Market Power in Electricity Markets

***Abstract*—Restructuring of the electric supply industry and the entry of independent power producers in the power sector have introduced the concept of market power. In the competitive power sector, the various physical as well as operational constraints of the electrical network influence the market power. The market power is fundamentally the capacity of a specific gathering of venders to keep up the costs over the focused level. The restructuring of the existing power system have resulted in emergence of competitive power markets which are procuring the advantage of lower prices. Different type of innovations arises due to competition. Such benefits cannot be utilized when the market power has been excised by the players which are using the electrical transmission system. This paper presents different methods which were utilized as a part of examination of market power and furthermore different techniques have been talked about and dissected for managing such circumstances.**

Keywords—Electricity market, Market power, Market power indices, Reactive power

I. INTRODUCTION

Earlier the electrical supply system which mainly includes generation, transmission and distribution was owned by the single authority but with the introduction of competition in the power sector the whole monopolistic system transformed into deregulated electricity system. Competition in electricity sector improves the efficiency of power generation which in turn benefits the consumers. Vertically incorporated utilities by and large recuperate their cost whether they work effectively or not but rather with the presentation of rivalry there is an imperative move in this approach [1]. The competition in the power markets provide a driving force to generators so that they can operate in most efficient manner and recover their various costs. The various advantages of competition in electricity market include cheaper electricity, valuing is taken a toll intelligent as opposed to set tariff, cost minimization, more choice, better service and employment.

Market power is the primary hostile to aggressive practice that keeps the opposition in the power showcase, particularly in age. In rebuilt power advertise, the market exists when any of the age organization impacts on the accessibility of electric power or on showcase estimating. Market power reduces the competitiveness and effects in the development of technology [2]. The market power may range from full market to local market. The extent to which market power can be excised depends on the market concentration, mechanism of market, nature of commodity, ease of market entry and price elasticity of demand.

The fundamental goal of this paper is to give an outline of the different market control issues on the electrical transmission framework, in light of keeping the different effects of congestion of transmission lines. Furthermore, compelling perception is done on the issues associated with advertise control investigation .This paper talks about a few kind of market control issues, test systems/devices for showcase control, distinctive sort of calculations to manage the issue of market control and diverse approaches to alleviate market power.

II. MARKET POWER INDICES

In the deregulated power advertise, the market power can be estimated effortlessly by various kind of market control records. These indices have many significances and limitations according to the type of conditions. By studying these indices it can be concluded that the market power vary according to the conditions and also with respect to time.

A. Herfindahl - Hirschman Index (HHI)

This strategy is a typical method for estimating market fixation that thusly mirrors the members and imbalance of offers in the power advertise [3]. HHI is characterized as "Weighted aggregate of piece of the overall industry of all members in the market".

$$\mathrm{HHI} = \sum_{i=1}^{N} S_1^2 \qquad (1)$$

Where N is the quantity of members and S_1 is the ith member piece of the overall industry in per unit or in rate.

B. Lerner Index

This list is utilized to gauge corresponding deviation of cost at the organizations benefit expanding yield from the organizations minimal cost at that specific yield. It can be characterized by the accompanying condition:

$$\mathrm{Li}_i = (\rho_i - mc_i)/\rho_i = 1/\epsilon_i^d \qquad (2)$$

Where Li_i is the Lerner index for firm i, ρ_i and mc_i are cost and minimal cost at the organizations benefit augmenting yield, separately and ϵ_i^d is the flexibility of the request seen by the firm. From the equation it can be surmised that if the estimation of Li is bigger than zero for any age organization than it can be inferred that there exist market power.

C. Must Run Ratio (MRR)

The transmission line constraints are sincerely considered in the Must Run Ratio. The MRR in the transmission zone i for supplier A is defined as follows:

$$\mathrm{MMR} = \mathrm{P}_d - \mathrm{P}_i - \left(\sum_{j-1}^{Ng} Pg_{j,}\,\mathrm{max} - \sum_{j-1}^{Ng} Pg_{j,}\,\mathrm{max}\right) / \left(\sum_{j-1}^{Ng} Pg_{j,}\,\mathrm{max}\right) \qquad (3)$$

Where P_l is the import furthest reaches of the zone, $Pg_{j,\,max}$ is the yield furthest reaches of generator j in the zone, Ng is the quantity of generators in the zone; NgA is the quantity of generators claimed by the provider A in the zone and P_d is the aggregate heap of the zone.

MRR gives the limit that can be produced by the generators to the heaps in the congested zone. It likewise helps by giving valuable market control motions in the congested zone.

D. Must- Run Share (MRS)

In [4], three unique sorts of market power are proposed which incorporates the effect of imperatives of transmission line, stack varieties and the surprising disappointments on showcase control. They are MRS, Nodal-Must Run Share (NMRS) and Expected Nodal Must-Run Share (ENMRS).

