A Review on Transmission Congestion Management in Restructured Power System

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Abstract—: In last some years the electrical supply industry is restructuring over all over the places. After restructuring of power industry congestion in electric grid become quite often which has brought several changes in organization and changes in Operations of electrical supply industry. In this today's competitive market of power sector the number of participants will increased and all participants will try to get benefits at low cost sources. A restructuring system allows the consumers to choose their supplier of electrical energy. By seeing this fact congestion management has become critical issue in restructuring electrical supply industry. In transmission system generation and distribution, frequently occur problem of congestion. This paper proposes congestion methods in past years using cost efficient generation, price, rescheduling and problem encountered.

Keywords- Independent system operator(ISO);Congestion management;Restructuring;Avaliable transfer capacity(ATC);Optimal power flow(OPF)

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I. INTRODUCTION

The transmission network is a vital mechanism in competitive electricity markets. In present days all our basic needs are linked with electricity. With the tremendous growth of population, the need for electricity is also tremendously increasing day by day. There is a need to enhance the existing power system or establish the new system to supply the power to meet the particular load requirements. The setup of most up-to-date power system is very costlier choice, thus improvement of the existing power system may be an alternative. As in the centralized system setup consumers hadn't option to select their power supplier due to monopoly. Deregulation prevents monopolies and also provides choices to consumers to pick up a good utility. Due to the lack of coordination, in between generation and transmission utilities, transmission congestion occurs. So due to the transmission congestion, it may not be possible to dispatch all contracted power transactions.

Now a day's transmission lines are often driven to beyond their thermal limit in order to satisfy the increased power demand. If the transmitted power is not controlled, some lines located in particular path may overload and cause damage to transmission line this phenomenon is called congestion [1]. Congestion can be caused by various reasons, like sudden change in energy demand, transmission line outage, generator outage etc. To deal with congestion in transmission line in competitive environment, several methods are used in all over the world like auctioning (Explicit auctioning and Implicit auctioning) method, nodal pricing method, zonal pricing method, re-dispatch method and counter trace method.

Restructured power system has more benefits so it is quite popular. Restructuring means transforming a vertically integrated system into a disclosed system. The disclosed system of the electric power system has evolved a new organizational structure. Restructuring itself means liberalization, deregulation and privatization [2]. Restructured power system has aspects like Generation, Transmission, and Distribution, Independent System Operator (ISO). In restructured environment, all the generation and distribution plans there transactions before time. But by the time of implementation there may be many congestion in transmission lines. There are two types of techniques that can be implemented on congestion management.

A. Cost-free means
(I) Operation of transformer taps changer or phase shifters.
(II) Operation of FACTS controller particularly series devices.
(III) Out-aging of congested transmission lines.

B. Non-cost-free means:
(I) Curtailment of demands and the exercise of (not-cost free) load interruption options.

(II) Re-dispatch of power generation in a manner different from the natural settling point of the market. Some generators decrease their efficiency levels while others increase their output. This in turn results that generators no longer operate at equal incremental costs[3].

This paper is an attempt to review the different methods to remove congestion in transmission under restructured system environment. Transmission pricing and congestion management are the key elements of competitive electricity Market based on direct access. The focus of the earlier works is much on the debate concerning alternative

approaches to the market design and the implementation of a common carrier electricity system.

II. CONGESTION MANAGEMENT

In this, the system is split into three different pricing areas. Spot market bidders have to submit separate bids for each price area in which they have generation or load. If no congestion occurs during market settlement, the market will be stable at one price, which will be same as if no price area existed. If congestion does occur, price areas are separately settled at prices that satisfy transmission limitations. Areas with higher generation have lower prices, and areas with higher load have higher prices. Reference [3] suggests a model for area price in congestion management.

A. Avilable Transfer Capability In Congestion Management

In this ATC is measure of how much additional electric power can be transferred from starting point to end point of a path. The ATC values for next hour and for each hour in the future are placed on a web site know as Open Access Same-time Information System (OASIS), operated by ISO. Anyone wishing to do transaction would access OASIS web pages and use ATC information available there to determine if system would accommodate the transaction or not [4].

B.Optimal Power Flow(OPF) In Congestion Management

Optimization is performed to minimize generators cost and maximize consumer's benefits subject to limitation. In this the generator send a cost function and those wishing to purchase load send a bid function to the ISO. The ISO has a complete transmission model and can then do an OPF calculation. In some countries zonal pricing method is followed in which system is divided in various zone. The zonal price are determine by the OPF are as follows:

1. Generators are paid the zone price of energy.
2. The loads must pay the zone price for energy.

If there is no congestion there is zone price throughout the system, generators are paid the alike cost for their energy as the loads pay. When there is congestion, zone price differ, each generator is paid its zone's price and each load pays its zone's price for energy.

