Effects of Firm Transmission Rights on Transmission Revenue Allocation in California

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***Abstract*— This paper provides an integrated treatment on the subjects related to California Firm Transmission Rights (FTRs), such as congestion charge, FTR auction revenue, congestion revenue, transmission revenue requirement, transmission revenue balancing account, and transmission access charges. The core subject of the paper is the effect of issuing Firm Transmission Rights (FTR) on the allocation of transmission revenue requirements. Much attention in the literature has been paid to the subject of revenue adequacy for an ISO. This paper brings attention to the subject of revenue adequacy for end users. This paper can also serve as a tutorial on California transmission markets and a technical reference for evaluating FTRs.**

***Index Terms*—Power System Economics, Firm Transmission Rights (FTR), Transmission Congestion, Transmission Revenue Requirement, Electric Power Market, Deregulation.**

I. Introduction

THIS paper presents the results of a study that investigates the financial consequences of issuing Firm Transmission Rights (FTR) by the California ISO (CAISO) based on first hand experience and historical data. The CAISO assumed operational control of California's electricity transmission grid on March 31, 1998. The CAISO is charged with maintaining reliability and directing the flow of electricity on the transmission network that connects power supplies to demands, and California with neighboring states as well as Mexico and British Columbia. The CAISO ensures equal access to 25,526 circuit miles of transmission lines through markets. The CAISO manages the transmission lines and supervises maintenance, but the transmission systems are still owned and maintained by individual utilities. The CAISO also acts as a transmission planner, identifying and approving enhancements that transmission owners propose to make to the grid.

The CAISO operates a small fraction (less than 10 percent) of the total wholesale electricity marketplace, using such markets only to allocate transmission usages, maintain operating reserves and match supply with demand. The market functions of the CAISO include the following:

- The Day-Ahead (DA) Markets manage transmission congestion and procure ancillary services.
- The Hour-Ahead (HA) Markets manage transmission congestion and procure ancillary services.
- The Real-Time energy market maintains the power balance of the system.

Congestion management, a critical function of the CAISO, is the process that ensures the transmission system does not violate its operating limits. The power transfer capability in California may become constrained due to a variety of reasons. Congestion can cause both curtailment of schedules and collection of congestion charges from schedules that use congested transmission interfaces. Congestion charges can be high relative to the cost of energy being transported. However, the occurrence of congestion and its associated charges cannot be predicted easily. Therefore, congestion charges are an unknown element of cost and a risk to energy traders and can hinder free trade of electricity across interfaces susceptible to congestion. The Firm Transmission Right (FTR) in California is a binding contract that entitles the holder to receive scheduling rights and a stream of revenues from potential congestion charges across pre-established congestion zones. The issuing of FTRs provides a means for transmission customers to manage the risks associated with the use of congested transmission interfaces.

This paper is primarily concerned with the California ISO FTRs defined in the current CAISO tariff and protocols [1–4]. A brief introduction to the new FTRs to be implemented with the proposed new market design 2002 is also presented at the end of this paper [5]. However, the focus of this paper is studying the effects of issuing FTRs on transmission revenue allocation in California based on past experiences. We did not find similar studies being documented in the literature. We found a few publications discussing other aspects of transmission rights in a deregulated environment. A power marketer's perspective of PJM's financial transmission right is presented in [6]. An approach for creating zones in relation to FTRs is presented in [7]. Examples are provided in [8] to show strategic uses of financial transmission right options. The role of FACTS devices in financial transmission rights auction is demonstrated in [9]. Historical development of the concepts of transmission rights can be found in [10] and [11] and their references.

This paper is organized as follows. Section II describes the Firm Transmission Rights in California. Section III describes the Transmission Access Charges in California. Based on an analysis of the relationships between Transmission Revenue

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Requirements, Transmission Access Charge, Congestion Charges, and FTR Revenue, Section IV evaluates the effects of issuing FTRs on the allocation of transmission revenue requirements. Section V presents the numerical results of the study based on historical data. Section VI presents a brief introduction to the new FTRs to be implemented with CAISO market design 2002. Section VII presents conclusions.

