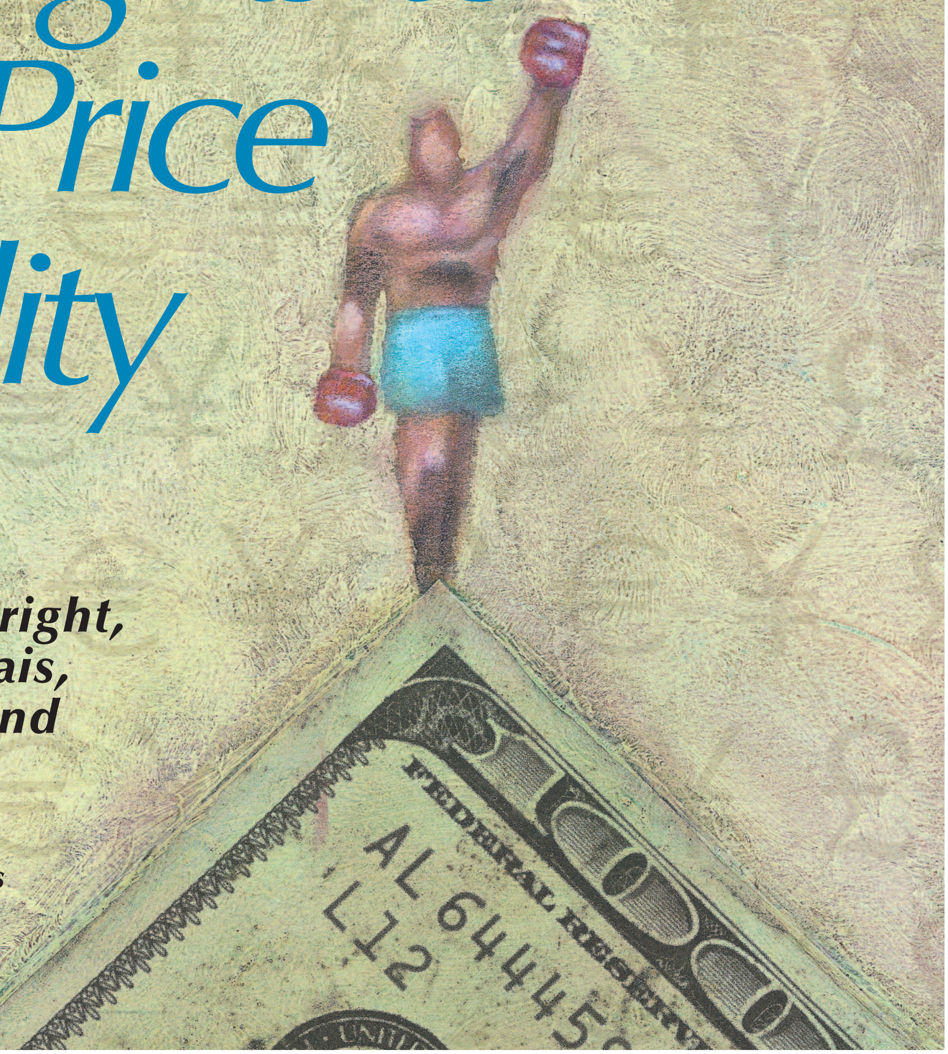
The Rights to Fight Price Volatility



by O. Alsaç, J.M. Bright, S. Brignone, M. Prais, C. Silva, B. Stott, and N. Vempati

with contributions from the New York and Midwest ISOs

ELECTRIC ENERGY DEREGULATION IS A BREEDING GROUND FOR ANCILLARY AND OTHER MARKETS. Among the most important such markets in North America are those dealing in financial transmission rights (FTRs). Recently introduced and still developing, these markets will soon enjoy annual turnovers of many billions of dollars. The transmission organizations running these markets are known by various names. Throughout this article we will use the most popular name to date—independent system operator (ISO).

FTRs are nontraditional, nonintuitive financial instruments (see the sidebar "What is an FTR?"). They are intimately linked to the locational marginal pricing (LMP) system that may become a standard in North America (see the sidebar "LMP-Based Congestion Pricing").

Financial Transmission Rights Are an Important Tool in Hedging Against Congestion Cost Volatility and Promoting Liquidity in Energy Markets

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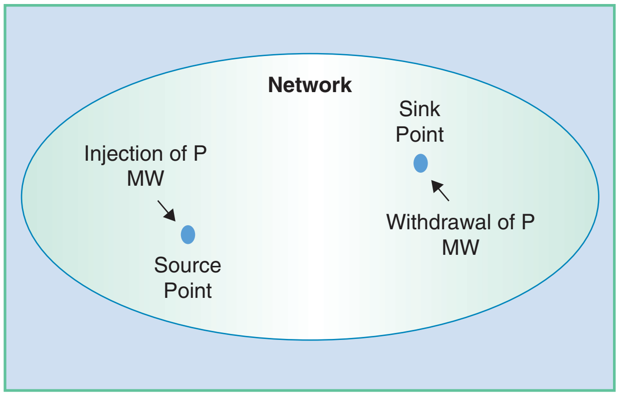

figure 1. A point-to-point FTR.

