Grid-Enhancing Technologies Participation in FTR Auctions

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***Abstract*—The increasing need for flexibility and transfer capability of the future electricity grid has brought grid-enhancing technologies into the spotlight. Steeply growing intermittent energy sources, besides the large fleet of electric vehicles increasing electricity demand on the other side, have created new congestion patterns that cannot be addressed solely by grid expansion. However, the economy of scale and regulated rate of return for transmission system investments provide minimal incentives for enhancing the grid. This paper introduces a competitive incentive mechanism in which grid-enhancing technology investors are reimbursed by the increment they bring to financial transmission right auction revenues. After solving the linearized version of the auction co-optimization with the grid-enhancing technologies, the payments are based on each technology's marginal value of susceptance, capacity, or voltage phase adjustment. The method is illustrated on a stylized 3-bus system, and the numerical simulations on a 30-bus system show the effectiveness of the method and revenue adequacy.**

***Index Terms*—Grid-enhancing technologies, electricity markets, financial transmission rights, FTR auction, power system operation, transmission planning, FACTS.**

NOMENCLATURE

Indices

i	FTR index.
l	Line index.
m	"To" bus index.
n	"From" bus index.

Sets

$\mathcal{A}$	Set of auction FTRs.
$\mathcal{B}$	Set of base FTRs.
$\mathcal{L}$	Set of lines in the network.
$\mathcal{K}$	Set of lines equipped with GETs.
$\mathcal{N}$	Set of buses in the network.

Parameters

B_l^0	Original susceptance of line l.
B_l^{max}	Maximum adjusted susceptance of line l.
B_l^{min}	Minimum adjusted susceptance of line l.
B_i	Bid value for FTR i.
F_l^{max}	Power capacity of line l.
ΔF_l	Capacity adjustment of DLR on line l.
$M_{n,i}$	FTR mapping matrix element for bus n and FTR i.
P_i^B	MW amount of base FTR i.
$\bar{P}_i^{FTR}$	Maximum amount of auction FTR i.
φ_l^{max}	Maximum voltage phase angle adjustment on line l.

Variables

f_l	Total flow of line l.
f_l^0	Initial flow of line l.
f_l^A	Flow of line l induced by Auction FTRs.
p_i^{FTR}	MW amount of auction FTR i.
s_l	Susceptance price on line l.
z_l	Binary variable for the flow direction on variable FACTS device l.
$\bar{\alpha}_l$	Dual variable for upper bound on directional line flow l.
$\underline{\alpha}_l$	Dual variable for lower bound on directional line flow l.
$\bar{\beta}_l$	Dual variable for upper bound on phase angle adjustment on line l.
$\underline{\beta}_l$	Dual variable for lower bound on phase angle adjustment on line l.
$\bar{\mu}_l$	Dual variable for upper bound on line flow l.
$\underline{\mu}_l$	Dual variable for lower bound on line flow l.
θ_n	Voltage angle of bus n.
λ_n	Market Clearing Price at node n.
φ_l	Voltage phase adjustment of line l.
$\bar{\gamma}_i$	Dual variable for upper bound on FTR i.
$\underline{\gamma}_i$	Dual variable for lower bound on FTR i.
Δb_l	Susceptance adjustment of line l.

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I. INTRODUCTION

Decarbonizing the electricity sector requires fundamental changes in all areas, including generation, transmission, and demand [1]–[3]. The steep growth of intermittent energy sources and new technologies, including EV fleet and energy storage systems [4]–[6], have added to the complexity of this transition. More specifically, for the transmission sector, the flexibility factor is necessary for future upgrades in the face of the intermittency of renewable generation [7]–[9]. Therefore, expansion projects to build new transmission lines to accommodate the dispatch of deterministic generation to the load center are no longer sufficient [10]–[12]. Grid-enhancing technologies (GETs) mainly procure the transmission system flexibility, which offers several upgrades to the legacy transmission grid, including reliability upgrades, dynamic response, and voltage regulation [13]–[17]. From the environmental aspect, GETs have shown huge potential in reducing carbon emissions and increasing renewable energy adoption through increasing grid flexibility to cope with the intermittency of the renewables [18]–[20]. On the economic side, GET projects are on a smaller scale compared to bulk transmission projects and require shorter construction time and smaller investments. Therefore, the regulated rate of return compensation scheme, designed for large-scale projects falling under the economy of scale paradigm, is neither compatible nor competitive enough for such projects that must keep pace with the steep growth of renewables in generation and increased demand in the load centers [21], [22].

