An approach to Offer price (Generating station) arrival process through Game theory for the deregulated environment

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Abstract – *As all Pool participants use a price curve, rather than a cost curve, to exchange power. Participants consider market prices which maximize their benefits, while Pool coordinators try to maximize the system-wide benefits In a deregulated system, generation cost is treated as confidential; however, the spot price of electricity may be computed by searching for the minimum price offered in the market that satisfies load and generation constraints. Using constrained economic dispatch, Pool benefits will be maximized when all participants trade power at marginal cost*

***Key Words*: Gaming possibilities, Pool, Bids, Marginal cost, deregulated system, Pay off matrix.**

1. INTRODUCTION

This theory is the general theory of strategic behaviour. General depicted in mathematical form and Plays an important role in modern economics. Different economic situations are treated as games. The rules of the game state who can do what, and when they can do it. A player's strategy is a player for action in each possible situation in the game. A player's payoff is the amount that the player wins or losses in a particular situation in a game. A player has a dominant strategy if that player's best strategy does not depend on what other players do.

1.1 Game

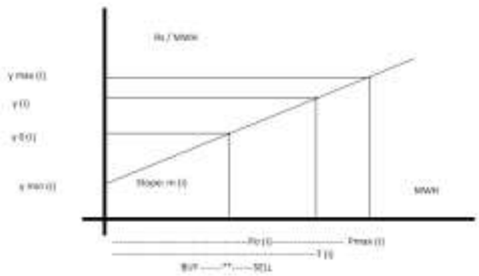

Fig. [1]: Price curve for Generators

When network losses are not considered, the spot price of electricity can be defined as $\rho = \partial C / \partial P_i$ for bus i in the Pool.

Where,

ρ Spot price of electricity

C Total generation cost and

P_i Generation level in bus i,

In a deregulated system, generation cost is treated as confidential and top secret; however, the spot price of electricity may be determined by searching for the minimum price offered in the market that satisfies load and generation constraints as this is very essential for the stability of power supply and open market conditions. Though the issue of power quality of the supplier may be neglected here

1.2 Strategies

Using constrained economic dispatch, Pool benefits will be maximized when all participants trade power at marginal cost, m (i)=2c(i). As participants try to maximize their own benefits, they may either decrease their bids in order to sell more power or increase the price in order to earn more.

(1) H- Trade power at 1.15 times the marginal cost,

m (i) = 2.3 c(i).

The participant's strategy is to bid high.

(2) M- Trade power at marginal cost,

m (i) = 2c (i)

The participant's strategy is to *cooperate with the Pool.*

(3)L- Trade power at 0.85 times the marginal cost,

m (i) = 1.7c (i)

The participant's strategy is to *b*id low*.*

Table -1: Assumed Generation Data

Gen.	**Bus** No.	Cost Coefficients			(MW)		Marginal power(MW)	Marginal Price(Rs/MWh)
		a(i)	b(i)	c(i)	Min	Max	Po(i)	λ_0(i)
A	1	0	2	0.022	0	75	23.5432	197.00
B	2	0	3	0.027	0	35	37.1234	325.00
C	3	0	1	0.066	0	45	21.5791	248.00

2. Generation of pay off matrix

The economic benefits of participant 'Eb' is expressed as Benefit

(Eb) =∑ ([a(i) + b(i)Po(i)+c(i)Po(i)^2]-[a(i)+b(i)P(i) + c(i)p(i)^2] + T(i).

Pay off AB =

(A-B)	H	M	L
HH	2724.039	2786.202	2870.133
HM	2711.034	2773.19	2857.121
HL	2693.46	2755.616	2839.547
MH	2715.389	2777.552	2861.483
MM	2702.385	2764.541	2848.472
ML	2684.811	2746.967	2830.897
LH	2703.705	2765.867	2849.798
LM	2690.693	2752.856	2836.787
LL	2673.119	2735.282	2819.213

After generating payoff matrix we apply max of min condition to payoff matrix to find optimal bidding.

Min AB = Rs2673.119 2735.282 2819.213

Maxmin AB = Rs/h 2819.213

OUTCOME:

Here utility A and B bid at marginal cost because the bid offers the highest benefit when other pool participant is minimizing the coalition's benefit (negative)

1. Game theory can be used to increase the benefits of participants.
2. From the results obtained, we foresee that in a perfect competition, all participants try to maximize their benefits by cooperating with the power pool to obtain the maximum system wide benefits.