C. FACTS Controller In Congestion Management

Flexible alternative current transmission system (FACTS) is used to improvise the maximum loading of transmission line by introducing the reactive power that reduces power flow in line, which results in minor power loss and developed stability of system. In restructured power systems, feasibility of transmission network components is necessary to be identified. It can be calculated by ATC network for number of applied power transactions. ATC is a key term in restructured power system that can be considered in the planning and controlling of transmission infrastructure. The FACTS devices are used to enhance Available Transfer Capability in deregulated environment. Main constraints for Available Transfer Capability (ATC) are thermal limits, stability limits, voltage limits & steady state. The variable load is advised as, data to calculate ATC of network.

III. CONGESTION MANAGEMENT METHODS

The congestion management schemes are strongly coupled with the overall market design. Competent allocation of sparse transmission capacity to the desired participants of the market is one of the main objectives of congestion management schemes. Thus, difference between them can be prepared based on market based congestion management methods and other methods. Market-based solutions for congestion are deemed fairer as they contribute better to economic efficiency than other methods. Other methods of market based make uses some criteria to allocate the transmission capacity. These methods are invented to introduce some kind of arbitrariness as they do not contribute towards efficient pricing of congested link. Taxonomy of congestion management schemes on these lines is shown in figure 1.

Non - market Methods		Market Based Methods	
1	Type of contract	1	Explicit Auctioning of network capacity
2	First come First serve	2	Coordinated Auctioning
3	Pro - rata Methods	3	Nodal pricing (OPF based congestion management)
4	Curtailment	4	Zonal pricing
		5	Price area congestion management
		6	Re – dispatch
		7	Counter trace

Figure 1. Classification of congestion management method

Non-market methods:

A. Types of contract

In this type of capacity allocation, network capacity is assigned to a specific type of transactions. If in the real-time operation, the re-dispatching of injections is necessary to be made, the short term transactions are truncated first ahead of long term or firm transactions.

B. First come First serve

There are some systems in which the bilateral contracts are awarded for transmission network access on first come first served basis. The calculation of ATC provides participants to determine whether there is enough capacity available for him to do the transaction between two nodes of concern. If adequate capacity is present on the network so as to make a transaction, the participant books the transaction with the system operator. Thereafter, the system operator updates the ATC. The transaction in line then checks whether there is enough corridor capacity available to do the transaction.

C. Pro-rata methods

Various norms can be set to assign network capacities on pro-rata basis. The capacities can be assigned on generation, average load, or percentage of long span transactions or utmost demand, etc. That means, all participants receives an equal percentage of the total amount of capacity they apply for. These standards are used for capacity allocation as well as for congestion improvement, which is used in real time.

D. Curtailment

In this transaction-based curtailment approach is another methodology that is used for congestion management. In real-time operation, the ISO monitors the system for possible security violations. In the event of such violations occurring or being imminent, the TLR method of curtailing transactions is exercised. The transactions are prioritized for curtailment on the basis of criteria that consider the size of the transaction, its relative impact on the congested line flows, and the firmness level that was fixed before dispatch. In this scheme, price and the actual value of transmission are not important considerations. So, whereas this method gains reliability-wise, it might lose on the economic front.

Market Based Methods:

A. Explicit Auctioning

The principle of explicit auctioning is based on selling the available capacity of the tie line to the highest bidder through auction. This is not anything but auctioning of the tie line capacity. The explicit auctioning distinct the energy market from transmission capacity market. This approach is commonly used in Europe for capacity allocation at numerous borders. In explicit auctioning, the system operators (or the TSO in Europe) determine ex-ante, the available transmission capacity (ATC) considering safety analysis, accepts bids from possible buyers and allocates the capacity to the ones that value it most. This, auctioning is a market based an idea, which provides economic signals. Thus, with perfect insight, bidders for transmission capacity would predict the electricity market outcome with efficient use of transmission.

B. Coordinated Auctioning

The coordinated auctioning splits the markets into two market energy market and transmission capacity market. Participants have to make sure that they hold enough transmission rights to conclude their energy exchanges. Coordinated auctioning, hence tries to overcome problems associated with explicit auctioning by accounting for the effects of loop flows within the network. A central auctioneer is introduced who looks after the capacity allocation at all borders included in the Internal European Market (IEM). For coordinated auctioning, three steps are necessary:

- Every system operator informs the central auctioneer about the available transmission capability.
- Market participants then finally submit their bids to the central auctioneer.
- The auctioneer then allocates transmission capacity using a model analogous to nodal pricing.