Alternative payment schemes to attract investors to GET implementation have been proposed in the literature [23]. The compensation schemes can be categorized into two groups based on the markets used to compensate the developer. The short-term schemes focus on spot markets, including day-ahead, real-time and intra-day markets [24]. These compensation schemes mainly seek to calculate payments based on the social welfare or generation cost reduction incurred by GET implementation in the energy market. The second approach focuses on long-term financial transmission rights (FTR) contracts and multi-interval FTR auctions to design compensation methods for developers [25]. FTR is a market mechanism the ISO allocates to hedge market participants against congestion risk in spot markets [26]. Each FTR is defined by injection and extraction nodes and quantity in MW. The FTR holder is entitled to collect the nodal price difference between injection and extraction points multiplied by the quantity, known as congestion rent, in the energy market. FTRs can further be traded in FTR auctions or secondary markets based on stakeholder risk and financial preferences. Fig. 1 shows the FTR functionality in electricity markets over various time horizons. Beyond hedging purposes, FTRs can incentivize merchant transmission projects compensated out of a regulated rate of return system [27]. Compensation for merchant transmission projects has been formulated using two approaches in the literature. The first approach allocates incremental FTRs to the developer while maintaining the simultaneous feasibility of previous and new FTRs through a bi-level optimization structure [28]. The second approach reimburses the developer by pricing the physical characteristics of each line, i.e., susceptance and capacity price [29]. The latter approach has the merit of simultaneous reimbursement of multiple merchant developers with less computational burden.

In this paper, we introduce a compensation mechanism for GETs based on pricing the physical nature of GETs adjustment. This approach is straightforward for GETs with linear adjustments. However, for GETs with nonlinear impact on the market model, such as variable-impedance FACTS devices, the increased computational burden becomes a major obstacle that can even undermine the merits of this approach.

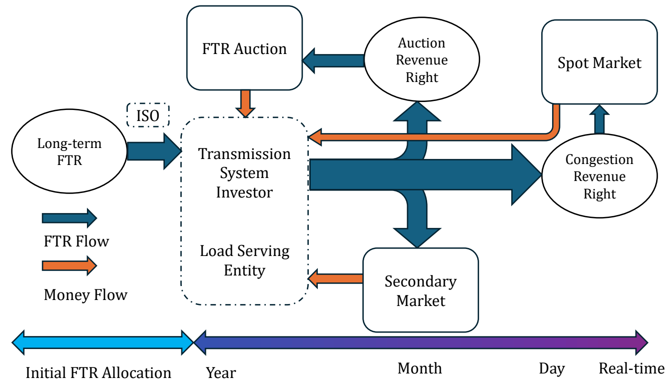

Fig. 1. FTR Markets Overview

Therefore, we first linearize the auction model in the presence of FACTS devices. Then, the payment will be derived from the developers based on the marginal value of the GET asset in the FTR auction. We illustrate the proposed mechanism on a stylized three-bus system and show the method's effectiveness on the IEEE 30-bus system.

II. Model Outline

To promote the financial opportunities of FTR contracts, ISO holds FTR auctions over various time horizons, including annual, seasonal, and monthly auctions. The auction aims to maximize the social welfare from FTR transactions while maintaining simultaneous feasibility and system limits. The auction is formulated as follows:

$$\text{Maximize} \sum_{i\in\mathcal{A}} B_i p_i^{FTR} \tag{1}$$

s.t.