The analysis may be used by Pool coordinators to identify non-competitive situations and to encourage pricing policies that lead to maximum system-wide benefits.

GAMING POSSIBILITIES

A Gaming Possibilities for Generator are as under.

Case 1: Generator over Declaring

Case 2: Generator under Declaring

B Gaming Possibilities of Load

Case 3: Load over Declaring

Case 4: Load under Declaring

Case 5: Load Shedding

Gaming Possibilities for Generator Regional Load Dispatch Center (RLDC) can ask to demonstrate this capacity in case it is not convinced. The generators can revise schedule 6 blocks ahead for planned outage and 4 blocks ahead for forced outage.

Case	Actual capacity	Declared capacity	Scheduled Capacity	Actual Generation	Loss	Gain	Comment
Generator Over declaring	100 MW	120 MW	110 MW	100 MW	UI for 10 MW at peak time taken as 8 blocks	Capacity charge on20 MW for whole day -96 blocks	Can be applicable to any load condition

Case 1: Generator over declaring

Actual capacity= 100 MW

Declared capacity= 120 MW

Scheduled capacity= 100 MW at peak time

Actual generation= 100 MW

Loss

= UI for 10 MW at peak time
= 10* 1000* (1/4)* 5.06* 8 (At freq. = 49.75 Hz UI rate
= 5.06 Rs)
= 1, 01,200 Rs / day (for 8 time block)

Gain

= Capacity charge on 20 MW for the whole day
= 20* 74*96 ⇒ 1, 42,080 Rs per day

Loss	Gain
UI=SI-AI =110-100=10 Incremental Fuel cost =1000Rs/MWH Length of time block in hours =1/4 UI rate = 5.32 Rs at freq. 49.75 Hz So, 10*1000*1/4*5.32*8 =1,06,400 Rs/ day.	Capacity charge = Rs 74/MW/15 Minute time block . For whole day = 96 blocks So 74*96*20 = 1,42,080. Rs/day

Net gain =1, 42,080 – 1, 06,400 = 36,400 Rs

COMMENT: It is observed that during off peak load periods generators should over declare its generation so that the gain can be maximized

Case	Actual capacity	Declared capacity	Scheduled Capacity	Actual Generation	Loss	Gain	Comment
Generator Under declaring	100 MW	90 MW	80 MW	100 MW	Capacity charge for 10 MW for whole day -96 blocks	UI for 10 MW for at peak time taken as 8 blocks	Can be applicable to peak load condition

Case 2: Generator under declaring

Actual capacity = 100 MW

Declared capacity = 90 MW

Scheduled capacity = 80 MW at peak time

Actual generation = 100 MW

Loss

= Capacity charge on 10 MW for the whole day
= 20* 96*74 ⍰ 1, 42,080 Rs per day

Gain

= UI for 20 MW at peak time
= 20* 1000* (1/4)* 5.32* 8 (At freq = 49.75 Hz UI rate = 5.32 Rs)
= 212,800 Rs / day (for 6 time block)

= Net gain =2, 202,040 – 1, 42,080 = Rs. 70,000 Rs

COMMENT: To gain an advantage, the generators should under declare during peak load periods and they should over declare during off peak load periods.

Case 3: Load over declaring

Actual cap = 100 MW, Scheduled cap. = 120 MW at peak time

Loss

= Energy charges on 20 MW during peak hours

= 20* 1000* (1/4)* 6*0.75 (Peak load for 6 time block)

= 22,500 Rs / day(Energy charges 0.75 Rs/kwh))

Gain

= UI for 20 MW at peak time
= 20* 1000* (1/4)*4.00* 6 (assuming f = 49.44 Hz UI rate = 4 Rs)
= 1, 20,000 Rs per day

Net gain =1, 20,000 – 22,500 = 97,500 Rs

Case 4: Load under declaring

Actual capacity = 100 MW

Scheduled capacity= 90 MW

There are two times on gains

Gain

= Energy charges on 10 MW during off peak hours
= 10* 1000* (1/4)* 6*0.75 (Under declaring for 6 time block)
= 11,250 Rs / day(Energy charges 0.75 Rs/kwh))