II. The Firm Transmission Rights In California

A. Congestion Charges

Currently the CAISO uses an inter-zonal congestion management scheme in both the DA market and the HA market to allocate transmission to energy schedules through the use of adjustment bids. Adjustment bids reflect the market participant's valuation of transmission access. For example, an incremental adjustment bid indicates the cost that the market participant would incur by increasing the resource's output. Conversely, a decremental adjustment bid indicates the savings that the market participant would achieve by decreasing the resource's output. In each market (i.e., DA or HA market), congestion charges are assigned to pre-established inter-zonal interfaces based on the users' marginal value for the needed capacity as reflected in its adjustment bids. Market participants do not pay for transmission when there is no congestion and pay the full marginal cost of that transmission capacity during congestion periods. This methodology sends marginal cost signals to the transmission users and promotes the most economic utilization of the transmission system. However, it also introduces financial risks associated with the uncertainty of congestion charges. The implementation of FTRs addresses the risk associated with the uncertainty of congestion charges. FTRs can provide transmission users with fixed-price transmission service across the ISO-controlled grid by hedging hourly variations in the cost of transmission service due to congestion.

B. California Firm Transmission Rights

Procurement of FTRs in CAISO is voluntary; a market participant does not have to have FTRs in order for its schedules to be accepted by the CAISO. The California FTRs are used to mitigate the risks associated with congestion charge and curtailment uncertainties. The FTRs are not used to allocate transmission usage. The congestion management mechanism is used to allocate transmission usage in forward markets.

FTRs have different meanings in different ISOs or RTOs (Regional Transmission Organization). FTR definitions mainly differ with respect to whether the rights are:

1) Defined on a specific transmission interface or a source-to-sink (point-to-point) pair;
2) Financial or physical entitlements;
3) Options or obligations.

Consistent with the zonal congestion management approach, each FTR in California is defined on a transmission path from an originating Zone to a contiguous receiving Zone. Each transmission path is called a Branch Group consisting of a predetermined group of transmission branches.

California FTRs encompass both financial and physical rights. The financial right of each FTR entitles the FTR holder to receive an amount of congestion revenue equal to the amount of congestion charge attributable to transferring 1 MW of power across the congested path. Therefore, if a market participant uses a congested interface for which it holds FTRs by an amount equal to the amount of its FTR holdings, the market participant is revenue neutral regardless of the magnitude of the cost of congestion. This is because the congestion charges flow from the market participant, through the ISO to the FTR holder, which is the same market participant. By using FTRs, a transmission user is able to obtain price certainty for its transmission service. Therefore, the exposure to congestion costs is only limited by the user's willingness and ability to purchase its needed FTRs.

An FTR in California is a right in one direction only; an FTR holder is not entitled to share in congestion charges attributable to congestion from the designated receiving zone to the designated originating zone. FTRs in California are options; the holder is entitled to receive congestion revenue when the congestion is in the same direction as the FTR; the holder is not obligated to receive negative (i.e. pay for) congestion revenue when the congestion is in the opposite direction of the FTR.

In California, the users of transmission services prefer that the FTRs provide more than just financial certainty for congestion costs. The California market participants want FTRs to provide scheduling certainty on specific interfaces so that their generating resource can be scheduled to a specific load. This concern is resolved by assigning a physical right to the FTRs. The physical right of each FTR entitles the FTR holder the second scheduling priority (next to Existing Transmission Contracts, i.e., transmission leases between transmission owners and other entities signed before the operational control of the CAISO) in the event of DA administrative curtailment when there are insufficient adjustment bids to mitigate the congestion economically. The physical right only applies in the DA market to avoid hoarding of transmission by the FTR holders.

C. Allocation of FTRs

The CAISO allocates FTRs through an annual primary auction. The FTRs sold in the primary auction can be traded in the secondary market through bilateral contracts.

To determine the available transmission capacity for FTR auction, non-simultaneous ratings of the interfaces are used. The non-simultaneous ratings are determined through technical studies. Simultaneous ratings often vary by the time of day or season, while non-simultaneous ratings tend to be much more constant. In addition, because most paths currently are rated based on non-simultaneous ratings rather than simultaneous ratings, basing FTRs on non-simultaneous ratings is more consistent with the current practices. Inasmuch as transmission interfaces generally have different ratings for different flow

directions, different quantities of FTRs may be created for each direction.

The initial term for the California primary auction is one year. Due to uncertainty about the value of FTRs, a longer term may not be desirable. In addition, with a one-year limit, there is an annual opportunity to create and eliminate new zones. Moreover, issuing FTRs more frequently than annually creates excessive administrative burdens on the ISO and on the market participants for forming active secondary markets.

D. Allocation of FTR Auction Proceeds

In California the proceeds from the FTR auction goes to transmission owners to offset their respective transmission revenue requirements. The higher the auction revenue, the lower the transmission access charges will be.