C. Nodal Pricing

Nodal pricing is to model an electricity market with its various economical and technical specifications that includes generation limits, generators' cost functions, line power flow limits, demand elasticity and develop the system for improvising social welfare & development. This fact represents one of the frequently employed formulations of Optimal Power Flow (OPF). The name OPF does not stand for any specific optimization flaws, rather a number of optimization problems falls into the OPF group. The basic aim of an OPF analysis is to achieve an optimum power transfer situation without violating the network protocols & rules. Hence we can say, the congestion management problem is resolved by solving an optimization problem, with a set or group of constraints that represents network constraints. One of the outcomes of this optimization problem is the price at each node known as nodal price. It affects the temporal and spatial variation of energy price associated with the demand on that node. Nodal pricing is considered as a fully coordinated implicit auction.

d. Price Area Congestion Management

Both inter-zonal and intra-zonal congestion management schemes, these methods comprises of splitting a power exchange into geographical bid areas with limited capacities of exchange. When congestion is identified, system operator then declares that the system is split into areas at predicted congestion bottlenecks. Spot market bidders must compulsorily submit separate & individual bids for every price area in which they have generation or load. If there is no congestion identified during market settlements, the market will settle at one common price, which will be identical as if no price areas existed. If congestion persist, price areas are discretely settled at prices that satisfy transmission constraints.

e. Re-dispatch

Re-dispatching is implemented as a command scheme and control scheme, i.e., ISO cut shot or increases injections irrespective of market based incentives. As generators have to be reimbursed, the ISO holds an incentive to keep re-dispatch cost low.

f .Counter trace

Counter trading follows the same principles as re-dispatching, however, it may be considered market oriented. Rather than applying command and control, the ISO will buy and sell electricity at prices determined by a bidding process. The principle of counter trading is thus a buy back principle which consists of replacing the generation of one generator ill- placed on the grid as regards to congestion by the generation of a better placed generator. The ISO has to

buy electricity downstream of the congestion at higher cost and sell it upstream. Thus, there is no congestion rent, instead a congestion cost for ISO. This cost exposure is also regarded as an incentive for investment into grid capacity. Counter trading is used for real time congestion relief in the Norwegian system.

IV. UNDESTANDING THE RESTRUCTURING PROCESS

Restructuring in the electricity industry is spreading across the United States and around the world. Some of these initiatives are well under way for instance, in California, Pennsylvania, Australia, Norway, and the United Kingdom but far more are in the design and early implementation stages. Restructuring means deregulation of power industry on market bases. The restructuring process starts with the unbundling of originally vertical integrated utility. Analysis of the electricity industry begins with the recognition that there are three rather distinct components of it Genco, Transco, and Disco. just the once electricity is generated, either by burning fossil fuels, or by harnessing wind, solar, or hydro energy, or through nuclear fission, it's then carry forward through high-voltage-capacity transmission lines to the local regions in which the electricity will be consumed. When the electricity arrives in the area in which it is to be consumed, it is then changed to a lower voltage and sent through local distribution wires to the end use consumers. In which all three of these vertically related sectors have typically been tied together within a service, which has been either investor-owned or owned by the local municipality. For several years, each sector was thought of as a natural accepted monopoly. In the transmission and distribution sectors, effective competition that require that rival firms duplicate one another's wire networks, which would be incompetent. If wires owned companies were allowed to interconnect to form a single network, the laws of physics show that there would be significant externalities: the flow on one line affects the capacity of other lines in the system to carry power. Generation was argued to be a natural one companies because of the large scale of efficient generation plants and the losses that occurred with long distance transmission, which has been made it more efficient to have local areas served by one or a small number of generating plants. Very less people argue that the basic economics of transmission and distribution have changed. But on the other hand, over the time, optimal scale of generating plants has decrease, not increased, as many thought it would in the 1960s and 1970s with the growth of the nuclear power. In the addition, technology improvements reduced the losses that occurred during transmission, which make it more feasible for plants hundreds of miles apart to compete with from one another.

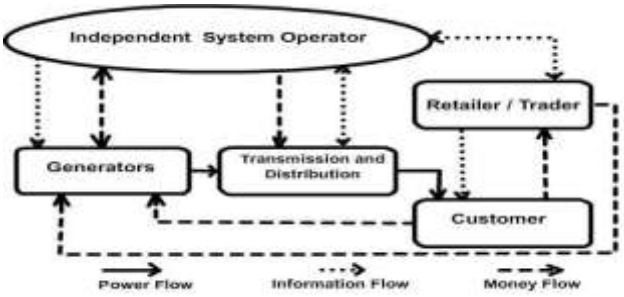

Figure 2. Structure of Restructured Power System

Figure 2. Shows the representative structure of restructured power system. In distinction to the vertically integrated utility structure, it is observed that there are many alternative paths along with the money can flow. A system operator is appointed for whole system with the responsibility of keeping the system balanced, to ensure that the production and demand match continuously. For that it will not required to be independent authority without involving market competition nor could it generate facilities for business. This system is called as Independent System operator (ISO). The conditions that led to restructured of power system is technical innovation, improvement of material, computerized control system, data communication and off-site monitoring system. Deregulation reduces the risk involved in investing money of government by introducing privatization which will help to reduce the cost to drop. This is bilateral power system which flow in both directions.

V.CONCLUSION

In the fast emerging restructured power system scenario, congestion management has become crucial task. Ever developing challenges and factors are forcing evolution of new techniques. In this paper we have discussed congestion management methods and techniques available for restructured system. An attempt has been made to encompass the emerging trends in Congestion Management however the list is not exhaustive.

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