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Market Based Criteria for Congestion Management and Transmission Pricing

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Abstract--Congestion Management is one of the major tasks performed by system operator to ensure the operation of transmission system within operating limits. In the emerging electric power market, the congestion management becomes extremely important and it can impose a barrier to the electricity trading. In the present paper, a concept of transmission congestion penalty factors is developed and implemented to control power overflows in transmission lines for congestion management. Here we presents a Re-dispatch methodology for cost of transmission network to its user. The transmission price computation considers the physical impact caused by the market agents in the transmission network. The paper includes case study for IEEE 5 bus power system.
Keywords: Optimal power flow, Congestion Management

I. INTRODUCTION

All over the world, the electricity industry is converging towards a competitive framework and a market environment is replacing the traditional monopolistic scenery for the electricity industry. In the regulated framework, electricity supply was considered a public service with the electric energy industry organized a regulated and vertically integrated , joining generation , transmission and distribution of electricity in government owned monopolistic companies . Thus predicting future price involved matching regional electricity demand to regional electricity supply. The future regional demand was estimated by escalating historical data and the regional supply was determined by stacking up existing and announced generation units in some wise order of their variable operating cost.

Congestion results when power flows in the transmission line are higher than allowed by the operating reliability limits. In a competitive electricity market, congestion occurs when the transmission network is unable to accommodate all of the desired transactions due to violation of system operating limits.

Congestion management means the activities of the transmission system operator to relieve transmission constraints in competitive electricity market. In the present day competitive power market, each utility manages the congestion in the system using its own rules and guidelines utilizing a certain physical or financial mechanism. Congestion management schemes suitable for different electricity market structure. Optimal Power Flow based approach that minimizes cost of congestion and service cost is proposed [1]

As such, electricity prices tended to reflect the government's social and industrial policy at any price forecasting which was under taken was really based on average cost. In this respect, it tended to be over the longer term, taking a view on tax prices.

Electricity has been turned into a traded commodity in nowadays, to be sold and brought at market prices, although with distinct characteristics since it cannot be stored economically with the exception of pumped storage hydro plants when appropriate conditions are made.

The new electricity industry competitive framework coming from the deregulation of the electricity markets was intended to encourage competition among companies in order to decrease the cost of electricity.

An accurate forecast of electricity prices has become a very important tool for producers and consumers. In the short term, a producers need to forecast electricity prices to derive its bidding strategy in the pool and to optimally schedule its electric energy resources. Price forecasting has become in recent years an important research area in electrical engineering and several techniques could be used to predict the electricity prices. The hard computing techniques, where an exact model of the system is built and solution is found using algorithm given below.

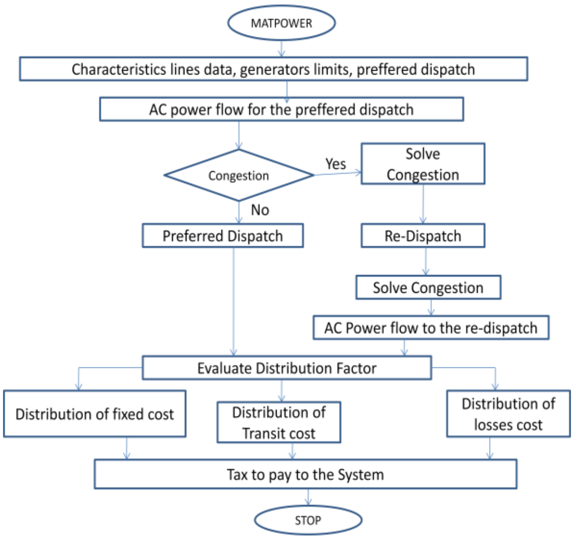

Fig 1: Algorith for Re-dispatch Technique

In this paper we also proposed transmission re-dispatch technique. Transmission Re-dispatch is means to resolves transmission congestion by changing relaxing the transmission line limits by specified range to reduce congestion. This methodology could be a lower cost faster solution to new transmission service than building new transmission lines. Hence it is cost effective one.

This paper present a software tool using MATPOWER to assist decision making in competitive market environment .The initial dispatch is based on all the electricity transaction negotiated in the pool and in the bilateral contracts. It must be cheated if the proposed initial dispatch leads to congestion problem; if a congestion situation is detected, it must be solved. and taxes calculation given in this paper. We also present a software tool to assist the decision in competitive market.