FTRs hedge against price volatility and contribute to liquidity in the overall energy market. They can substantially affect an energy market participant's competitiveness and profitability. However, buying and selling FTRs is a sophisticated activity that requires great experience of the power system's congestive tendencies and the FTR market's characteristics.

Since 1996, the authors have been intimately engaged in the formulation, design, and development of first- and second- (the present) generation FTR software solutions for the currently established North American ISOs. In this article, we summarize FTR basics and main market features, and we outline current FTR issues and future prospects. This applies to any LMP-based markets, but we make specific references only to the experience and perspectives acquired so far in North America.

The Need for FTRs

LMP-based congestion prices are inherently volatile (that is, they fluctuate considerably). To illustrate, consider a transmission line or interface that contributes nothing to system congestion prices as long as its flow is below rating. But at the moment when its flow hits its limit and becomes binding in the bid-based dispatch, congestion prices undergo step function increases. The reverse happens when a previously binding element falls below its limit. These price jumps are rarely local in effect, and they tend to interact with each other. Thus, since congestion itself varies continually—as a result of changes in loading levels, generation patterns, and transmission topologies—so do the congestion prices.

The transmission user who is vulnerable to congestion price volatility can hedge (insure) against it by buying a suitable FTR. This FTR then generates payments to the holder that in effect "refund" some of, all of, or more than the user's congestion expenses. At the same time, to combat market power and to promote liquidity, the market also allows FTRs to be bought and sold by nontransmission users (arbitragers), who pit their congestion expertise against the rest of the FTR players.

What Is an FTR?

An FTR, also known as a transmission congestion contract (TCC) or a congestion revenue right (CRR), is a financial risk-management instrument. It represents a specified MW amount between (usually) two points in the power transmission network. It is valid over a defined period of time, typically a month, season or year, and often only for peak or off-peak hours. Whenever there is transmission congestion in the FTR's defined direction, the FTR will earn congestion revenue for its holder from the ISO.

The FTR's primary purpose is to offset a transmission user's LMP congestion charges, which are typically quite volatile. However, in today's open FTR auctions and secondary markets, FTRs can also be arbitraged by any accredited transmission nonuser.

Sources and Sinks

Nearly all FTRs are of the "point-to-point" type. That is, the FTR represents a defined megawatt (MW) amount injected at a source point and withdrawn at a sink point (see Figure 1). Each point can be an individual node or a collection of nodes (e.g., a trading hub or a load zone). The FTR MWs follow the physical power flow distribution through the network.

A second much less common type of FTR is the flowgate. This represents a transfer capacity reservation through a defined interface or "flowgate." It does not model physical flows, and it is basically a legacy of previous reservation methodologies.

FTR Settlement System

For illustration, consider a transmission user who transfers T MW per hour between points A and B. The ISO levies an hourly congestion charge based on the LMP's congestion component LMP^C:

$$\text{Payment by user} = T \times \left(LMP^C_B - LMP^C_A\right) \qquad (1)$$

Now suppose that the user has acquired an FTR of F MW between the same points. In the FTR settlement process, the holder receives congestion revenue:

$$\text{Payment to holder} = F \times \left(LMP^C_B - LMP^C_A\right) \qquad (2)$$

Comparing (1) and (2), it is clear that if the FTR of F MW equals the transfer of T MW, the user ends up with a congestion bill that nets to zero. The cost of this price stability is the one-time cost of buying the FTR.

The same principle applies to the MW supplier or consumer at any network point in the spot market. In this case, the other point can be chosen as a remote trading hub. It is also

> In North America, a couple of markets (NYISO, PJM) have pioneered the FTR field and have logged the most experience to date.

possible to specify a single point (a so-called "unpaired" FTR), in which case the other point automatically becomes the system reference bus, whose marginal congestion price is zero.

A "perfect hedge"—full self-cancellation between (1) and (2)—is rare because it is difficult to exactly match the FTR MWs to the transfer MWs. Also, an FTR might not be available between points A and B but instead only between closely related points. The most nearly perfect hedges are possible with block loaded base-load units and import/export schedules. But partial matches can still provide very worthwhile hedging.

In the case of the transmission nonuser, T in (1) is zero—then the FTR is a pure investment whose "dividends" derive from (2) alone and are cumulatively profitable if they exceed the cost of buying the FTR.