The CAISO applies a difference FTR allocation methodology to new facilities. Those entities that pay for the expansion of the transmission grid receive FTRs for the incremental transfer capability resulting from that expansion. If the cost of these new facilities is rolled into the transmission access charge (which is described in the next section), the revenue from the sale of FTRs will go to offset the transmission access charges. If the cost of the transmission addition is not rolled into the transmission access charges, the owners of the transmission addition will receive the auction revenues.

III. Transmission Access Charges In California

A. Transmission Revenue Requirement

Participating Transmission Owners (PTOs) are the transmission owners that have handed over the operational control of their transmission networks to the CAISO. The Transmission Revenue Requirement (TRR) for each PTO reflects the PTO's costs associated with all transmission facilities under the operational control of the CAISO. A PTO's TRR is based on a twelve-month test period and include the PTO's:

1) Transmission operations and maintenance expenses
2) Transmission-related administrative and general expense,
3) Transmission-related tax expenses,
4) Transmission depreciation expense or debt amortization,
5) Capital costs,
6) Cost of transmission by others under existing contracts
7) Credits of revenues from transmission for others under existing contracts,
8) Other (non-ISO-related) revenue credits allocable to transmission, and
9) Transmission Revenue Balancing Account (TRBA).

Each PTO must allocate all of its transmission facilities under the CAISO's operational control into one of two categories:

1) High Voltage (≥200 kV) Transmission Facilities, and
2) Low Voltage (<199 kV) Transmission Facilities.

Only the cost of High Voltage Transmission Facilities is recovered in the Transmission Access Charge (TAC) administered by the CAISO.

B. Transmission Access Charge

The TRR for each PTO is recovered through transmission access charge to gross load, charges to wheeling schedules, congestion charges, and sales of FTRs. Prior to January 1, 2001, the CAISO's original transmission access charge methodology consisted of three separate zone rates based on the TRR of the three utilities, i.e., Pacific Gas & Electric Company (PG&E), Southern California Edison Company (SCE) and San Diego Gas & Electric Company (SDG&E). The methodology was criticized as pancaking of transmission rates; that is, a user of transmission service was required to purchase rights from several entities at different rates to complete a single transaction. This process was not only inefficient but also required complex accounting and settlement procedures.

Beginning on January 1, 2001 and continuing over a ten-year transition period, the High Voltage Transmission Access Charge, referred to as TAC hereafter, for all the PTOs will be combined to form a single CAISO grid-wide component. During the ten-year transition, ten percent per year of each PTO's High Voltage TRR will be combined as the ISO Grid-wide component of the TAC. During the transition period, the TAC rate consists of two components per TAC area, a CAISO grid-wide rate (referred to as Formula Rate) and a TAC area specific rate. Currently, PG&E is in the Northern TAC Area; SCE and City of Vernon are in the East Central TAC Area; and SDG&E is in the Southern TAC Area. If the Los Angeles Department of Water and Power chooses to become a Participating TO, its Control Area would become a fourth TAC area.

The ISO-wide TAC rate, i.e., the formula rate, is determined as follows:

$$R(y) = \frac{0.1 * y * \sum_k T_k(y) + \sum_k \Delta T_k(y)}{\sum_k L_k(y)} \quad (1)$$

where

y the y^{th} year in transition period; y=1 in year 2001.
$R(y)$ the ISO grid-wide TAC rate in year y.
$T_k(y)$ the TRR of existing transmission facilities for TAC area k in year y.
$\Delta T_k(y)$ the TRR of new transmission facilities for TAC area k in year y.
$L_k(y)$ the forecast of Gross Load in MWH for TAC area k in year y for the same twelve-month test period to which the TRR applies.

Gross Load means all energy (adjusted for distribution losses) delivered for the supply of loads. Gross Load does not include any energy associated with wheeling service. The PTOs ensure that their forecast of Gross Load is consistent with the CAISO-metered load on which the TAC is assessed.

The TAC area specific rate for each TAC area is determined as follows:

$$R_k(y) = \frac{0.1 * (10 - y) * T_k(y)}{L_k(y)} \quad (2)$$

where

$R_k(y)$ the TAC area specific rate for TAC area k in year y.

The combined TAC rate that applies to both gross load and wheeling schedules for each TAC area is determined as follows:

$$R'_k(y) = R(y) + R_k(y) \quad (3)$$

where

$R'_k(y)$ the combined TAC rate for TAC area k in year y.

