Financial Transmission Rights and Auction Revenue Rights

Mohammad Sadegh Javadi [1], Amin Javadinasab [1]
[1]Department of Electrical and Electronic Engineering, Shoushtar Branch, Islamic Azad University, Shoushtar, Iran
msjavadi@gmail.com

Abstract: This paper surveys on two important issues in restructured power systems. One of them is Financial Transmission (FTR). Financial transmission right is a financial instrument which can improve the liquidity of operation in power system from point of view of all decision makers in competitive power systems. Another approach is Auction Revenue Rights (ARR) which ARR allocation consistent with congestion as determined by the FTR Auction. Analysis of these two mechanism and their impacts on long-term operation of power system are considered in this paper. Suppliers and large consumer, therefore, desire to contract in FTR to hedge their long-term risks. The FTR mechanism is based on the after settling market and determination Locational Marginal Price (LMP). In this area, delivery of energy (quantity and price) from the amount of FTRs which supplier is bidding for distinct path, and the price that the supplier is willing to pay for each FTR, are determined. This paper surveys on the long-term conditions of the FTR and mature one.
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1. Introduction

Financial transmission rights (FTRs) are the most popular tools to hedge the risk of suppliers and large consumers in delivery of energy in the power markets. In restructured power system operation, the suppliers are competing with together in satisfying the consumer demand. In this area, operation of power market is based on two mechanisms. Uniform Pricing (UP) and Pay-as-Bid (PAB) are these mechanisms. In UP mechanism the supplier paid based on Market Clearing Price (MCP), which determined by more expensive generation units which accepted in the market and considered in Day-Ahead generation scheduling (Javadi and Javadinasab, 2011). This mechanism also called Marginal Pricing (MP) (Kahn et al., (2001). Another mechanism is PAB. In Pay-as-Bid mechanism each supplier receives his offers which submit in the market (Javadi and Javadinasab, 2011). In the PAB mechanism after settling the market and determination of LMP in all buses in network; the final payment of consumers in the corresponding bus are determined. The LMPs may be different in network. One of the main components in LMP is congestion lagrangian multiplier (Ren and Galiana, 2004). In a power grid congestion is caused by limitations in transmission capacity. When a transmission line is congested, the maximum acceptable energy transferring is reached and the further loading is not allowed.

A transmission congestion charge is incurred when the system is constrained by physical limits. So a reasonable transmission pricing method should provide some economic signal to reflect the charge due to the physical constraints. One option is to base the change on locational marginal prices. That is, the congestion charge for a specified path is the product of the flow along the path and the price differences between the two terminals of the path.

The transmission congestion charge may skyrocket in some cases, and create a big loss for a market participant. To hedge the risk, the participant can purchase a right to transfer power over a constrained transmission path for a fixed price, which is called a firm transmission right. The holder of such a right receives a credit that counteracts the congestion charge (Ren and Galiana, 2004).

Financial instruments awarded to bidders in the FTR auctions that entitle the holder to a stream of revenues (or charges) based on the hourly Day-Ahead congestion price differences across the path.

Main challenges in this area are exposes LMP in some ordinary power market, such as Pennsylvania, New-Jersey and Maryland, PJM, participants to price uncertainty for congestion cost charges. During constrained conditions, PJM Market collects more from loads than it pays generators (PJM, 2011).

2. Financial Transmission Rights

Firm transmission rights (FTRs) are proposed as purchased rights that can hedge congestion charges on constrained transmission paths. By holding FTR, a transmission customer has a mechanism to offset congestion charges when transmission lines are congested. Besides providing financial certainty, FTR could maximize the efficient

use of the system and make users pay for the actual use of congested paths (Shahidehpour, et al. 2002).

As LMPs and FTRs have been widely utilized in many power restructuring models to resolve problems associated with transmission congestion and pricing, it should be detailed these key subjects in a comprehensive manner. Then, a transmission congestion management scheme that incorporates LMPs and FTRs should be discussed.

The ISO would adjust preferred schedules on a nondiscriminatory basis to keep the system within its limits and applies curtailment priority according to the participants' willingness to avoid curtailing transactions. In this paper a general restructuring model where pool, bilateral, and multilateral contracts exist concurrently assumed. In this scheme, transmission congestion and losses are calculated based on LMPs. A flow-based tracing method is utilized to allocate transmission charges. FTR holders' credits are calculated based on line flow calculations and LMPs.

