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## ОПТИКО-ЕЛЕКТРОННІ ПРИСТРОЇ ТА КОМПОНЕНТИ В ЛАЗЕРНИХ І ЕНЕРГЕТИЧНИХ ТЕХНОЛОГІЯХ

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### ANALYSIS OF PROFIT OF GENERATION COMPANY IN POWER MARKET

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**Abstract.** In recent decades, the operation of power systems in the power market model has been researched and applied by many countries. The profit of generation companies is always interested in research to ensure operation and balance of power market. This paper studies and analysis profit of generation companies to participate in the power market. In addition, this paper has analyzed the participation of new generation in the power market with 39-bus IEEE power system.

**Keywords:** power market, generation company, optimal power flow.

#### BID AND AUCTION OF GENERATION COMPANIES IN THE POWER MARKET

In the day ahead market, GenCos and DisCos will submit quotations through market operation center. In the real-time power market, market operation (MO) operates power market and combines with system operation (SO) to dispatch power system [4, 5].

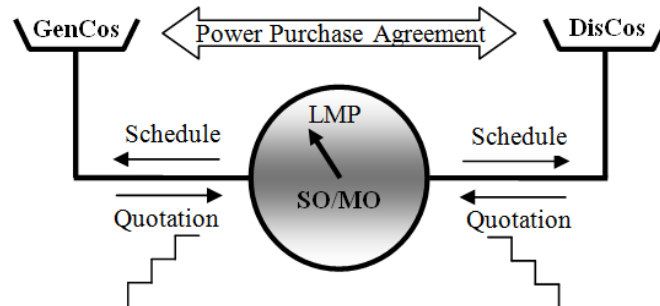


Figure 1. Bid and auction in the power market

#### LOCATIONAL MARGINAL PRICES IN POWER MARKET

The objective function in the optimal power flow of power market is a minimum objective function of operating cost in total [1, 2, 3]:

$$\min f(P_G) \quad (1)$$

Subject to  $G(P_G, Q_G, V, \theta) = 0 \quad (2)$

$$H(P_G, Q_G, V, \theta) \leq 0 \quad (3)$$

The Lagrangian function defined as:

$$L = f(P_G) + \lambda G(P_G, Q_G, V, \theta) + \mu H(P_G, Q_G, V, \theta) \quad (4)$$

Where  $f(P_G) = \sum_{i=1}^n f_i(P_G)$ : scalar, short-term operating cost, such as fuel cost;  
 $G(P_G, Q_G, V, \theta) = \sum_{i=1}^n g_i(P_G, Q_G, V, \theta)$ : vector, equality constraints, such as bus power flow balances (Kirchoff's laws);  $H(P_G, Q_G, V, \theta) = \sum_{i=1}^n h_i(P_G, Q_G, V, \theta)$ : vector, inequality constraints including limits of all variable;  $\lambda = \sum_{i=1}^n \lambda_i$ ,  $\mu = \sum_{i=1}^n \mu_i$ : the Lagrangian multipliers as sociated to (2) and (3).

Therefore, locational marginal price (LMP) at node i is three components included in the marginal price at reference node, marginal loss cost from reference node to node i and marginal congestion price from reference node to node i.

$$LMP_i = \pi_i = \lambda_{Ref} + \lambda_{Ref} \frac{\delta P_{Loss}}{\delta P_i} + \sum_{j=1}^n \mu_j \frac{\delta P_{ij}}{\delta P_i} = \lambda_{Ref} + \lambda_{Lossi} + \lambda_{Congestioni} \quad (5)$$

**CASE STUDY. TEST MODEL**

Table 1 and Figure 2 show parameters and diagram of IEEE 39-bus:

**Table 1.**

Data of GenCos					
GenCo	b (\$/MW)	c (\$/MW <sup>2</sup> )	Pmin (MW)	Pmax (MW)	
G <sub>30</sub>	6.9	0.019	100	350	
G <sub>31</sub>	3.7	0.011	100	1150	
G <sub>32</sub>	2.8	0.01	100	750	
G <sub>33</sub>	4.7	0.009	100	732	
G <sub>34</sub>	2.8	0.013	100	608	
G <sub>35</sub>	3.7	0.009	100	750	
G <sub>36</sub>	4.8	0.01	100	660	
G <sub>37</sub>	3.6	0.011	100	640	
G <sub>38</sub>	3.7	0.007	100	930	
G <sub>39</sub>	3.9	0.006	100	1100	

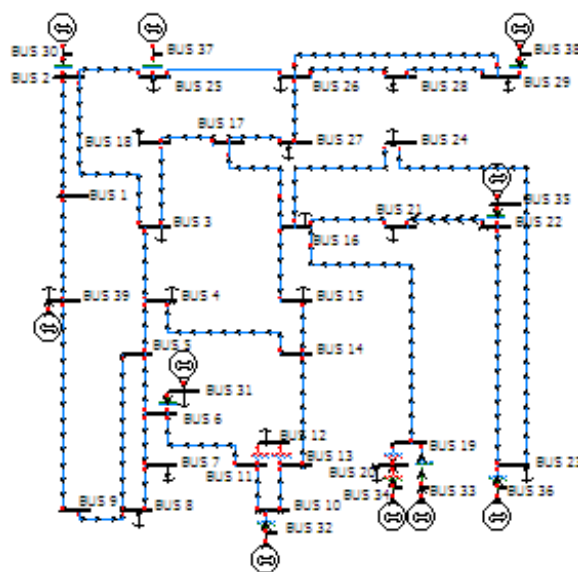


Figure 2. IEEE 39-bus power system

CALCULATION AND DISCUSSION

In Table 2, New GenCo ( $b=4\$/MW$ ,  $c=0.01\$/MW^2$ ) participates in the power market, it is connected to Bus 3. If there is no distinction, New GenCo will have benefit from the law of supply and demand of the market like any other member. New GenCo can actively earn profit by bidding strategy. Example, output capacity of New GenCo is 600MW, the profit of New GenCo is 3540\$/h.