FTR Obligations and Options

Obligations

The first of two main types of FTR is the "obligation," which is a literal application of (2). Then congestion in the *opposite* direction makes the LMP difference negative. This turns the payment *from* the ISO to the holder into a payment *to* the ISO from the holder. At the same time, (1) reverses sign, so that (1) and (2) are still partly or fully self-canceling. Nevertheless, an FTR holder's prospect of paying instead of being paid is never attractive.

Options

The FTR "option" is a unidirectional interpretation of (2). When congestion is positive, the ISO pays the FTR holder as usual. But when the congestion is in the opposite direction, the FTR holder pays nothing. In other words, the FTR holder's downside risk is zero. Naturally, however, an FTR option tends to cost more at auction than its equivalent obligation.

FTR Initial Allocation

When an ISO launches a new FTR market, one of its biggest concerns is how to deal with existing transmission entitlements. Different approaches are possible, ranging from one-time cash compensation to transmission revenue sharing. A popular compromise is to allocate to each entitlement holder an equivalent amount of FTRs that will remain valid for some period of time after market startup. During this period, the holder may keep the FTRs or sell them in the FTR market. For the ISO, the downside of this approach is that the initial allocations tend to use up almost all the FTR capacity of the network, thereby delaying the establishment of a competitive, high-volume, liquid FTR market. In PJM, for instance, it was found that the FTR market grew enormously after the initial entitlements expired.

The FTR initial allocation process itself is not simple, and it always involves extensive special-purpose network calculations. Since the network is rarely able to accommodate all entitlements as FTRs (see the sidebar "Revenue Adequacy and Simultaneous Feasibility"), many holders will receive FTRs representing less than 100% of their previous entitlements. The ISO's problem is how to ensure that these initial allocations are equitable.

Revenue Adequacy and Simultaneous Feasibility

In running an FTR market, an ISO is generally required to achieve "revenue adequacy." That is, its congestion revenues need to be sufficient to cover its payouts to the FTR holders. For a linear, lossless "dc" network model, it can be proved that this adequacy is achieved if at settlement the FTRs do not exceed the network's capacity (no such proof is available for loss-compensated and/or nonlinear network models).

In each calculation that awards FTRs, it is therefore important to test that the FTRs are within network capacity. This is achieved by representing all the FTRs simultaneously in the network model, together with any loop flows from the external network. The network flows are solved for in both the pre- and post-contingency states and are checked for limit violations. This "Simultaneous Feasibility" test is embedded in, and is performed repeatedly during, FTR award calculations.

Nevertheless, revenue inadequacy does sometimes occur. In one approach, FTR payouts then become reduced prorata. In another approach, the ISO's deficits are carried forward in the hope that they will be met by excess future FTR revenues.

figure 2. Bid curve in an FTR auction.

There are many possible "equitable" allocation approaches, such as the "equal pain" method (FTRs prorationed according to MW entitlements) and the "least-squares" method (FTRs allocated in proportion to the congestion impacts of the entitlements). Another aspect is whether the existing entitlements should be converted to FTR obligations or the more-desirable options.

FTR Auctions

The auction is the central mechanism of an FTR market. Each auction deals in FTRs that are valid over a specific time period, e.g. the coming month, season or year, and for peak hours, off-peak hours, or both. At present, all FTR auctions are of the "sealed" (blind) type. During a "bidding window" of time, would-be purchasers submit bids to acquire specified FTRs, and existing holders submit offers to sell their FTRs.

In a flexible implementation such as that of the Midwest ISO, a participant is able to submit a bid or offer that varies in price, as illustrated in Figure 2. At the end of the window, all submittals are simultaneously fed into the auction "clearing calculation," which is a security constrained optimal power flow whose objective is to maximize the dollar value of the auction while maintaining simultaneous feasibility; i.e. remaining within the FTR capacity of the network. Bids to buy and offers to sell FTRs become awarded, partially awarded, or rejected. Figure 3 illustrates the process.

Note that owners of FTR obligations that tend to generate negative revenue—because of reverse congestion—can offer to sell them at negative price; i.e. they will pay to get rid of them. Likewise, bidders may look for bargains among these kinds of obligations (this also applies in the FTR secondary market).

A characteristic of this auction process is that successful bids to buy and offers to sell are cleared at their marginal (shadow) prices, not at their bid/offer prices.

Transmission Service FTRs

An ISO routinely receives requests for transmission service between points A and B, for durations ranging from days to weeks or longer. In some ISOs, the requester is also entitled to ask for a corresponding FTR to hedge the congestion costs. These transmission service FTRs can be granted on a first-come, first-served basis if residual FTR capacity remains after the allocation and auction processes. The requests are not easy to manage, since their durations rarely match the FTR auction periods. In order to respond to the requester, the ISO has to run an analysis for each such period or part of a period, to determine how much (if any) of the requested FTR can be granted.