LMP is the marginal cost of supplying the next increment of electric energy at a specific bus considering the generation marginal cost and the physical aspects of the transmission system. LMP is given as:

LMP = generation marginal cost + congestion cost
+ Cost of marginal losses

Mathematically, LMP at any node in the system is the dual variable (sometimes called a shadow price) for the equality constraint at that node (sum of injections and withdrawals is equal to zero). Or, LMP is the additional cost for providing one additional MW at a certain node.

A firm transmission right4 (FTR) is a purchased right that can hedge congestion charges on constrained transmission paths. In other words, it provides FTR owners with the right to transfer an amount of power over a constrained transmission path for a fixed price.

Market participants pay congestion charges under a constrained situation based on LMP differences. These charges arise when the energy demand across a transmission path is more than the capability of transmission lines on that path. Under constrained situations, each participant is charged for congestion based on the MWh value of generation ordered to serve its load. The charge will be based on MWh and the difference in LMPs of injection and extraction points. If it happens that FTR is also called fixed transmission right or financial transmission right.

Each FTR holder receives a congestion credit in each constrained hour that is proportional to the FTR value. This credit allocation is based on preferred schedules, while congestion charges are based on actual deliveries. From the preferred schedule FTRs, the total congestion credits are calculated and compared with the total congestion charges, which are based on the cost of re-dispatched schedules at each hour. If the total congestion credits are less than or equal to the total congestion charges, the congestion credit for each FTR holder is equal to the one calculated. If there are any extra congestion charges, the extra charges are distributed among market participants at the end of the month. Otherwise, the congestion credit for each FTR will be equal to a share of total congestion charges in proportion to its credit allocation. The insufficiency in hourly congestion charges may be offset by excessive charges in other hours at the end of the accounting month.

If a market participant does not hold a FTR and its contract is not curtailable, this participant will incur a congestion charge and have no mechanism to offset the congestion charge. In comparison, FTR holders will receive a credit that counteracts the congestion charge for the specified path. The credit is computed as follows, where LMP1 and LMP2 represent LMPs at starting and ending points of the FTR respectively:

FTR credit = amount of FTR × (LMP1 - LMP2)

Instead of being defined from point to point, FTRs can be attached to a branch or flow-gate in the network. They are then called flow-gate rights (FGRs). FGRs operate like FTRs except that the value of these rights is not tied to the difference in nodal prices, but to the value of the Lagrange multiplier or shadow cost associated with the maximum capacity of the flow-gate. When a flow-gate is not operating at its maximum capacity, the corresponding inequality constraint is not binding, and the corresponding Lagrange multiplier μ has a value of zero.

The only FGRs that produce revenues are thus those that are associated with congested branches.

2.1. The FTR versus FGR

There are some debates on the advantages and disadvantages of FTRs and FGRs. Here is a summary of the main points of this debate:

- The market for FGRs should be more liquid than the market for FTRs because there are many more possible combinations of point-to-point rights than there are branches likely to be operated at maximum capacity.

- However, it may be difficult to predict which branches will be congested. Trading on a fixed set of critical flow-gates may cause other branches to become congested.
- The value of FTRs is difficult to determine because the point-to-point transmission capacity changes with the configuration of the network. On the other hand, the maximum capacity of a given branch is much more constant, particularly if the flow on this branch is only limited by its thermal capacity.
- FGRs are simpler because there are typically only a few congested branches in a network. On the other hand, as soon as one branch is congested, all the nodal prices are different.
- Participants must take into consideration and understand the operation of the network when purchasing flow-gate rights. In practice, this means that they must know the matrix of Power Transfer Distribution Factors (PTDFs). Participants who buy FTRs do not need to concern themselves with the operation of the network. They can base their decisions on their perception of the fluctuations in nodal prices.

In a perfectly competitive market, FTRs, FGRs and even physical transmission rights are equivalent. If competition is less than perfect FGRs, it may provide more opportunities for gaming, particularly if trading focuses on a fixed set of flow-gates (Kirschen and Strbac, 2004).