Table 2.

Targets with New GenCo connect Bus 3

GenCo	P (MW)	LMP (\$/MWh)	Revenue (\$/h)	Charge (\$/h)	Profit (\$/h)
(1)	(2)	(3)	(4)=(2)*(3)	(5)=b.(2)+c(2) <sup>2</sup>	(6)=(4)-(5)
<b>G<sub>new</sub></b>	600	15.9	9540	6000	3540
<b>G<sub>30</sub></b>	250	15.9	3975	2913	1063
<b>G<sub>31</sub></b>	520	15.9	8268	4898	3370
<b>G<sub>32</sub></b>	620	15.9	9858	5580	4278
<b>G<sub>33</sub></b>	606	15.9	9629	6147	3482
<b>G<sub>34</sub></b>	506	15.9	8052	4752	3300
<b>G<sub>35</sub></b>	620	15.9	9858	5754	4104
<b>G<sub>36</sub></b>	548	15.9	8713	5633	3080
<b>G<sub>37</sub></b>	532	15.9	8459	5028	3430
<b>G<sub>38</sub></b>	930	15.9	14787	9495	5292
<b>G<sub>39</sub></b>	1077	15.9	17127	11163	5964
<b>Σ</b>	<b>6209</b>		<b>98726</b>	<b>61364</b>	<b>37363</b>

From Figure 3, survey with other cases, if New GenCo connect to Buses 3, 4, 7, 18 and 27, profit of New GenCo will be more efficient than the other cases.

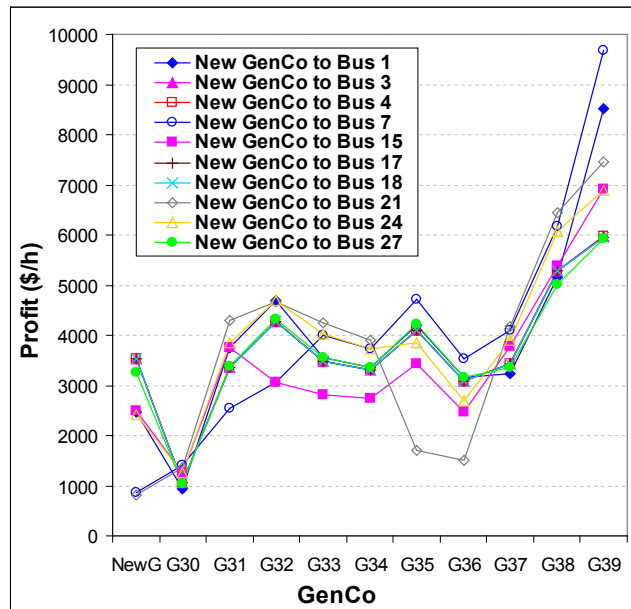


Figure 3. Profit of GenCos with connection cases of New GenCo

In addition, Figure 4 shows congestion profile at the branches that was significantly reduced when New GenCo connect to Buses 3, 4, 17, 18 and 27. If new GenCo connect to Bus 3 and 4, improvement of congestion at branches will be more efficient than the other cases. This congestion will affect the distribution of LMPs and profits as Figure 3.

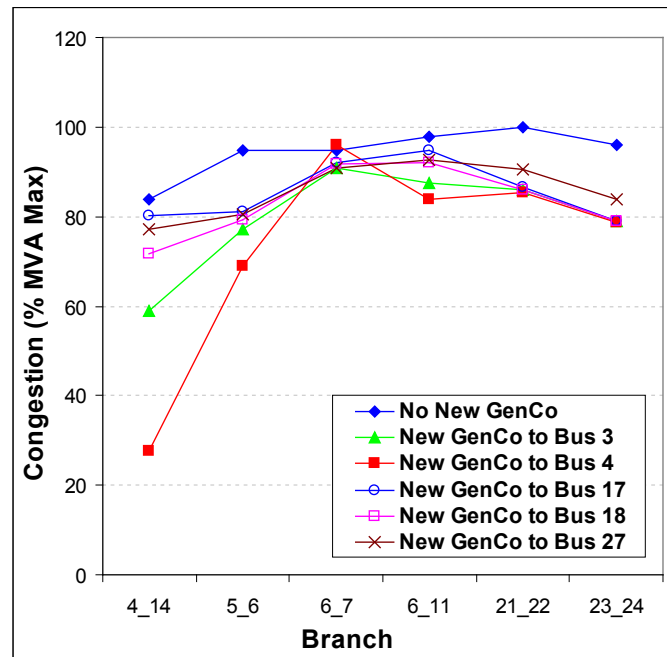


Figure 4. Congestion of branches with connection cases of New GenCo

In summary, If to participate in the power market, New GenCo will be profitable under market rules, the profits are vital and need special attention. This reflect the cost of GenCos in the transaction cycle, reflect the market price, increasing the transparency of the market.

Therefore, before implementing the investment project, the new generations should be carefully calculated building positions of power plant in the power systems, this will optimize the profits of the business, improve the safety and stability in the power system.

## CONCLUSION

This paper has focused on analyzing and assessing the profit of generation companies to participate in the power market. If the generations sign long- term contracts with power trading companies, they will encounter investment risks such as exchange rates, inflation ... However, this risk will lessen if generations participate in power market. Participating in the electricity market and knowing how to choose location for investment, to forecast load, to forecast LMP, to offer reasonable bid in the transaction cycle, the generations are able to control their profits.

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