditional philosophy of power system operation and control and economic load dispatch for revolutionary. A MATLAB programming tool is introduced in determining the nodal/zonal constraints into consideration. With above all techniques the congestion is clearly depends on the voltage stability. In the real time operation the congestion take place due to voltage security problems which indicates power quality issues and stability problems. So it can be dealt with proper technique to address voltage stability a margin in identification of congested areas in application of nodal analysis has proved as powerful tool.

Conclusion

In this paper detailed about the congestion management under Deregulated Power System environment are discussed. It has become important task in ever developing challenges and factors are forcing evolution of new techniques. A literature survey on the congestion management methods with different system applications is discussed. The issues encountered in the Congestion management with roles and responsibilities of the ISO and power Exchangers are briefed. Various methods and their compensation level are detailed.

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