C. Transmission Revenue Balancing Account

Should the forecast of gross load be perfectly accurate, the total TRR would be recovered completely from Gross load according to the TAC rates determined in the formula set forth above. The application of the TAC rates to wheeling schedules would result in over collection of transmission revenue because wheeling quantities are not considered as gross load in computing the TAC rates. The congestion charges and the proceeds from FTR auctions are also extra transmission revenues. Transmission Revenue Balancing Account (TRBA) is established to ensure that revenues received by a Participating TO for wheeling service, congestion charges, and sales of FTRs are flowed through to its transmission customers. TRBAs also ensure the each PTO's regulated transmission revenue requirement is fully recovered over time regardless of forecasting errors and cost shifts (referred to as transition charge) between the new and existing PTOs.

The TRBA element of the TRR for each PTO is the summation of the unamortized balance in the TRBA as of November 30 of the prior year and the test year forecast of transmission revenue credits, and the interest balance for the TRBA. The total amount of TRBA for the PTOs of each TAC area for each year can be expressed as follows:

$$B_k(y) = W_k(y) + C_k(y) + F_k(y) \quad (4)$$

where

$C_k(y)$ the congestion charges collected by PTOs of TAC area k in year y

$F_k(y)$ the FTR auction proceeds allocated to PTOs of TAC area k in year y

$W_k(y)$ other revenues or payments (revenue imbalance caused by load forecasting error, wheeling charges, transition charges and etc) applicable to PTOs of TAC area k in year y

The total amount of TRR for existing transmission facilities of the PTOs of each TAC area for each year can be expressed as follows:

$$T_k(y) = T'_k(y) - B_k(y-1) \quad (5)$$

where

$T_k(y)$ the TRR for existing transmission facilities owned by PTOs of TAC area k in year y, which is used to calculate TAC rates.

$T'_k(y)$ the gross TRR for existing transmission facilities owned by PTOs of TAC area k in year y, which includes itemized expenses of 1) to 8) described in Section III-A.

$B_k(y)$ Total amount of TRBA for the PTOs of each TAC area for each year.

IV. Effects of FTR on Transmission Revenue Allocation

A. Relationship between FTR and TAC

The amount of congestion charges collected by the PTOs depends on the amount of FTR sales by the PTOs because part of the total congestion charge goes to FTR holders. This relationship is described as follows:

$$C_k(y) = C'_k(y) - F'_k(y) \quad (6)$$

where

$C'_k(y)$ the total amount congestion charges collected from transmission facilities owned by PTOs of TAC area k in year y

$F'_k(y)$ the amount of congestion charges collected from transmission facilities owned by PTOs of TAC area k that are paid to FTR holders in year y..

By substituting (6) into (4), we get::

$$B_k(y) = W'_k(y) + \left[F_k(y) - F'_k(y)\right] \quad (7)$$

where

$$W'_k(y) = W_k(y) + C'_k(y) \quad (8)$$

The first term in (7) is independent of the FTR sales. The second term, i.e., the bracket in (7) is dependent upon the difference between FTR auction proceeds and congestion charges paid to FTR holders

The relationship between FTR auction proceeds and the TAC rates is obtained as follows using (1) to (8):

$$R'_k(y) = X_k(y) - Z_k(y) \quad (9)$$

As defined below, $X_k(y)$ is a term independent of FTR auction proceeds; and $Z_k(y)$ is a term dependent of FTR auction proceeds.

$$X_k(y) = \frac{0.1 * y * \sum_k \left[T'_k(y) - W'_k(y-1)\right] + \sum_k \Delta T_k(y)}{\sum_k L_k(y)} + \frac{0.1 * (10 - y) * \left[T'_k(y) - W'_k(y-1)\right]}{L_k(y)} \quad (10)$$

$$Z_k(y) = \frac{0.1 * y * \sum_k \left[F_k(y-1) - F'_k(y-1)\right]}{\sum_k L_k(y)} + \frac{0.1 * (10 - y) * \left[F_k(y-1) - F'_k(y-1)\right]}{L_k(y)} \quad (11)$$

It is the second component in (9), i.e. the expression in (11) that represents the effect of issuing FTR on the transmission

revenue allocation.

B. Effect of FTR on Transmission Revenue Allocation

The effect of FTR sales on transmission revenue allocation varies according to the following scenarios:

