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

When network losses are not considered, the spot price of electricity can be defined as \( p = \frac{\partial C}{\partial P_i} \) for bus \( i \) in the Pool.

Where,

- \( p \): 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, \( m(i) = 2.3c(i) \).

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 bid low.

Table 1: Assumed Generation Data

<table>
<thead>
<tr>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1</td>
<td>( a(i) )</td>
<td>( b(i) )</td>
<td>( c(i) )</td>
<td>Min</td>
</tr>
<tr>
<td>B</td>
<td>2</td>
<td>2</td>
<td>0.022</td>
<td>75</td>
<td>23.5432</td>
</tr>
<tr>
<td>C</td>
<td>3</td>
<td>0.066</td>
<td>35</td>
<td>35</td>
<td>37.1234</td>
</tr>
</tbody>
</table>

2. Generation of pay off matrix

The economic benefits of participant ‘Eb’ is expressed as Benefit

\( (Eb) = \sum ([a(i) + b(i)P(i) + c(i)P(i)^2] - [a(i) + b(i)P(i)] + c(i)P(i)^2]) + T(i) \).
Pay off AB =

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

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

Min AB = Rs2673.119
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 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

Net gain = 1,42,080 – 1,01,200 = 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 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 = 2,202,080 - 1,42,080 = Rs. 2,77,000 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)
= 120,000 Rs per day (for 6 time block)

Net gain = 120,000 - 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 = 3,750 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**