$$\sum_{i\in\mathcal{B}} M_{n,i}^B P_i^B + \sum_{i\in\mathcal{A}} M_{n,i}^{FTR} p_i^{FTR} = \sum_{l\in\sigma^-(n)} f_l - \sum_{l\in\sigma^+(n)} f_l$$

$$(\lambda_n) \quad \forall n \in \mathcal{N} \tag{2}$$

$$f_l = b_l(\theta_n - \theta_m + \varphi_l) \qquad (s_l) \quad \forall l \in \mathcal{L} \tag{3}$$

$$-F_l^{max} - \Delta F_l \le f_l \le F_l^{max} + \Delta F_l \quad (\underline{\mu}_l, \bar{\mu}_l) \quad \forall l \in \mathcal{L} \tag{4}$$

$$-\varphi_l^{max} - \le \varphi_l \le \varphi_l^{max} \qquad (\underline{\beta}_l, \bar{\beta}_l) \quad \forall l \in \mathcal{K} \tag{5}$$

$$0 \le p_i^{FTR} \le \bar{P}_i^{FTR} \qquad (\underline{\gamma}_i, \bar{\gamma}_i) \quad \forall i \in \mathcal{A} \tag{6}$$

The objective function is to maximize the social welfare where it is formulated as the summation of bids (B_i) submitted by each party times the MW amount of FTR allocated through the auction process (p_i^{FTR}), as shown in (1). The bid is positive for purchasing parties and negative for selling parties. The simultaneous feasibility of FTRs and system margin constraints are formulated in (2)-(6). Equation (2) shows the node balance where the total power injection by FTRs equals the net power outflow from the node. The power injection is formulated using the mapping matrix $\mathbf{M}$ where the $M_{n,i}$ value is +1 for injection and -1 for the extraction node. M^B, P^B are used for long-term FTR owners who do not participate in the auction yet need to be considered in the simultaneous feasibility. The outflow and inflow for node n are shown with σ^- and σ^+ respectively. The line flow limits are formulated in DC format using the b-θ structure in (3)-(4), where b_l denots line susceptance and θ_n, θ_m line's "from" and "to" bus voltage angles. Finally, the maximum amount of FTR requested by each party is shown by $\bar{P}^{FTR}$ in (6). The dual variables are shown in front of each constraint. After clearing the linear auction, the payment to each line can be calculated using the capacity and susceptance marginal values and the flow induced by FTRs allocated through auction process as follows:

$$TP_l = CP_l + SP_l = (\lambda_m - \lambda_n) f_l^A \quad (7)$$

$$CP_l = (\bar{\mu}_l - \underline{\mu}_l) f_l^A \quad (8)$$

$$SP_l = s_l b_l = (\lambda_m - \lambda_n - \bar{\mu}_l + \underline{\mu}_l) f^A \quad (9)$$

$$f_l = f_l^0 + f_l^A \quad (10)$$

where the total payment for the congestion on the line (TP_l) is calculated by the MCP (λ) difference at the ends of the line, which can be split into line susceptance and capacity payment as in (12). The capacity and susceptance payments provide an interpretable link between the physical characteristics of the line and the payments to the right holders. The capacity and susceptance payments can be separately calculated using the marginal value derived from the auction dual variables as in (8) and (9), respectively. In payment calculations, the flow induced by base FTRs not participating in the auction should be subtracted from the total flow before multiplication in marginal values as in (10).

Calculating payments to the GET developers with linear adjustment is straightforward using the dual variables from the original auction problem (1)-(6). For the phase angle controllers the sensitivity can be directly calculated using s_l. Therefore, total payment to the phase angle controller can be calculated as follows:

$$GP_l = (\bar{\beta}_l - \underline{\beta}_l)\varphi_l = s_l b_l \varphi_l \quad (11)$$

where φ_l is the phase adjustment by the phase controller. with a similar approach total payment to the DLR developer can be calculated using the capacity sensitivity as in:

$$GP_l = (\bar{\mu}_l - \underline{\mu}_l)\Delta F_l \quad (12)$$

where the payment is calculated using the marginal value of DLR capacity adjustment ΔF_l. As mentioned, the original auction is a linear programming problem with well-defined dual variable values. However, after implementing impedance control, constraint (3) becomes nonlinear, making the whole problem computationally expensive NLP. To overcome the nonlinearity challenge, we rewrite constraint (3) based on the FACTS device's flow direction and maximum adjustment range as follows:

$$z_l\theta_n + (1 - z_l)\theta_m \geq z_l\theta_m + (1 - z_l)\theta_n \qquad \forall l \in \mathcal{K} \quad (13)$$

$$f_l \leq (z_l B_l^{max} + (1 - z_l)B_l^{min})(\theta_n - \theta_m) \qquad \forall l \in \mathcal{K} \quad (14)$$