So as to comprehend MRS, we should first find out about the idea of Must Run Generation (MRG). It is characterized as the base limit which is given to the heap by the generator thinking about transmission and age imperatives. It can be characterized by the straight streamlining issue.

$$\text{Minimum } P_{gk} \tag{4}$$

$$\text{Such that } e^T = (Pg - Pd) = 0 \tag{5}$$

$$0 \leq Pg \leq Pg_{max} \tag{6}$$

$$-Pl_{max} \leq F\ (Pg - Pd) \leq Pl_{max} \tag{7}$$

Where e is a vector having all ones, Pg is control dispatch factor, Pd is request vector, Pl_{max} is the line limit vector, and F is the distribution factor grid. Eq. (5) signifies control adjust condition and Eqs. (6) and (7) signifies the generator yield breaking points and transmission line restrains separately.

The Must Run Share (MRS_k) of the K^{th} generator in the power market is given by:

$$MRS_k = Pg_k^{must} / Pd \tag{8}$$

Where Pd is the aggregate request in the market, it is to be noticed that the MRS ought to be more noteworthy than zero for market power.

E. Nodal Must-Run Share (NMRS)

For this situation, MRS is connected to each heap transport with the goal that the impact of land distinction of market control is incorporated. $NMRS_k$ speaks to the base limit gave by the must run generator k to supply a given load at hub i is given by the accompanying condition:

$$NMRS_{k,i} = Pg_{k,i}^{must} / Pd_i \quad i = 1,2\ldots\ldots N \tag{9}$$

Where N is the number of buses in the power system, Pd_i is the load at bus i and$Pg_{k,i}^{must}$ is the contribution of the must run generator k to Pd_i.

F. Expected Nodal Must- Run share (ENMRS)

Because of sudden disappointments, under the possibility express, an age organization has the opportunity to practice advertise control. Subsequently in NMRS distinctive sort of possibility states must be incorporated. Consider a power framework with n number of free parts, with precisely m fizzled segments for a framework state s, the state likelihood is given by:

$$P_S = \prod_{i-1}^{m} U_i x \prod_{i-m+1}^{n} A_i \tag{10}$$

Where A_i and U_i are the accessibility and inaccessibility segment i, separately.

ENMRS of GENCO A at bus i can be ascertained as takes after:

$$ENMRS_{A,i} = \sum_{s-1}^{Nc} p_s x NMRS_{A,i^s} \tag{11}$$

Where Nc is the quantity of disappointment possibilities.

III. Simulators/Tools on Market Power

Numerous test systems, distinctive kind of programming apparatuses and imagining helps have been outlined by the scientists keeping in mind the end goal to investigate the power advertise and to recognize the producing organizations that can practice market power.

In [5], D.P. Chassin, K. Schneider and C. Gerkensmeyer designed a simulator to deal with power flow control operations and also help in managing market-based incentive programs. This simulator helps in end use modeling and integrated with high performance computing capabilities.

In [6], Contreras et al. proposed an electricity market simulator. This simulator is based on wisely used simulator MATLAB and a computer communication net. Various case studies are explained in this paper. Behavior of price makers and the competitive fringe producers can be studied using this simulator. S. de la Torre et al. [7] proposed a tool that is useful in regulating the market and which in turn may be used to monitor the market. It is also helpful in spotting the producers which are exercising the market power. The test system in this paper considers three unique kinds of members to be specific, producing organizations (GENCOS), devouring organizations (CONCOS) and the market operator (MO). Simulation is performed to determine the strategy of every GENCO and all the strategies are optimally combined through the market clearing algorithm in order to simulate the market results.

Overbye et al. [8] analyzed bulk electricity market by considering the transmission line constraints. This paper analyzed and visualized the situation of market power, including the impact of congestion.

IV. Reactive Power Based Market Power

In [9], Jin Zhong and Kankar Bhattacharya introduced outline for responsive power subordinate administrations in a focused market. Generators attributes having responsive power ability are utilized as a part of request to examine the reactive power costs with the goal that an offering system can be developed. A programming approach in light of ideal power stream show is utilized to settle the reactive power advertise on a uniform value sell off. In this paper, an Expected Payment Function is planned by watching generator responsive power ability attributes and an offer-value system has been proposed.

In [10], Federico depicted power framework tool stash for examination and outline of little and medium size electric power frameworks. Market Data which incorporates control supply offers and cutoff points, generator hold control and the power request offers can be effortlessly examined and information can be mimicked utilizing the product.

In [11], Donghan et al. explored the issues of reactive power must run limit in control framework tasks. This must run list strategy is utilized to gauge the market control practiced by the reactive power makers. It additionally recognizes the states of market control event in the power showcase. It has been watched that the reactive power must run lists stay unaltered when the reactive power yields and voltages change. Market power can be practiced by the GENCOS of the having generators at various hubs by controlling the yields of its generators.