Loss

= UI for 10 MW at off peak time for over drawal
= 10* 1000* (1/4)*1.00* 6 (At freq. = 50.16 Hz UI rate
= 1 Rs)
= 15,000 Rs per day (for 6 time block)

Net Loss =11,250 - 15,000 = 03,750 Rs

Case 5: Load shedding

Load demand = 100 MW

Scheduled load = 90 MW

Actual load supplied = 90 MW

(Load shedding of 10 MW at peak time)

Gain

= UI for 10 MW at peak time
= 10* 1000* (1/4)*4.00* 6 (assuming f = 49.44 Hz UI
= rate = 4 Rs)
= 60,000 Rs per day (for 6 time block)

Net gain =60,000 Rs.

COMMENT: To gain an advantage, the load should over declare during peak load periods and they should under declare during off peak load periods. Load shedding during peak load periods is also a possible option.

Mechanisms to Prevent Gaming

- Supervising and enforcement of generation availability may be accomplished through auditing plant records and conducting unannounced tests.

- If a unit fails to reach the level of availability which was declared by the plant operator, the capacity charges should be reduced to cover the actual availability for that day.

- The capacity charges should stay reduced until a higher availability can be demonstrated.
- If a unit fails in an availability test, severe penalty should be imposed, possibly retro- active for some period.

General Game Theory for ABT

Over declaration to increase fixed charges and rate of return Under declaration to increase unscheduled interchange charges

a) Game theory is the general theory of strategic behavior.
b) General depicted in mathematical form.
c) Plays an important role in modern economics
d) Economic situations may be treated as games.
e) The rules of the game state who can do what, and when they can do it.
f) A player's strategy is a player for action in each possible situation in the game.
g) A player's payoff is the amount that the player wins or losses in a particular situation in a game. A player has a dominant strategy if that player's best strategy does not depend on what other players do.

REFERENCES

[1] Bhanu Bhushan, (Power Grid Corporation of India Limited) and Anjan Roy, and P. Pentayya (Western Regional Load Despatch Centre), "The Indian Medicine " IEEE PES General Meet, 2004

[2] Bhanu Bhushan, (CERC, India), "The Indian Medicine" CIGRE 2005, 21, rue d'Artois, F-75008, PARIS.

[3] Bhanu Bhushan "ABC of ABT - A Primer On Availability Tariff " June 2005

[4] Sushilkumar Soonee, S.Ramesh Narasimhan and Vivek Pandey, "Significance of Unscheduled Interchange Mechanism in the Indian Electricity Supply Industry" ICPSODR-2006, Department of Electrical Engineering, ITBHU.

[5] Ashkan Kian and Ali Keyhani, "Stochastic Price Modelling of Electricity in Deregulated Energy Market" IEEE, 34th Hawaii International Conference on System Science-2001 - 0-7695-0981-9/01 2001

[6] Javier Contreras and Tomás Gómez," Auction Design in Day-Ahead Electricity Markets (Republished) "IEEE Transactions, Power Systems, Vol. 16,pp. 88-96, August 2001.

[7] Claudia P. Rodriguez and George J. Anders , "Bidding Strategy Design for Different Types of Electric Power Market Participants" IEEE Trans, Power Systems, Vol. 19, pp.964-971, May 2004

[8] N.Vaitheeswaran and R.Balasubramanian, "Stochastic Model for Optimal Declaration of Day Ahead Station Availability in Power Pools in India," IEEE Trans, power system, vol.20, pp.701-708, June 2006.

[9] R.W.Ferrero, S.M.Shahidehpour and V.C.Ramesh" Transaction Analysis In Deregulated Power Systems Using Game Theory". IEEE Transactions on Power Systems, Vol. 12, No. 3, August 1997.

[10] Vasileios P. Gountis and Anastasios G. Bakirtzis, "Bidding Strategies for Electricity Producers in a Competitive Electricity Marketplace" IEEE Transactions On Power Systems, Vol. 19, pp.356-365, February 2004.

[11] R.M.Holmukbea, Ms.Yogini Pawar", R.S.DesaiC, T.S.Hasarmanid "Availability Based Tariff and Its Impact on Different Industry Players-A Review" Pune, India.