$$f_l \geq (z_l B_l^{min} + (1 - z_l)B_l^{max})(\theta_n - \theta_m) \qquad \forall l \in \mathcal{K} \quad (15)$$

where z_l denotes the flow direction. If the voltage angle difference is positive then constraint (13) drives $z_l = 1$ and constraints (14)-(15) to positive flow constraints and vice versa for the negative angle difference. However, (13)-(15) contain bilinear terms and need to be reformulated with big-M method as follows:

$$z_l M + \theta_m \geq \theta_n \qquad \forall l \in \mathcal{K} \quad (16)$$

$$(1 - z_l)M + \theta_n \geq \theta_m \qquad \forall l \in \mathcal{K} \quad (17)$$

$$f_l \leq B_l^{max}(\theta_n - \theta_m) + (1 - z_l)M \qquad \forall l \in \mathcal{K} \quad (18)$$

$$f_l \leq B_l^{min}(\theta_n - \theta_m) + z_l M \qquad \forall l \in \mathcal{K} \quad (19)$$

$$f_l \geq B_l^{min}(\theta_n - \theta_m) - (1 - z_l)M \qquad \forall l \in \mathcal{K} \quad (20)$$

$$f_l \geq B_l^{max}(\theta_n - \theta_m) - z_l M \qquad \forall l \in \mathcal{K} \quad (21)$$

With this formulation, the auction problem becomes MILP, which does not have a well-defined dual due to binary flow variables z_l. However, this can be transformed into an LP problem after solving the initial auction problem (1)-(6) to fix the flow directions. For calculating the marginal value of susceptance adjustment, we first write the lagrangian for the FTR auction in the presence of FACTS devices (1)-(6),(16)-(19):

$$\begin{aligned}
\mathcal{L} = & -\sum_{i\in\mathcal{A}} B_i p_i^{FTR} + \sum_{n\in\mathcal{N}} \lambda_n (\sum_{i\in\mathcal{B}} M_{n,i}^B P_i^B + \sum_{i\in\mathcal{A}} M_{n,i}^{FTR} \\
& p_i^{FTR} - \sum_{l\in\sigma^-(n)} f_l + \sum_{l\in\sigma^+(n)} f_l) + \sum_{l\in\mathcal{K}} \underline{\alpha}_l^1 (B_l^{min}(\theta_n - \theta_m) \\
& - (1 - z_l)M - f_l) + \sum_{l\in\mathcal{K}} \underline{\alpha}_l^0 (B_l^{max}(\theta_n - \theta_m) - z_l M - f_l) \\
& - \sum_{l\in\mathcal{K}} \bar{\alpha}_l^1 (B_l^{max}(\theta_n - \theta_m) + (1 - z_l)M - f_l) - \sum_{l\in\mathcal{K}} \bar{\alpha}_l^0 \\
& (B_l^{min}(\theta_n - \theta_m) + z_l M) - \sum_{l\in\mathcal{K}} \beta_l^0 (\theta_n - \theta_m + (1 - z_l)M) \\
& + \sum_{l\in\mathcal{K}} \beta_l^1 (\theta_n - \theta_m - z_l M) + \sum_{l\in\mathcal{L}} \bar{\mu}_l (f_l - F_l^{max}) - \sum_{l\in\mathcal{L}} \underline{\mu}_l \\
& (F_l^{max} + f_l) + \sum_{i\in\mathcal{A}} \bar{\gamma}_l (p_i^{FTR} - \bar{P}_i^{FTR}) - \sum_{i\in\mathcal{A}} \underline{\gamma}_l p_i^{FTR}
\end{aligned} \quad (22)$$

where flow constraint dual variables are denoted by $\bar{\alpha}_l^1, \underline{\alpha}_l^1$ for the lines with positive flow directions ($z_l = 0$) and $\bar{\alpha}_l^0, \underline{\alpha}_l^0$ for lines with negative flow directions ($z_l = 0$). The nodal Market Clearing Prices (MCP) are denoted by λ_n and flow-enforcing constraint dual variables by β_l^0, β_l^1. Finally, the line capacity constraint dual variables, which can also be interpreted as line capacity prices, are denoted by $\bar{\mu}_l, \underline{\mu}_l$. The