Secondary Markets

Any holder of an FTR can post an offer to sell part of its MWs and/or duration, or the entire FTR, for a specified price in the ISO-run FTR secondary market. Likewise, any accredited participant can post a bid to acquire a defined FTR at a specified price. The secondary market usually operates in real time for such offers and bids, on a first-come, first-served basis. The ISO's software automatically registers such ownership changes. Note that these changes do not affect the net FTRs—no simultaneous feasibility analysis is required.

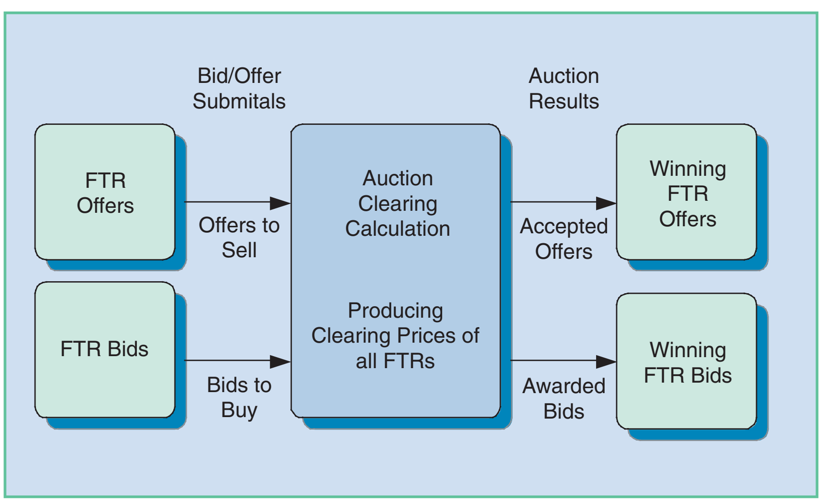

figure 3. The auction process.

Network Models

It follows from the sidebar "Revenue Adequacy and Simultaneous Feasibility" that reliable network models should be used in all phases of the FTR process—allocation, auction, transmission service, day-ahead and (where applicable) real-time settlement. At each phase, this requires

When an ISO launches a new FTR market, one of its biggest concerns is how to deal with existing transmission entitlements.

accurate modeling of the network's topology and external loop flows. The danger to revenue adequacy is that LMP and FTR settlement will take place on a network model, usually derived from the EMS's state estimator, whose FTR capacity is exceeded. The effect of unscheduled outages on this capacity is clearly a major factor (see the sidebar "Some New York ISO Perspectives"). Another factor, very difficult to quantify, is network model realism. Most current FTR market implementations use a linear "dc" network model, which relies on crude loss estimates (if any) and equivalent MW limits to reflect voltage-related constraints. Depending on the power system, such a model may not accurately reflect MW flows and available FTR capacity. Currently, only one FTR market—at the New York ISO—employs an "ac" network model that directly models losses and voltage effects, at the expense of considerable extra complexity in the data and the calculations.

Another complicating factor is the role of phase angle regulators (phase shifters) and FACTS devices, which can have a major influence on the model behavior, the algorithms, the computing times, and the FTR market results.

FTR Calculations

Security constrained optimal power flow (SCOPF) is the basis for most FTR calculations, including auctions and initial FTR allocations. SCOPF can also be used in a variety of other FTR calculations, such as auction revenue rights, expansion FTRs, and revenue shortfall analyses.

Each such SCOPF solution optimizes the FTRs with network limit constraints in both the pre- and post-contingency states, typically in the "n–1" security mode. The optimization objective functions and constraints vary according to the application. Many of these have some nonlinearity, even in the case of "dc" network models. For this reason, FTR problems are not conducive to formulation and solution as conventional linear programming problems.

Ordinarily, a SCOPF calculation would not be particularly time consuming, even with a large "ac" network model and many contingencies. However, this is no longer true with FTR options, whose constraints have to represent the most onerous combination of exercised options. The big problem is that these constraints are nonsparse and they involve considerable computation that tends to increase very roughly as the cube of the size of the power system. Given the trend of ISOs towards very large regional network models, this is a challenge, even with fast multi-CPU computers.

A common problem is that some market participants want to submit vast numbers of bids to buy small FTRs (e.g., 1 MW each) all over the network, for the purpose of price discovery and/or speculation. This can become a computational headache. It may therefore be expedient for the ISO to impose certain restrictions.

Market Implementations

Modern LMP-based FTR markets of the type described here have been operating for some years in New York ISO (NYISO) and in PJM. Also, the FTR market of the New England ISO is now operating. The FTR markets of the Midwest ISO (MISO) and the California ISO (CAISO) are due for startup soon.