II. POOL AND BILATERAL MARKETS

Throughout the world electric power industries are moving toward competition through market based which is an objective for higher operational efficiency the competitive market are widely employed electric utility which are based on pool and bilateral models. The special characteristic network of electric power within the process of electricity trading. This model released on the action of pool operator for attaining the initial dispatch which is economical. In contrast, the bilateral model is motivated by the concept that free market trading is the best way to achieve the competition in the electricity wholesale, However both model usually required a common transmission system to transmit the dispatched energy from supplier to customer.[2]

Two ways of trading are usually assumed: the pool trading and bilateral contract trading. In the pool trading, producers and consumers submit bids respectively for selling and buying electricity on established intervals , typically on an hourly basis . Finally, a market operator clears the market by accepting he appropriate selling and buying bids , giving rise to the electricity prices .

In competitive environment, two market models widely use though out the world i.e. pool and bilateral markets can be jointly implemented in an electricity market. The implementation of these market modes depends on physical characteristics of system load and generation together the market structure policy.

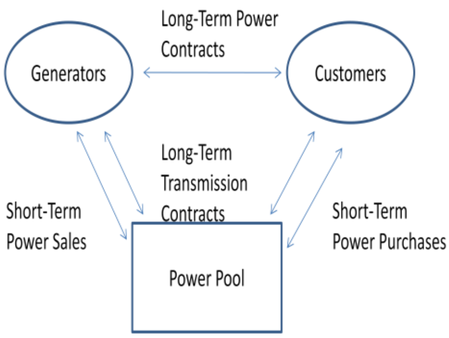

Fig.2: Diagram of Power Pool

In the pool model there are two main sides of entities participating in the market i.e. customer and supplier. The pool operator considers electricity transaction bids and offers from these two entities and dispatches this in an economic manner. In general the customer and supplier do not directly interact to each other, but only indirectly through the pool operator. After all the bids and offers have been received, and optimization tool will be use to solve the problems which includes congestion management [2].

In competitive environment, two market model widely use throughout the word i.e. pool and bilateral market, can be jointly implemented in an electricity market .The implementation of this pricing simulator depends on the tag allocated to the load and generation to get the market structure policy. In the pool model, there are two main sides on entities participating in the market i.e. customer and supplier .The pool operator consider the electricity transaction bids and offers from this two entities and dispatches them in an economic manner .Depending on the price and MW bidding . In general the customer and supplier do not directly interact to each other but only through the independent system operator After all bids and offer have been received an optimization tool will be used to solve the problem which includes tax allocated to the load and generator which also includes tax on losses[2].

2.1 COMPETITIVE MARKET TRADING:-

According to the competitive market the bilateral trading of electricity suppliers and consumers indepentently arranged power transaction with each other according to their own financial term . Economic efficiency is prompted by consumers choosing the least expensive generators . The bilateral approach gives a great latitude for decentralized decision making. It is motivated by the concept of free market completion providing he customers with 'direct access' to the producer of choice . Therefore the model is also referred to "direct access method".

2.2 CENTRALIZED ELECTRICITY TRADING:-

Within the centralized electricity approach no direct transactions between producers and consumers are possible. All the trading is done via a centralized market place. The method relies on a closed - order - book auctioning system. The pool operator receives price and quantity bids for generation and consumption whereas the equilibrium point of supply and demand determines the market clearing price. For this model four single stages can be find out:

1. Bidding
2. Production Planning and Pricing
3. Physical delivery
4. Financial transactions

Every bidding is made for the day ahead. For every section bid can be transferred to the operator until a fixed deadline. Generator place their production offers in terms of price and quantity for the scheduled sections. Consumers submit their bids relating to the demanded load and the maximum price they are willing to pay. The pool operator calculates the market clearing price (Pm) and the market clearing quantity (qm) for every scheduled section for day ahead. The market solution or equilibrium is set by the intersection of the supply and demand curves. The buyers pay the pool operator he consumed energy. Whereas the pool operator pay the generators the injected energy[3].