1) If the FTR auction proceeds collected by PTOs in a TAC area is exactly the same as the congestion charges allocated to the FTR holders in the same year, i.e., if $F_k(y\text{-}1) = F'_k(y\text{-}1)$, the sales of FTR has no effect on transmission revenue allocation because the TAC rate of the TAC area in the following year is not affected by the sales of FTR, i.e., $Z_k(y) = 0$. This scenario actually is expected over a period of time as FTR bidders discover the ways for forecasting congestion accurately under perfect conditions (e.g., stable market rules, minimum gaming influence, and etc.).
2) If the FTR auction proceeds collected by PTOs in a TAC area is greater than the congestion charges allocated to the FTR holders in the same year, i.e., if $F_k(y\text{-}1) > F'_k(y\text{-}1)$, the sales of FTR reduces the TAC rate of the TAC area in the following year, i.e., $Z_k(y) > 0$. In this scenario, FTR bidders overestimated value of the transmission interfaces. Consequently, they help to pay for a portion of the TAC for end users.
3) If the FTR auction proceeds collected by PTOs in a TAC area is less than the congestion charges allocated to the FTR holders in the same year, i.e., if $F_k(y\text{-}1) < F'_k(y\text{-}1)$, the sales of FTR increases the TAC rate of the TAC area in the following year, i.e., $Z_k(y) < 0$. In this scenario, FTR bidders get a bargain for the use of the transmission interfaces. Consequently, their benefit is paid for by end users through TAC.

C. Revenue Adequacy for End Users

Much attention in the literature has been paid to the subject of revenue adequacy for an ISO, meaning that sufficient amount of congestions charges must be collected by the ISO to pay for FTR holders' financial entitlements, i.e.,

$$\sum_k C_k(y) \geq 0 \tag{12}$$

Not much attention has been paid to the subject of revenue adequacy for end users, which is the core subject of this paper. Section V of this paper assesses whether sufficient amount of FTR auction proceeds were collected by the CAISO to pay for FTR holders' financial entitlements, i.e.,

$$F_k(y) - F'_k(y) \geq 0\ ? \tag{13}$$

or

$$\sum_k F_k(y) - \sum_k F'_k(y) \geq 0\ ? \tag{14}$$

However, unlike revenue adequacy for the ISO that is considered a requirement for issuing FTRs, revenue adequacy for end user should not be considered a requirement for issuing FTRs.

On one hand, it should be noted that the scope of the revenue adequacy issue for end users is limited to the effect of FTRs on *transmission revenue allocation* and not on overall market performance or financial outcome. Issuing FTRs can increase or decrease the TAC for end users. However, one should not make a conclusion based on this effect alone whether issuing FTR is good or bad to end users. To make the point using an analogy, consider the fact that whether an insurance company makes or loses money has no bearing on our needs for insurances. It is well-accepted fact based on the use of similar financial instruments in other business environments that FTRs as a tool for mitigating financial risks can facilitate liquidity and stability of the electric energy market and therefore can reduce the overall cost to end users.

On the other hand, it is important to make sure that end users' economic interests are fairly represented in the FTR allocation process. If the FTR prices are set too high, few FTRs will be sold and consequently end users will pay a higher energy price that includes a risk premium on the availability of transmission capacity for transporting economic power. On the other hand, if the FTR prices are set too low, inadequate FTR proceeds will be collected to cover FTR holders' financial entitlement and consequently end users will pay higher TAC that will outweigh the benefit of selling FTRs. Since end users are the ultimate payer for both energy and transmission revenue requirements, end users should be given adequate opportunities determining the prices at which the FTRs should be sold and accept the risks associated with that decision. The way that the CAISO addresses this issue in its market design 2000 effort is allocating FTRs to load serving entities initially free of charge; the load serving entities can then sell the FTRs in the subsequent auctions at prices they choose.

V. Outcomes Of FTR Operation In California

A. FTR Operation 2000

The CAISO conducted its first preliminary auctions in November of 1999 for FTR term from February 1, 2000 through March 31, 2001. Participation in the multi-round auctions involved 28 participants. As is shown in Table I, a total of 9,553 MW worth of FTRs were sold. This represents about one-third of the total transmission capacity available into and out of California. It resulted in a sale of $41 million in FTRs on 19 transmission interfaces. However, the total congestion revenue earned by the FTR holders amounts to $166 million. Based on the analysis given in the previous section, the FTR holders collectively made a profit of $125 million, which is passed to the TRBAs to increase the transmission revenue requirement in the following year. As can be seen from Table I, most of the FTR profit is realized on inter-ties connected to SP15 Zone and Path 26. Since SCE is a major load serving entity of SP15 Zone, it has financial interests in buying FTRs on these paths. In deed the only Load Serving Entity (LSE) that bought FTRs in the 1999 auction is SCE; and it was able to make a profit of about $18 million. Generators, energy trading firms and financial investment firms captured the rest of $107 million.