These ISOs represent a substantial proportion of the U.S.'s MW capacity. Other regions of North America seem

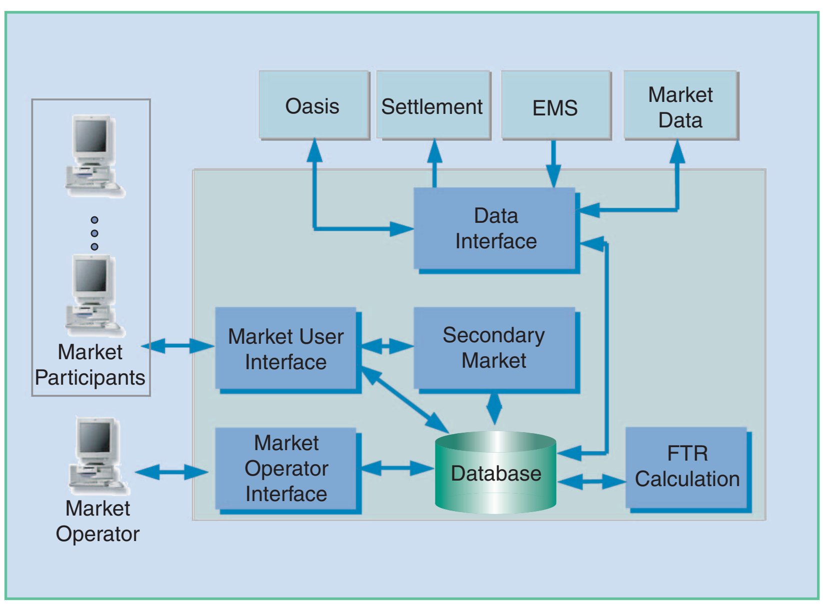

figure 4. A generic FTR system.

Some NYISO Perspectives

—by A.R. Desell and G.R. Williams, Resource Reliability, New York ISO

Transmission congestion contracts (TCCs) are the equivalent of FTRs at the New York Independent System Operator (NYISO), and they provide the same financial hedge for day-ahead market congestion costs.

NYISO Approach to Revenue Adequacy

In significant contrast with other ISOs, the TCC holders in New York are always paid their full day-ahead market value, even if a shortfall (revenue inadequacy) occurs in the collection of congestion costs. The New York transmission owners—six investor-owned utilities and two state public power authorities—share the net congestion surplus/shortfall and TCC auction revenues and are obligated to fully cover the above shortfalls. The TCC auction revenues are used to pay for the fixed and variable costs of owning and maintaining the transmission network through inclusion in the transmission service charge (TSC) rate computation. All market participants pay a transmission service charge for each megawatt-hour of energy withdrawn from the transmission network, payable to the transmission owners where the energy is withdrawn. Any congestion shortfall or surplus allocated to the transmission owners increases or decreases this charge.

TCC Auctions

These auctions offer the transmission capacity remaining after accounting for existing uses of the transmission network. Such uses include long-term transmission wheeling agreements in effect at the time of NYISO formation, which were either retained or converted into TCCs. Semi-annual auctions are conducted in spring (effective May 1) and fall (effective November 1) to sell transmission capability that becomes available through the expiration of previously held TCCs and any remaining wheeling agreements. Each auction offers for sale TCCs with effective periods of six months and at least one year (the NYISO previously offered TCCs for two-year and five-year terms). Currently, all TCCs are obligations and are in effect for all hours of their effective period. These auctions are conducted in multiple (at least four) rounds, each of which offers for sale a defined percentage of the remaining transmission capability. In consultation with market participants, the NYISO sets the percentage of transmission capability to be offered as six-month and longer term TCCs, and the percentage to be allocated to each round. After each round, awards and market-clearing prices are posted, so that market participants may adjust their bids in subsequent rounds based on the latest pricing information. As well as the semi-annual auctions, monthly "reconfiguration" auctions are held where existing TCCs are offered for sale and bids to purchase TCCs are submitted.

Network Model

The NYISO adopted the use of an "ac" network model for the TCC auction solution, to directly model losses and the effects of voltage limits. Computation times are significantly longer than using a "dc" approach, and convergence issues often appear that must be resolved

sure to follow suit, particularly if the Federal Energy Regulatory Commission's Standard Market Design becomes mandated in the United States.

All these FTR markets, both operational and under development, are under continuous review, with the aim of introducing new and improved FTR products and market features. FTR auction periods vary widely in the different implementations, from yearly (or multi-year), to seasonal, to monthly. FTR options are currently traded in PJM and will be included in MISO and CAISO. Two important sidebars in this article have been contributed respectively by the NYISO and the MISO, based on their experiences in the design and/or operation of a major FTR market.

A participant communicates with the FTR market via the ISO's user interface. This real-time, secure Web-based system is accessed via a browser. A typical system allows the user to download public data, including network data and auction results, and to upload or download private data, including FTR "bid portfolios" (sets of bids and offers). The user can maintain and edit any number of these FTR bid portfolios and submit them to the current auction during the prescribed bidding window of time. The interface also provides real-time access to the FTR secondary market. Figure 4 depicts a generic FTR system.