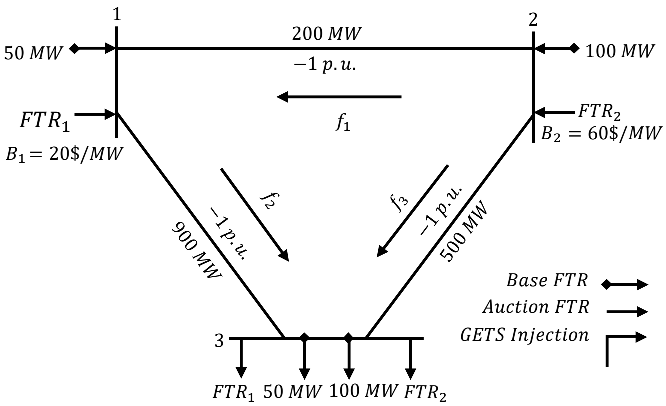

Fig. 2. Stylized 3-bus System

marginal value of susceptance adjustment can be calculated as follows for each adjustment direction:

$$\bar{s}_l = \frac{\partial \mathcal{L}^*}{\partial B_l^{max}} = \underline{\alpha}_l^0 - \bar{\alpha}_l^1 \tag{23}$$

$$\underline{s}_l = \frac{\partial \mathcal{L}^*}{\partial B^{min}} = \underline{\alpha}_l^1 - \bar{\alpha}_l^0 \tag{24}$$

where $\bar{s}_l, \underline{s}_l$ denote susceptance adjustment value in each direction. This value is equal to flow constraint dual variables. Based on the value of z_l, only one set of constraints are active and the dual variable has non-zero value which determines the susceptance adjustment value based on either $\bar{\alpha}_l^1, \underline{\alpha}_l^1$ or $\bar{\alpha}_l^0, \underline{\alpha}_l^0$ pairs. With the susceptance price derived the marginal value payment to FACTS developer can be derived based on the adjustment direction as follows:

$$GP = \bar{s}_l(B_l^{max} - B_l^0) + \underline{s}_l(B_l^{min} - B_l^0) \tag{25}$$

where B_l^0 denotes the line's original susceptance, which is used to derive the total adjustment in each direction and calculate the payment to the developer. It should be noted that based on the adjustment direction, only one of the prices is non-zero.

III. Illustrative Example

To illustrate the compensation scheme in section II, we employ the stylized 3-bus system in Fig. 2. Two interested parties bid for FTRs from bus 1 to bus 3 and bus 2 to bus 3, while the simultaneous feasibility must be maintained alongside 50 MW and 100 MW base FTRs in each direction.

After solving the auction in (1)-(6) for the base case without any GET implementation, results are indicated in table I. The first part of the table shows the amount of FTR allocated through the auction mechanism and the resulting nodal Market Clearing Prices (MCPs) followed by revenue collected from FTR bidders as in (12). The initial flow induced by the base FTRs, as well as flows from auction FTRs and the total flow for each line from (10), are shown in the second part of the table. Finally, the third part of the table shows the distribution

TABLE I
Auction results for base case

	λ_f (\$/MW)	λ_t (\$/MW)	Amount (MW)	Revenue (\$)
FTR_1	-20	0	50	1000
FTR_2	-60	0	600	36000
Total auction revenue (\$)		37000		
	$f^0(MW)$		$f^A(MW)$	$f(MW)$
$Line_{12}$	16.66		183.33	200
$Line_{13}$	66.66		233.33	300
$Line_{23}$	83.33		416.66	500
	$CP(\$)$		$SP(\$)$	$TP(\$)$
$Line_{12}$	3666		3666	7333
$Line_{13}$	0		4666	4666
$Line_{23}$	33333		-8333	25000
Total line payment (\$)		37000		