III. THE INDEPENDENTSYSTEM OPERATOR :-

In most liberalized electricity markets a special entity the so called system operator exists . This monopoly can be either a non-profit or a for - profit entity. It owns, operates and manages the transmission system as a natural monopolies. A TransCo could maximize its profit y withholding transmisssion capacities, thus it is heavily regulated.

The other choice is to introduce a non-profit entity which is usually called Independent System Operator (ISO) or Independent Grid Operator . In contrast to the TransCo the ISO does not own - but manage the transmission network.

It has to be mentioned that different countries follow different approaches in organizing the transmission market . It has been stated that there is generally one network owning monopolies in a national transmission market offering transmission and fulfilling objectives as a system operators. That would be called a TransCo. A country may be split into certain developed region. For each area there is a regulated transmission monopolist (TransCo), Owing the network and coordinating its local market, will the coordination is done by an independent system operator.

There are four main objectives of transmission market to keep the market functioning .

1. Provide a non-discriminatory access to the grid.
2. Offer a reliable, efficient and environmentally adopted transmission of power on the grid .
3. Keep the system in balance.
4. Provide ancillary services.

The independent system operator has to buy energy from suppliers when demand exceeds generation or has to schedule loads for compensating when generation exceeds demands [3].

IV. ELECTRICITY PRICING

The electricity price is of extreme importance in a competitive electricity market to all the market players and in particular for producers and consumers. A prior knowledge of the electricity price is important for risk management and may represent an advantages for a market player facing completion. For companies that trade in electricity markets, the ability to forecast prices means that the company is able to strategically set up bids for the spot market in the short term.

A good price forecasting tool in the deregulated market should be able to capture the uncertainty associated with those prices . Electricity price is influenced by many factors : historical prices and demand , bidding strategies , operating reserves, imports , temperature effects , predicted Power shortfall and generation outages . The amount of different types of reserves , power import and predicted power shortfall do not improve the forecast at all the effect of the temperature and other weather related variables can be in the demand , and unit outage information is generally proprietary not available to all market players .

In the recent years , the electricity industry has been undergoing unprecedented restructuring all over the world . A central tenet of electric power industry deregulation is that the delivery of electric power (a service) must be decoupled from the purchase of the power itself and priced and contracted separately. In this price based completion, transparent and predictable pricing framework of electricity is one of the major issues . Therefore, with this growing interest in determining the cost of supplying the ancillary services needed to maintain quality and reliable electricity service[4].

The electric power industry has been restructured with the aim of obtaining more competitive environment, power producers will have to consider the actions of other market players in their operational and planning decisions . Thus, planning decisions such as addition of new generation capacity will be highly influenced by competition. Adding new generation capacity to a power network may have positive or negative impacts , depending on where the new capacity will be installed and the amount of such a capacity have pointed out that generation companies , investment decisions may challenge the transmission system security .

The generation expansion problem involves increasing electric power generation capacity in an existing power network. The problem has been extensively studied with the least cost investment approach in centralized electricity markets. However, few models have been proposed for studying the capacity investment decisions in oligopolistic power markets.

Capacity expansion may encounter congestion in the transmission network by constrained single line limits as well as transfer capacities. Transfer capabilities are defined as bottlenecks in transmission lines where congestion takes place during certain operation conditions. Transmission line and transfer capabilities can both be modeled mathematically by making use of power transfer distribution factors (PTDF) and be included in the decision models that consider the transmission network.

In this paper, a generation expansion model that incorporates the features of the transmission grid is developed to study the interaction between competition and network transfer capabilities in capacity expansion.

Although power companies may compete on price in the short term, they also need to make long-term commitments to capacity, which supports adopting competition on quantities power plant wrens may reduce generation to deliberately induce higher profits, a features of competitive market can render simple analytical expressions that can be easy to manipulate.

The model is extended by including capacity expansion decisions variable and investment cost terms to the power producer profit maximization model. The cost of new capacity can be represented with the per unit annualized cost of investment, which is also followed. the cost of investment of the power generators are given per unit values with constant marginal cost of operation. Our software distinguishes between existing and new capacity of the power producers s that new entrants are modeled considering the current conditions of the competitors [5].

To study the interaction of the transmission constraints and competition on optimal generation expansion decisions, we use to different examples.