In [12], Emilia Nobile and Anjan Bose proposed a scheme for voltage control / reactive power in a competitive ancillary service market. In a certain geographical region automatic voltage control could dynamically control the reactive power. By dividing the system into voltage control areas (VCAs), the reactive power in each VCA is managed by adjusting the voltage reference values with the help of some controlling units. Further investigations are done in order to understand the best option for reactive power market in various regions.

V. ELECTRICITY MARKET IN VARIOUS COUNTRIES

A static computational diversion theoretic model has been talked about in this paper [13]. From the consequences of changing European power showcase, the financial and ecological outcomes have been created with the assistance of this model. This model is aligned to eight North Western European Countries. Diverse structures of market are looked at based on the capacity of the organizations to practice market power. This model aided in examining the effect of rivalry on discount power showcase, power requests, firms benefit and the diverse sort of contaminating emanations. From the outcomes it can be presumed that control over interconnection limit can be helpful in creating another wellspring of energy advertise.

In [14], the examination is directed on European Electricity showcase utilizing amusement hypothetical model .The model is keep running for various distinctive circumstances. Right off the bat, under the circumstance of flawless rivalry the costs shift as a result of various age advancements and restricted trade of power among various nations. Also, costs increment because of dry climate in hydro-rich Nordic nations took after by the Alpine nations. Thirdly, expanded transmission limit would bring down the costs in the nations which are having higher costs and the effect of market control lessens. Market aggressiveness would increment when the transmission limit increments. From the model runs it has been watched that the greatest value reactions are found in nations where the quantity of firms is low.

In [15], paper clarifies the level of market control in German discount power advertise. It has been watched that the market control is shown amid the pinnacle time frames. In [16], V. S. K. Murthy Balijepalli et al. presented more brilliant and shrewd matrix keeping in mind the end goal to improve control advertises. Brilliant lattices are work with reference to specific appropriation framework and sustainable power source assets. Power markets are by and large described by the poor request side reaction for the absence of legitimate foundation. Savvy matrices help in managing this issue. Power quality necessity for touchy clients can be accomplished through brilliant frameworks. In [17], Umesh Kumar Shukla and Ashok Thampy investigated rivalry and market control in discount power advertise. From this paper it can be presume that market control is one of the real purposes behind increment in showcase costs. Market energy of firms might be one reason at increment in power costs.

VI. MITIGATION OF MARKET POWER

A number of strategies can be implemented in order to tackle the problem of market power. Nature and magnitude of every problem decides the appropriateness of every strategy.

A. Ease of Entry

The problem of market power can be mitigated by encouraging the entry of more suppliers since the threat of entry is best deterrent to the exercise of market power. It can be concluded that entry should be easy and profitable.

B. Limitations of Individual Suppliers Market Share

There should be limit on the overall capacity and for the generating units which can be owned by each supplier. By opting this market share of dominant suppliers will reduce and the market will move towards more competition.

C. Expansion of Electrical Transmission Network

In power transmission system, congestion is the driver of market power abuse. Expanding or changing the network may be an appropriate step since enhancement of network can eliminate local market power. Network enhancement can induce several changes to the power flows in the other parts as well; this approach may always not be popular as some market participants will be having disputes to the changes in the market.

D. Contract Based Methods

Physically or financially, long term contracts play a significant role in minimizing market power which can be exercised by the dominant suppliers. The more suppliers output covered by the contract the less of an incentive it will have to participate in the spot market.

E. Price Cap

Market power can also be reduce by the use of price cap. Upper limit of the pool price can be easily provided by the price cap. During the period of high demand and low supply, the pool price is not allowed to increase. The prices are constrained to the capped value by the market operator. Price capping is a controversial task. If the price cap is set too low, it can depress prices and interfere with the price signal for new entrants. The issues with the price cap are more complicated in California as there exist many electricity markets. The price cap in one market may influence the behavior of suppliers in the other.

VII . CONCLUSION

This paper fundamentally gives a layout of the different research works did in the field of market power being practiced by the different market members. Distinctive kind of market power have been talked about which are utilized to quantify the market control in most recent 30 years. Market power regarding reactive power has likewise been investigated in different research works. The role of various simulators, algorithms and the application of game theory to deal with the problem of market power have also been studied. The electricity market of various European countries, Alpine countries, USA, Germany and India have been studied and the various case studies has been carried out in order to analyze how the market power is exercised in these countries. Different moderation strategies have been talked about with a specific end goal to handle the issue of market control. Legitimate examination and representation has been done in this audit work with a specific end goal to deal with the issue of market power in deregulated power industry.

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