TABLE II
Auction results for with susceptance adjustment

	λ_f (\$/MW)	λ_t (\$/MW)	Amount (MW)	Revenue (\$)
FTR_1	-20	0	264.285	6285
FTR_2	-60	0	600	36000
Total auction revenue (\$)		41285		
	$f^0(MW)$		$f^A(MW)$	$f(MW)$
$Line_{12}$	27.08		172.92	200
$Line_{13}$	77.08		437.20	514.28
$Line_{23}$	72.92		427.08	500
	$CP(\$)$		$SP(\$)$	$TP(\$)$
$Line_{12}$	3458		3458	6916
$Line_{13}$	0		8744	8744
$Line_{23}$	37827		-17431	20396
GET Payment(\$)		5229		
Total line payment (\$)		36056		

of revenues from the FTR auction between the right holders on each line as the capacity payment (CP), susceptance payment (SP), and total payment (TP) calculated by marginal values of susceptance and capacity and related to each other by (12)-(9). The total line payment equals the total capacity payment and is fully covered by the total revenue collected from the FTR auction. The role of susceptance payments is to redistribute the payments based on the physical characteristics of each line and signal the need for compensation on each line. As it can be seen, the susceptance payment on $line_{23}$ is negative, which means the susceptance on this line is negatively affecting auction revenue by limiting the transfer capability of the system. Therefore, a fixed or variable susceptance compensator needs to enhance this line. The line owner or other stakeholders can enhance the line for marginal value payments. After implementing a variable-impedance FACTS device to adjust the susceptance with adjustment range of $\pm 0.3 p.u.$ on $line_{23}$ in return for a share of the auction revenue. The settlements obtained from (1)-(6),(13)-(19) with fixed binaries are summarized in table III.

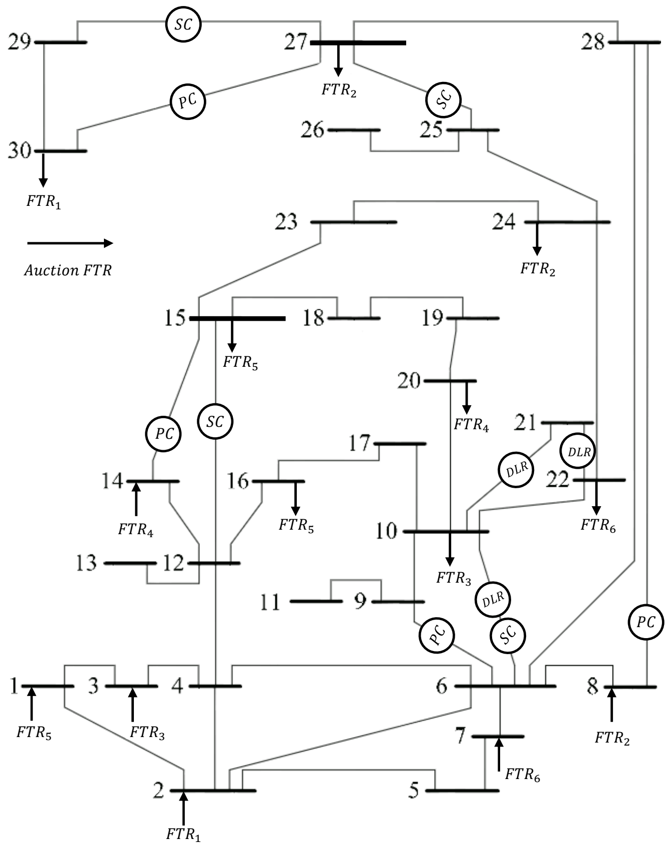

Fig. 3. Modified IEEE 30-bus system with FTRs

TABLE III
AUCTION RESULTS WITH GETS IMPLEMENTATION

	Bid ($/MW)	Base Amount (MW)	Base Revenue ($)	Amount (MW)	Revenue ($)
FTR_1	10	27.10	271.05	29.98	299.84
FTR_2	11	32.50	357.58	33.44	367.86
FTR_3	12.5	24.01	300.15	42.87	535.96
FTR_4	13	12.17	158.33	0	0
FTR_5	15	33.18	497.74	49.90	748.62
FTR_6	13.5	61.58	831.38	57.21	772.35
Total Revenue without GETs ($)			2416.26		
Total Revenue with GETs ($)			2724.26		