An after-the-fact observation leads to the conclusion that the FTRs should have been sold at higher prices to minimize the increase in transmission revenue requirements in the following year. This could have been done by setting higher seed (i.e., starting) prices on the paths such as Path 26. However, the ISO could not make decisions based on its risk preference but following the procedures for setting seed prices according to its tariff. SCE could have bought more FTRs on the highly congested paths to reduce the profit that non-load serving entities could make. However, such decisions are difficult under uncertainties. A reasonable reform of the FTR market should allow the LSEs to decide based on their risk preference at what price the FTRs should be sold because end users represented by the LSEs ultimately pay for transmission revenue requirements. In fact, in the newly designed FTR market to be discussed in Section V, the FTRs are initially allocated to the LSEs and it is up to the LSEs to sell their holdings at prices they desire.

TABLE I
2000 FTR OPERATION OUTCOME BY BRANCH GROUP

Branch Group	From Zone	To Zone	Total FTRs Sold (MW)	Total Auction Revenue ($)	Total Congestion Revenue Earned by FTR Holders ($)
CFE	MX	SP15	408	67,320	0
CFE	SP15	MX	408	112,200	7,593
COI	NW1	NP15	422	13,293,000	618,003
COI	NP15	NW1	33	*60,885*	*1,468,264*
ELDRD	AZ2	SP15	694	*6,922,650*	*11,680,651*
ELDRD	SP15	AZ2	615	230,625	0
IID-SCE	II1	SP15	600	255,000	0
MEAD	LC1	SP15	366	*316,590*	*1,835,856*
MEAD	SP15	LC1	380	*564,300*	*1,575,816*
NOB	NW3	SP15	347	2,602,500	1,259,569
NOB	SP15	NW3	442	*245,310*	*29,724,380*
PLVRD	AZ3	SP15	1,650	*9,570,000*	*51,200,804*
PLVRD	SP15	AZ3	852	489,900	0
PATH26	SP15	ZP26	127	*78,740*	*384,367*
PATH26	ZP26	SP15	1,621	*5,835,600*	*66,404,786*
SLVRPK	SR3	SP15	10	89,850	5,220
SLVRPK	SP15	SR3	10	5,500	3,056
VICTVL	LA4	SP15	386	38,600	43
VICTVL	SP15	LA4	182	*30,940*	*287,498*
Totals			9,553	40,809,510	166,455,906

B. FTR Operation 2001

The 2001 FTR term is effective from April 1, 2001 through March 31, 2002. Table II shows the outcome of FTR operation of 2001 by branch groups. Table III shows the outcome of FTR operation of 2001 by TAC Areas. As is shown in the tables, a total of 10,475 MW worth of FTRs were sold. It resulted in a sale of $83 million in FTRs. However, FTR holders only earned a total of $33 million in congestion revenue. Therefore, the FTR holders collectively had a net loss of $50 million, which is passed to the TRBAs to reduce the transmission revenue requirements in the following year.

TABLE II
2001 FTR OPERATION OUTCOME BY BRANCH GROUP

Branch Group	From Zone	To Zone	Total FTRs Sold (MW)	Total Auction Revenue ($)	Total Congestion Revenue Earned by FTR Holders ($)
CFE BG	MX	SP15	408	122,400	1
CFE BG	SP15	MX	408	104,040	13,503
COI BG	NW1	NP15	600	*1,940,400*	*2,391,515*
COI BG	NP15	NW1	56	2,662,072	506,352
ELDORADO BG	AZ2	SP15	707	13,452,796	757,227
ELDORADO BG	SP15	AZ2	626	1,333,380	9
IID - SCE BG	II1	SP15	600	375,000	1,441
MEAD BG	LC1	SP15	461	1,099,946	199,411
MEAD BG	SP15	LC1	430	3,150,610	241,220
NOB BG	NW3	SP15	430	1,652,490	92
NOB BG	SP15	NW3	29	1,858,001	344,727
PALOVRDE BG	AZ3	SP15	1,819	*12,660,240*	*25,130,140*
PALOVRDE BG	SP15	AZ3	796	11,223,600	23,881
PATH 26 BG	SP15	ZP26	199	*510,236*	*2,782,138*
PATH 26 BG	ZP26	SP15	1,727	30,609,348	459,007
SLVRPK BG	SR3	SP15	10	283,740	935
SLVRPK BG	SP15	SR3	10	21,000	2
VICTRVL BG	LA4	SP15	938	157,584	3
VICTRVL BG	SP15	LA4	221	*167,960*	*488,886*
Totals			10,475	83,384,843	33,340,490

During the ten-year transition period, all end users do not have the same TAC rate. Although collectively end users in the CAISO control area enjoy a reduction of $50 million in TAC, the benefit is not shared equally across all TAC areas. As is shown in Table III, the FTR auction revenues allocated to the Southern TAC area is $2 million less than the congestion revenue paid to the FTR holders out of the share of the Southern TAC area. Each TAC area takes a share of socialized benefit (or burden) of FTR auctions according to the first term of (11); and each TAC area is also obligated to receive the TAC area specific benefit (or burden) described in the second term of (11). In the 2001 FTR operation example, these two components are illustrated in Table IV. As is show in Table IV, 20% of the $50 million benefit is shared in 2002 by all the TAC areas prorate according to their gross load. The rest of the $40 million is shared in 2002 by the TAC areas according their individually determined benefit.