The four bus and six bus IEEE power system Test. MATPOWER software is used to solve the models of both systems.

V. RESULTS OF IEEE 5 BUS CASE STUDY :

The one line diagram of an IEEE-5 bus system is as shown in the fig. The line data, bus data and load are as shown in Table 1 and 2.The system consists of 2 synchronous generators and the system had 4 load points.Associated flow results are given in the fig below.
The data is on 100MVA base.

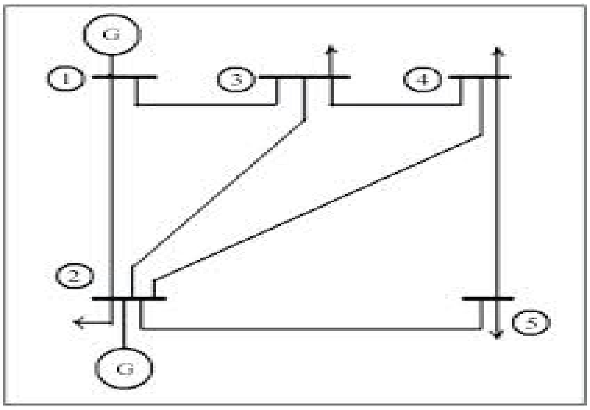

Fig 3: Single line diagram of five bus system

Table 1: Generator cost coefficient.

Unit	Bus No.	A ($/Mwh^2)	B ($/Mwh)	C ($)
G1	1	3	0.001	7.94
G2	2	3	0.002	7.0

Table 2: Flow Limits

Line No.	From	To	X(p.u.)	Flow Limit(MW)
1	1	2	0.02	10
2	1	3	0.08	10
3	2	3	0.06	10
4	2	4	0.02	10
5	2	5	0.04	10
6	3	4	0.01	10
7	4	5	0.08	10

Table 3 : Congested lines for Initial Dispatch

Line	Maximum Capacity	Expected line flow capacity	Actual Line flow
1	10	9.0	11.7
2	10	9.0	16.0013
3	10	9.0	17.3665
4	10	9.0	15.2928
28	10	9.0	30.5976