	SP ($)	CP ($)	TP ($)
Line Payments without GETs	0	2416.26	2416.26
Line Payments	0	2480.39	2480.39
DLR_{12}	0	51.47	51.47
DLR_{27}	0	6.57	6.57
DLR_{29}	0	6.57	6.57
SC_{12}	32.09	0	32.09
SC_{35}	0.22	0	0.22
SC_{18}	74.23	0	74.23
SC_{37}	0	0	0
PS_{11}	21.44	0	21.44
PS_{40}	1.05	0	1.05
PS_{20}	43.4	0	43.4
PS_{38}	7.22	0	7.22
Total Payment ($)		2724.65	

The variable-impedance FACTS installed on $line_{23}$ allows for 214.28 MW more flow to be redirected to $line_{13}$ with available capacity, therefore allowing 214.285 MW additional FTR_1 to be allocated in return for $4285 increase in auction revenue. The additional revenue, as well as the previous revenues, are distributed among right holders and the GET developer based on the updated marginal values as shown in the second part of table III. $5229 is paid to the GET developer for the compensation of susceptance on $line_{23}$, which has reduced the same amount from $line_{23}$. The total payment to $line_{13}$ has almost doubled to $8744 as the increased flow has been redirected through this line. Finally, The payment to $line_{12}$ has decreased as its fixed capacity and susceptance marginal value have declined due to surplus susceptance compensation on $line_{23}$. Therefore, this mechanism incentivizes line developers to invest in reinforcing the transmission system to maintain competition with merchant GET developers.

IV. IEEE 30-BUS SYSTEM

To further show the effectiveness of the proposed method we with a wider variety of GETs, we used the IEEE-30 bus system [30] to replicate an FTR auction how the GETs impact the auction results and how the developers get paid through the auction process. Dynamic Line Rating (DLR), voltage phase controller (PC), and series impedance controller (SC), all with an adjustment range of 10%, have been implemented to control various parameters of the grid, including line capacity, voltage phase angle, and line impedance. The system is shown in Fig. 3 with GET implementations and FTR requested directions. The first section of Table III shows the auction results for the base case without GETs and after GET implementation. GET implementation increases auction revenue from accepted FTR requests by 11.2% by allowing more FTRs to flow without violating simultaneous feasibility. Interestingly, the amount of FTR_6 decreased after GET implementation, allowing for more FTRs to be allocated to other stakeholders, which means that social welfare improvement by GETs is not aligned with a certain participant's benefit. Further, the nodal price difference decreases due to congestion relief, which leads to more competition in the transmission market above other benefits. The second section of the table shows the total payment to the line right holders and GET developers before and after GET implementation. GET implementation increases the line payment marginally due to increased flow in the grid and increased value of flowgates. As shown in the previous section, the total susceptance payment to the lines is zero. The role of susceptance payment is to redistribute capacity payments based on the marginal value of line susceptance and signal for the line fortification need. The payment to each GET developer is based on the type of adjustment and effectiveness of the implementation. DLR implementations are paid from the capacity price as they directly interact with the maximum amount of the flow gate. However, impedance controllers and phase shifters are paid a susceptance price according to their role of redistributing flow to flowgates with available transfer capability. The payments are based on the severity of the congestion on a line. The most effective implementations are DLR_{12} and SC_{12}, SC_{18}. This shows that line 12 is highly capacity-scarce. Therefore, both rerouting the flow and increasing the capacity are highly valuable. On the other hand, SC_{37} is installed on an uncongested line and, therefore, receives no payment for the susceptance adjustment. This shows the importance of market study before the commencement of a GET project. Finally, the total revenue collected from the approved FTRs equals the total payment to GET developers and line owners, which shows the revenue adequacy of the proposed method.

V. Conclusion

This paper introduces a revenue-adequate payment scheme to incentivize GET implementation through FTR auctions. The proposed method addresses both linear and nonlinear GET adjustments. The problem is first transformed into a MILP for the nonlinear GET adjustments. Then, the marginal values are calculated after fixing the binaries indicating flow directions on each line in the system. The payments are linked to the physical nature of each adjustment and ensure revenue adequacy as long as the flow directions are preserved. The results show the proposed method's effectiveness in incentivizing the effective implementation of GETs and increasing the auction revenues through congestion relief. Future research can be dedicated to studying the performance of the proposed method under changing flow directions and the calculation of possible uplift payments. Additionally, alternative schemes can be studied, including the allocation of incremental FTRs to GET investment.

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