Two interesting observations are made: (i) the 2001 FTR holders lost money in buying FTRs, and (ii) the amount of loss is less than the amount of profit made from 2000 FTR. A plot

of the loss and profit as shown in Figure 1 suggest that the market learns from the past experience and the FTR auction revenue and congestion revenue tends to converge.

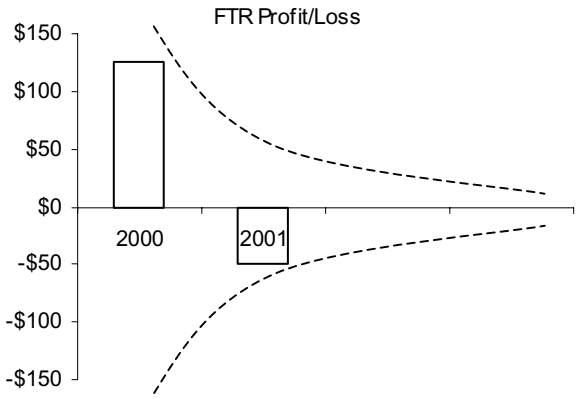

Figure 1 Expected Convergence of FTR Auction Revenue and Congestion Revenue

TABLE III
2001 FTR Operation Outcome By TAC Area

TAC Areas	Total Auction Revenue ($)	Congestion Revenue Earned by FTR Holders ($)	Total Reduction in TAC ($)
N (PG&E)	17,617,016	4,013,559	13,603,457
EC (SCE & Vernon)	54,299,386	15,575,039	38,724,347
S (SDG&E)	11,468,441	13,751,892	*-2,283,451*
Totals	$83,384,843	$33,340,490	$50,044,353

TABLE IV
2001 FTR Operation Benefit and Burden By TAC Area

TAC Areas	Reduction in ISO-wide TAC ($)	Reduction in Area-wide TAC ($)
N (PG&E)	10,008,871	10,882,766
EC (SCE & Vernon)		30,979,477
S (SDG&E)		*-1,826,761*
Total		40,035,482

C. FTR Operation 2002

The 2002 FTR term is effective from April 1, 2002 through March 31, 2003. Table V shows the outcome of FTR operation of 2002 by branch groups. As is shown, a total of 10,419 MW FTRs were sold for $59 million. It is apparent that the FTR bidders lowered their bids based on congestion revenue of the previous year.

TABLE V
2002 FTR Operation Outcome By Branch Group

Branch Group	From Zone	To Zone	Total FTRs Sold (MW)	Total Auction Revenue ($)	Total Congestion Revenue Earned by FTR Holders ($)
CFE BG	MX	SP15	408	$67,320	Not known yet
CFE BG	SP15	MX	408	$67,320	
COI BG	NW1	NP15	658	$11,587,380	
COI BG	NP15	NW1	165	$510,102	
ELDORADO BG	AZ2	SP15	793	$6,686,576	
ELDORADO BG	SP15	AZ2	702	$294,840	
IID - SCE BG	II1	SP15	600	$165,000	
MEAD BG	LC1	SP15	452	$3,209,950	
MEAD BG	SP15	LC1	430	$2,028,576	
NOB BG	NW3	SP15	610	$570,945	
NOB BG	SP15	NW3	108	$3,623,950	
PALOVRDE BG	AZ3	SP15	1,167	$17,350,956	
PALOVRDE BG	SP15	AZ3	601	$1,670,780	
PATH 26 BG	SP15	ZP26	712	$1,433,790	
PATH 26 BG	ZP26	SP15	1,566	$9,250,362	
SLVRPK BG	SR3	SP15	10	$102,000	
SLVRPK BG	SP15	SR3	10	$4,500	
VICTRVL BG	LA4	SP15	851	$412,735	
VICTRVL BG	SP15	LA4	168	$187,842	
Totals			10,419	$59,037,082	

VI. Future FTRs In California

Recently CAISO filed its new Market Design 2002 (MD02) with FERC in accordance with FERC's Standard Market Design. Since the new energy markets are based on nodal pricing, the FTR market rules are substantially changed. The characteristics of the new FTRs are summarized as follows.