3. Auction Revenue Rights

ARR are the mechanism by which the proceeds from the Annual FTR Auction are allocated. Auction Revenue Rights are entitlements allocated annually to Firm Transmission Service Customers that entitle the holder to receive an allocation of the revenues from the Annual FTR Auction. Auction Revenue Rights will be allocated to Network Transmission Service Customers and Firm Point-to-Point Transmission Customers. Market Participants will request ARRs, and PJM will approve all, part or none of the request based on the results of the Simultaneous Feasibility Test. At the beginning of each Annual Planning Period, ARRs are allocated to Network Transmission customers and to Firm Point to Point Transmission customers for the duration of the Annual Planning Period.

- Network Integration Service-Network Integration Service ARRs are designated along paths from specific generation resource(s) to the customer's aggregated load. The Network Service Customer has the option to request ARRs for all or any portion of an historic generation resource. A Network Service Customer's total ARR designation to a zone cannot exceed the customer's total network load in that zone. Network Service Customers make ARR requests through PJM eTools.
- Firm Point-to-Point Service-PJM allocates ARRs to Firm Point-to-Point Service customers for approved service requests, subject to passing the Simultaneous Feasibility Test. The point of receipt is either a generation resource within the PJM RTO or the interconnection point with the sending Control Area. The point of delivery is the set of load buses designated in OASIS or the point of interconnection with the receiving Control Area. The duration of the ARR is the same as for the associated Transmission Service Request (TSR). The Point-to-Point Customer has the option to request ARRs consistent with the transmission reservation.

Auction Revenue Rights are defined from a source Price Node to a sink Price Node for a specific MW amount. The economic value of each ARR is based on the MW amount and on the Locational Price differences between the sources and sinks node for FTR Obligations resulting from the Annual FTR Auction. The economic value of an Auction Revenue Right can either be positive (a benefit) or negative (a liability). Annual FTR Auction revenue is distributed to Auction Revenue Rights holders in proportion to, but not to exceed, the economic value of the ARRs when compared to the clearing prices for FTR Obligations in each round of the Annual FTR Auction proportionally. The settlements for Auction Revenue Rights will be based on the clearing prices from each round of the Annual FTR Auction. The amount of the credit that the ARR holder should receive for each round is equal to the MW amount of the ARR (divided by the number of rounds) times the price difference from the ARR sink point (delivery point) to the ARR source point as shown in the following formula:

$$\text{ARR Target Allocation} = (\text{ARR}/\#\text{ Allocation Target}) * (\text{LMP}_{\text{Sink}} - \text{LMP}_{\text{Source}})$$

Note that the LMP values in the above equation are results for FTR Obligations from the appropriate round of the Annual FTR auction.

Holders of Auction Revenue Rights may retain allocated ARRs, and receive associated allocations of revenues from the Annual FTR Auction. ARR holders may also convert ARRs into FTRs by “self-scheduling” an FTR into the first round of the Annual FTR Auction. When “self-scheduled”, an FTR must have the same path as the associated ARR. Additionally; holders of ARRs may

also reconfigure ARRs by bidding into the Annual FTR Auction to acquire an FTR on an alternative path or for an alternative product.

The following is a list of business rules and guidelines to follow when requesting Network Integration Service ARRs:

- All Network Integration Service ARR requests must pass a Simultaneous Feasibility Test before being given PJM approval.
- PJM can approve all, part, or none of the ARR request based on the results of the Simultaneous Feasibility Test.
- The path for each Network Integration Service ARR is defined from specific historical generation resources to aggregate Network Customer Load in the Transmission Zone or other designated Load Aggregation Zone.
- The total ARRs for a historical generation resource to the (Load Supply Entity) LSE load cannot be greater than the MW amount of the resource that was assigned to the LSEs on a pro-rata basis.
- A participant's total ARR amount to a transmission zone or load aggregation zone cannot exceed the participant's total network load in that zone or load aggregation zone.
- ARRs are specified to the nearest 0.1 MW. (PJM,
- **Corresponding Author:**

Mohammad Sadegh Javadi
Department of Electrical and Electronic Engineering, Shoushtar Branch, Islamic Azad University, Shoushtar, Iran
E-mail: msjavadi@gmail.com

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