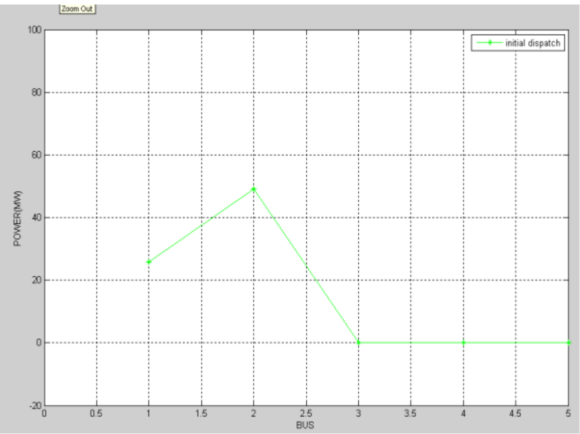

Fig 4: Initial power flow at all buses in power system

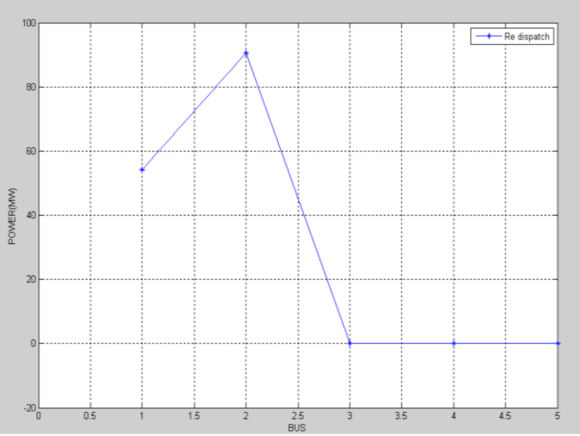

Fig 5: Redispatched power flow at all buses in power system

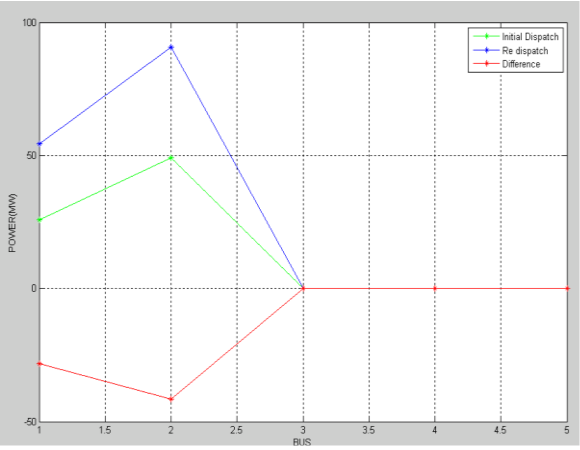

Fig 6: Difference in initial power flow and re-dispatched power at all buses in power system.