FTR Development Areas

FTR markets are still in their early years of evolution. In North America, a couple of markets (NYISO, PJM) have pioneered the field and have logged the most experience to date. Understanding and satisfying the user's needs and bidding to produce an auction solution. While acknowledging these obstacles, the NYISO feels that a more valid set of TCCs is sold on the network by using the "ac" model.

Future Developments

As historical congestion patterns have developed and TCC market participant sophistication has increased, the amount of surplus transmission capability left unsold after the auctions has decreased. As a result, any unanticipated transmission outage usually leads to a day-ahead market shortfall in congestion cost collection. Transmission owners are charged for shortfalls caused by actions they take that lead to either the forced or scheduled outage of transmission facilities in the day-ahead market. In addition, surplus revenues are paid to transmission owners when their actions cause the return of facilities previously modeled as out of service. These charges and payments are added to the congestion costs collected to fund payments to TCC holders.

The NYISO has initiated the development of generalized multiperiod TCC auction software. The type of auction contemplated by this new software would allow bids for differing and nonsequential time periods over perhaps a five-year time span. The auction solution's selection criterion maximizes the value of the bids awarded, and the market participants thus determine the effective periods of TCCs sold in the auctions. The NYISO will no longer play the role of arbitrator in setting the effective period of TCCs sold and the percentage of transmission capability offered for each effective period. The multi-round concept could be included in these multiperiod auctions, if so desired by the market participants.

The NYISO is evaluating the introduction of TCC options into the market. Since congestion in New York runs predominantly from west to east and north to south, there has been little demand for TCC options, except on the borders of New York with neighboring ISOs where the direction of congestion changes based on the economics of the moment. The co-optimization of TCC obligations and TCC options complicates the algorithm used in the "ac" network model, while significantly increasing auction solution run times. One consultant has developed a pure theoretical "ac" network model solution for this problem, but development and run times are currently not known. The NYISO has been exploring other alternatives that may allow TCC options to be obtained across the New York boundaries from a limited numbers of internal New York buses to the external "proxy" buses in the neighboring ISOs.

Further Remarks

The combination of TCC obligations and TCC options in a multiperiod, multiround auction appears computationally daunting, particularly faced with the trend towards the formation of larger markets and correspondingly larger transmission networks and numbers of monitored constraints. Faster computers will certainly help in the solution to these problems; however, the industry should be looking at other solution techniques in conjunction with historical powerflow options. Branch and bound techniques could play an important role in this area.

behaviors in an FTR market is a work in progress. Here are a few pointers.

New FTR Products

Clearly, one of an ISO's FTR priorities is to provide the hedging products that the user wants. This involves defining and implementing increasingly sophisticated FTR markets and handling the increased computational complexity of advanced analytical formulations, solution processes, and number crunching. Clever formulations and algorithms will be needed. Several new FTR trading products are described as follows. Others will undoubtedly emerge.

Hybrid and Conversion Bids

More flexible variants on the basic types of FTR bids are possible. For example, a bid may be characterized as part obligation and part option. In another example, a bid can be made to convert some portion of an existing FTR obligation to an option, or vice versa.

Expansion FTRs

Whenever an entity makes a transmission system addition, calculations are needed to assign new FTRs (also called incremental FTRs) to the entity, reflecting its contribution to congestion relief.

Contingent FTRs

An application of the so-called "contingent" FTR is illustrated as follows. Consider a power producer who intends to fulfill a bilateral contract from a number of generators at

Some MISO Perspectives

—by R. Doying, Market Development and Analysis, Midwest ISO

The Midwest ISO (MISO) financial transmission rights (FTRs) market design is based on sound and successful FTR markets implemented by other ISOs, with some additional features that capture the Midwest energy market characteristics.

Types of FTRs

The Midwest ISO initially will offer point-to-point FTR obligations. FTR options will be phased in as the market develops. FTR obligations are now well-known instruments, having been the staple for several years in other ISO markets. FTR options have more recently been introduced in PJM, and market participants are exploring their use. Financial instruments based on flowgate rights have been discussed at a theoretical level for several years but have not yet been implemented. The Midwest ISO plans to phase in FTR flowgate rights (FGRs) as the Midwest market matures. Because of the difficulty of constructing a portfolio of FGRs that mirrors a transaction between a specific generation and load, FGRs will likely be most useful as partial hedges and as arbitrage instruments. Moreover, FGRs have properties that make them potentially unattractive as long-term financial instruments. As a result, MISO will likely first phase in FGRs as monthly instruments.