- The new FTRs are defined by sources and sinks as opposed to paths. Two types of FTRs are available: Point-To-Point (PTP) right and Network Service Right (NSR). The PTP right is defined between a pair of source and sink with balanced injection and ejection. The NSR is defined between a group of sources and a group of sinks with balanced injections and ejections.
- Both PTP rights and NSRs issued by the CAISO through auction are financial obligations. An owner of the PTP right or NSR is obligated to receive congestion revenue or pay congestion charges (i.e., when congestion revenue is negative) depending on the difference between the nodal prices.
- In addition to financial obligation, the PTP right owner is entitled to Day-Ahead physical scheduling priority in the situation when administrative curtailment is needed. NSRs do not have physical scheduling priority.
- The terms of FTRs are 3 year (long term), 1 year (mid term) and 1 month (short term). FTRs with different terms are allocated separately.
- Existing Transmission Contracts (ETC) may be converted to PTP rights only. The owners of ETCs may choose between financial obligation rights or financial option rights. The latter entitles the owner to receive positive congestion revenue when the congestion and the FTR are in the same direction but not to pay if the congestion revenue is negative.
- The initial allocation of the transmission capacity is done as follows. The available transmission capacity is used first to honor non-converted ETCs subject to simultaneous feasibility test. After deducting the

capacity for non-converted ETCs, option FTRs are given to converted ETCs subject to simultaneous feasibility test. After deducting the capacity for option FTRs, obligation FTRs are given to converted obligation ETCs and Load Serving Entities (LSEs) subject to feasibility test.

- After the initial allocation of FTRs, the remaining network capacity is used to auction FTRs. The FTRs assigned to converted obligation ETCs and the LSEs are represented by fixed injections in the auction.
- FTR holders can trade their holdings in secondary bilateral markets. The transactions need to be registered with the CAISO.

VII. Conclusions

This paper has demonstrated the effect of auctioning Firm Transmission Rights (FTR) on the allocation of transmission revenue using historical data in California. It is demonstrated that each particular auction of FTR may increase or decrease the transmission access charges although issuing FTR is expected to have minimum effect on transmission revenue allocation under perfect conditions over time.

We offer the following conclusions for the paper:

1. Much attention has been paid in the literature to the subject of revenue adequacy for an ISO. Revenue adequacy for end users also deserves attention in FTR market design.
2. Unlike revenue adequacy for the ISO that is considered a requirement for the definition and issuing of FTRs, revenue adequacy for end users should not be considered a requirement for the definition and issuing of FTRs.
3. End users as ultimate payers for transmission revenue requirements should be given adequate opportunities in determining the prices at which the FTRs should be sold and accept the risks associated with that decision.

The way that the CAISO addresses this issue in its market design 2000 effort is allocating FTRs to load serving entities initially free of charge; the load serving entities can then sell the FTRs in the subsequent auctions or secondary markets at prices they choose.

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IX. Biographies

Ziad Alaywan (M'1987) brings more than 12 years of experience in the utility industry to his position as Director of Market Operations, overseeing more than $4 billion in annual gross Market activities for the day ahead, hour ahead and real time. Mr. Alaywan was one of the first employees hired in June 1997 and was instrumental in start-up of the pioneering organization. Prior to the formation of the CAISO, Mr. Alaywan was working for the CAISO trustees and led the effort in the design of the "blue-print" for the CAISO "Market Rules and Protocols."

Before joining the CAISO, Mr. Alaywan worked at Pacific Gas & Electric in various positions in system operations, power plant operation, and transmission planning. From 1994-1997, Mr. Alaywan supervised the real time operations of PG&E generation, transmission, and scheduling. Mr. Alaywan received a Bachelor and Master degrees in Electrical Engineering from Montana State University in 1987. He is also a certified Professional Engineer in the State of California.

Tong Wu (M'1995) received a B.S. degree in 1986 from Shanghai Jiaotong University, a M.S. degree in 1992 and a Ph.D. degree in 1995 from Drexel University, in Electrical Engineering.

Dr. Wu is currently an Independent Consultant affiliated with ECCO International, Inc., providing consulting services primarily to the California ISO. Prior to his consulting career, Dr. Wu was a Principal Regulatory Analyst with Pacific Gas and Electric Company. He also held teaching and research positions with the University of Hong Kong, Tokyo Electric Power Company and Philadelphia Electric Company. His special fields of interest include design of electric markets and computer applications.