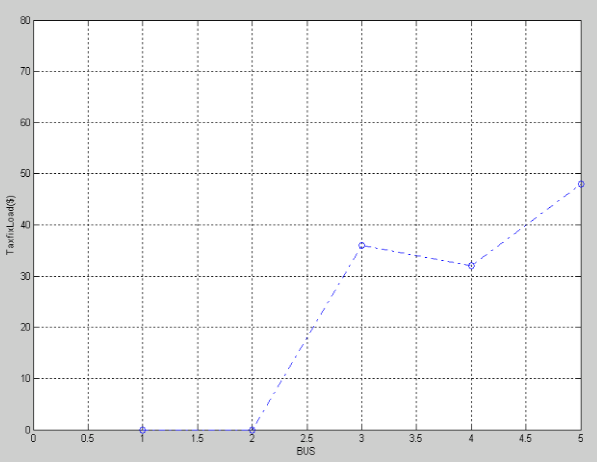

Fig 7: TaxFixLoad in dollar's per MW

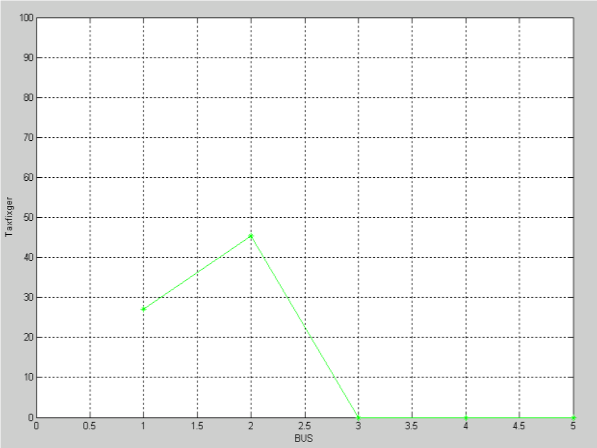

Fig 8: TaxFixGen in Dollar's per MW

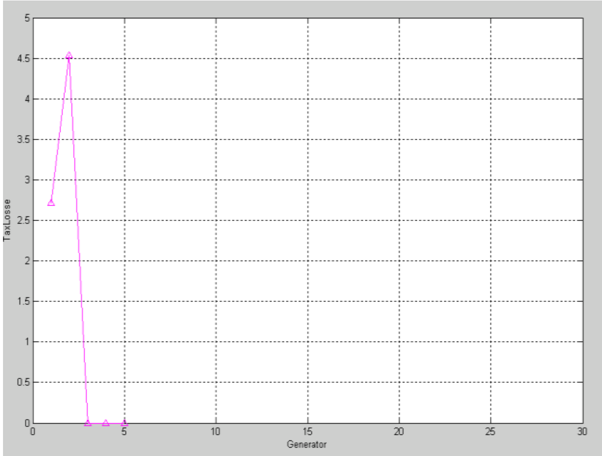

Fig 9: TaxLosses in Dollars per MW

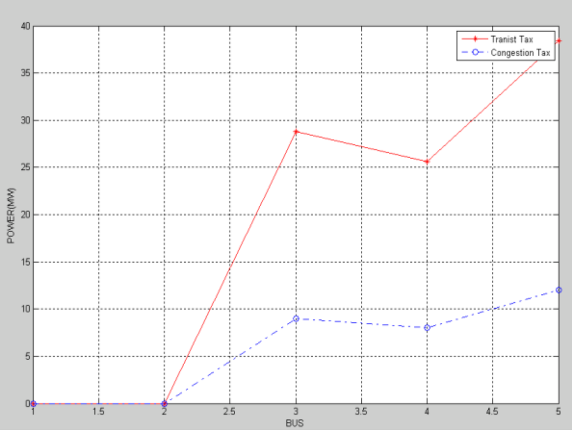

Fig 10: Transit Tax and Congestion Tax at different Buses

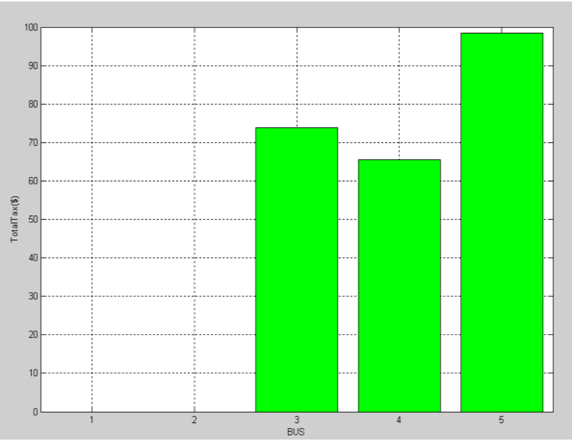

Fig 11: Total Tax due to load at different buses

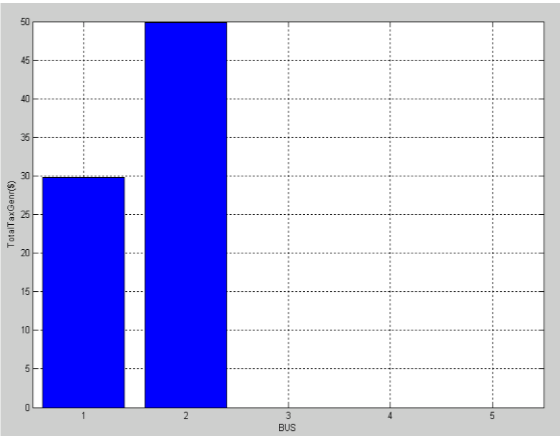

Fig 12: Total Tax due to Generator at specific buses

VI. CONCLUSION :-

A technique of transmission planning for a deregulated power market has been presented. It utilizes the level of congestion in the transmission network as the indicators for the need of additional transmission lines. The procedure can be applied to formulate expansion schemes, which are sets of time - ordered investment decisions for the network planner

A methodology for analyzing the effect of System Congestion and competition on generation expansion decisions in deregulated electricity markets is proposed. The present approach considers the behavioral models of the market players and transmission network in the generation expansion modeling. By using the suggested model the effect of the network transmission constraints on the generation expansion decision under competitive market are evaluated. Transmission constrains represented in modeling generation expansion decisions under competition. It has been shown that if transmission constrains may affect the outcome of competition by limiting expansion decisions of producers according to where the generators are located relative to the transmission limits. It has also been shown that if transmission constrains are not considered in planning derisory, the consumers benefit may diminish due to higher prices and higher congestion charges.

The above section provided information on energy markets. It was stated that energy markets are suitable for deregulated, while there are different approaches of organizing the market. Solutions range from direct, bilateral settlements between generators and loads to the trading of energy via a pool.

VII. ACKNOWLEDGEMENTS

[1] Ashish Saini and A.K. Saxena, " *Optimal Power Flow based Congestion Management Methods for Competative Electricity Markets*" International journal of computer and electrical engineering February 2010.

[2] Surachai Chaitusaney and Bundhit Eua-Arporn, " *Generation Dispatch with Pool and Bilateral Coordination*" IEEE Transaction on power system,2002.

[3] Thailo Kruase, "*Evaluation of Transmission Pricing Methods for Liberalized Markets*" July 2003.

[4] Kai Xie,Yong-Hua Song,John Stonham,Erkeng Yu and Guangyi Liu, "*Decomposition Model and Interior Point Methods for Optimal Spot Pricing of Electricity in Deregulation Environments*" IEEE Transaction on power system, Vol. 15,pp. no.39-50,2000.

[5] G.B.Shrestha, and P.A. J. Fonseka, "*Congestion-Driven Transmission Expansion in Competitive Power Markets*", IEEE Transaction on power system, Vol .19 No.3,pp. no.1658-1665,2004.