Annual Allocation

Prior to the opening of the Midwest market, FTRs will be allocated to existing transmission customers. The allocation process, jointly developed by the Midwest ISO and its stakeholders, involves several steps. Customers will be allocated FTR obligations in four tiers. FTRs allocated in each tier will be based on customer nominations, subject to a simultaneous feasibility test. During a three-year transition period, a "restoration" process will be performed between the second and third tiers. The restoration process will allow customers to request restoration to full nominated value of eligible FTRs that were curtailed in the second tier. Eligibility for restoration is restricted to high capacity factor ("baseload") resources, and requests for restoration will be accommodated to the extent made possible by adding baseload FTRs that were not previously allocated but that would provide necessary counter flow. The proposed restoration step is designed to maximize the amount of historical counter flow in the allocation model and hence the number of FTRs that can be allocated from "baseload" units for all transmission customers. The third and fourth nomination and allocation tiers will follow the restoration process. Midwest ISO's FTR allocation in each of the four tiers will be for four seasons and for on-peak and off-peak periods. Each of the eight allocations per tier will be independent in that the ability to award an FTR in one season and period does not depend on the ability to award FTRs in any other season or period.

different locations. However, the generators' proportional contributions are likely to vary during the contract period. It would be expensive to buy at auction a set of separate FTRs to cover all combinations. Instead, a single contingent FTR can provide such coverage more economically (noting that such a specific hedge may not be too tradable).

Modeling

The ISO has to know how much of the network's FTR capacity is at its disposal in the allocation, auction, and transmission request calculations. This depends on accurate network modeling, which in turn depends on the maintenance of an accurate database of the EMS-supervised network and the external system, including the expected loop flows through the ISO's network. The ISO's state estimator and its supporting telemeasurement system must perform accurately and reliably. For most ISOs, this is still a goal to be achieved.

Seams

An ISO in North America is necessarily regional, and it connects with other networks that are likely to be conducting their own LMP-based markets. At present, an FTR can go no further than its market's boundary, using a proxy source/sink that does not reflect the true flow of power. How to handle FTR or other transmission reservations across these "seams" is a challenge.

Monthly True-Up

To ensure that the maximum possible FTRs are awarded to transmission users, awarded FTRs are subject to a "true-up" each month. Customers may request that FTRs that were prorated in the annual allocation to achieve a simultaneously feasible solution beevaluated to determine whether incremental FTR capacity is available. If the network conditions in support additional FTRs, they will be awarded up to the amount that had been prorated in the annual allocation.

Annual Auction

The Midwest ISO will also offer additional mechanisms to obtain FTRs. First, an annual auction will take place after the annual allocation. As with the allocation, the annual auction will comprise eight separate and independent auctions—for each of the four seasons in the year, and for peak and off-peak in each. The Midwest ISO will also hold monthly auctions after each monthly true-up.

FTRs for New Service Requests

MISO transmission customers will be able to request FTRs for new "in", "out," and "through" service. Request for FTRs associated with new transmission service will be made via the OASIS system as a normal transmission service request (TSR). When submitting a TSR, customers may request FTRs up to the amount of the TSR. MISO will analyze the TSR and FTRs requested and will either approve, decline, or counter-offer as appropriate.

Secondary Market Bulletin Board

Finally, the MISO will administer an FTR secondary market bulletin board. Buyers and sellers of FTRs may post bids and offers on the bulletin board. Customers will negotiate and bilaterally settle trades based on bulletin board postings. The Midwest ISO will transfer official ownership of the instrument if requested and the purchasing party meets credit requirements. FTRs may be reconfigured in terms of size and term via bulletin board transactions.

Further Remarks

Adopting products that have been successfully incorporated into other markets is expected to facilitate a successful market launch in the Midwest. At the same time, details unique to the Midwest ISO have been incorporated into the FTR market design and processes to meet the specific needs of MISO customers. For example, seasonal and peak/off-peak FTRs allow customers to better match allocated FTRs to existing uses of the system. Providing multiple products (FTR obligations, FTR options, and FGRs) provide greater flexibility for customers as they adapt and respond to evolving market conditions, giving them greater control over the management of their businesses.

Public Data

Frequently, a market participant needs to perform extensive analysis in order to make educated FTR bids and offers. It therefore needs the ISO to publish in a timely manner all the nonprivate information required for such analyses. In principle, the ISO will provide all this data in the spirit of open access. In practice, this is not yet fully happening.

Auction Revenue Rights (ARRs)

Under its nonprofit charter, an ISO will distribute its revenue from FTR auctions to transmission users, owners, etc. Two main policy decisions have to be made—who is eligible and what is an equitable distribution? This will usually involve extensive network calculations.

Revenue Shortfalls

The sidebar "Revenue Adequacy and Simultaneous Feasibility" explains that congestion revenue shortfalls can sometimes occur. The biggest causes are thought to be unscheduled transmission outages. Studies can be performed to accurately analyze the economic impacts of these outages on revenue, and to assign quantitative responsibility.

FTR Trends

FTR markets will continue to develop in conjunction with

FTR markets will continue to develop in conjunction with LMP-based energy markets, and new and improved FTR products will be introduced.

LMP-based energy markets, and new and improved FTR products will be introduced. To date, participation in the well-established FTR markets (NYISO, PJM) has been vigorous, and the evidence is that all such markets will grow up to a certain point and remain active thereafter. Here are a few predictions.

Options

FTR options will become standard in all markets. Markets that formerly only offered FTR obligations will experience large increases in computational requirements when options are introduced.

Multiperiod FTRs

A very important variant that will become widespread is the multiperiod FTR auction. One of its many uses is illustrated as follows. Consider a new plant that is expected to be active only during the summer seasons. The owner wants to protect his investment by purchasing FTR congestion hedging, not just for the coming summer but for all summers over the next five years. He wants to submit a single bid that, if successful, awards him all the desired coverage. Note: NYISO has piloted a generalized multiperiod FTR auction, whose software has the flexibility to permit bids for any arbitrary numbers and combinations of time periods, with different networks, sources/sinks, contingencies, and monitored elements for each period. PJM's second-generation FTR market caters for two periods permitting peak, off-peak, and 24-hour bids.

Multiround Auctions

Multiround FTR auctions will become more common. This gives an auction a more flexible and competitive characteristic. Following the results of an auction round, both the winners and the losers may change their bids and try again.

Auction Periods

Both shorter- and longer-term FTR auctions than at present are likely. Even weekly or daily auctions have been proposed, but these involve extra implementation and management complications.

LMP-Based Congestion Pricing

The LMP approach penalizes users who contribute to transmission bottlenecks and rewards users who tend to alleviate them. The marginal price of each point in the network is computed at each hour in the real-time and day-ahead markets, using a network model derived from the EMS state estimator. Each LMP (expressed in $/MWh) has three components:

$$LMP = LMP^E + LMP^L + LMP^C$$

where superscripts E, L and C denote energy, losses, and congestion, respectively. The energy component is the same throughout (except in different islands). The loss component varies but is usually small. It is sometimes lumped with the congestion component, or it may disappear altogether if a lossless network model is used to compute the LMP. The congestion component can be large, and it adds to or subtracts from the LMP, according to whether a power injection at the network point marginally increases or alleviates congestion.

Each supplier of MWs to the network is paid at its LMP and each consumer of MWs from the network is charged at its LMP. LMPs are also used to charge congestion fees for transmission usage (bilateral transfers). These fees are positive when the transfer contributes to congestion and negative when the transfer alleviates congestion. The hourly congestion charge by (or payment from) the ISO for transmitting T MW between points A and B is:

$$T \times \left(LMP^C_B - LMP^C_A\right).$$

Inter-Market Coordination

Compatibility and standardization between markets will increase. Adjacent markets will cooperate to facilitate the acquisition of cross-regional FTRs, which will reduce the "seams" problem. Network model sizes and the numbers of held FTRs will continue to grow.

FTR Training Systems

FTRs are intricate instruments, and they need to be thoroughly understood in the context of the specific power system and in the use of the Web-based bidding interface. A Web-accessed FTR training system exactly mimics the FTR market interface and assists the user to self-train in FTR principles and bidding mechanics. Up to now, only the MISO has specified such a system for its participants.

Market Analysis

The buying and selling of FTRs will become the province of specialized risk management computer analysis, based on past market history and projections of future congestion. In general, the more sophisticated the analysis and its software, the more will be the user's market advantage.

Power System Planning

Planning and the efficient operation of the market are inseparable. Clearly, transmission expansion should largely be focused on the economics of congestion relief or avoidance, in which FTR analysis can play an important role. Generation siting studies will also benefit greatly from similar analyses.

Market Power

Both in the operation and planning of FTR markets, it is important to identify congestive elements that cannot be hedged with FTRs. Equally, it is important to monitor situations in which holders can increase their FTR payouts by deliberately increasing the relevant congestion. Operational safeguards against such "price gouging" should be adopted.

Concluding Remarks

The FTR is a natural antidote to congestion price volatility in an LMP-based market. Such markets have thus far taken root mainly in North America, where they are in varying stages of operation, development, and planning. FTR market products and flexibilities will clearly evolve much further.

Every ISO will encourage competitive participation in its FTR market. A challenge, then, for the ISO is to provide its participants with enough data and feedback to allow them to make fully informed FTR buy, sell, and hold decisions. With current fears of market power, the "rules of the game" prohibit competitors from knowing each others' FTR auction bids (at least until this data has become too old to be immediately useful). In future, more advanced online technologies may permit FTR auctions to evolve in different, more open, directions.

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Biographies

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