Optimal Bidding Strategy in Deregulated Environment

K.Vijaya Kumar, M.Lakshmi Prasanna
SRM University, Chennai

ABSTRACT

In this paper, particle swarm optimization algorithm is proposed to determine the optimal bidding strategy in competitive auction market. The market includes generating companies (Gencos), large consumers who participate in demand side bidding, and small consumers whose demand is present in aggregate form. By using previous bidding data and multi-round auction process, the optimal bidding strategy for both Gencos and large consumers is obtained. Test results indicate that the proposed algorithm converge much faster and more reliable than Monte Carlo Simulation algorithm.

***Key words*: electricity auction market, particle swarm optimization algorithm, optimal bidding**

i. INTRODUCTION

Deregulated power system structures means all major tasks (Generation, Transmission and Distribution) are unbundled. Deregulation has paved the ways for private players to emerge and also it brings competitiveness among the existing companies. Generation is done by Generation companies (GENCOs).e.g., NTPC, NHPC, DVC, NPCIL, Tata Power etc. Transmission is done by Transmission companies (TRANSCOs).e.g., PGCIL Distribution is done by Distribution companies (DISCOs).e.g., State electricity boards. Now days we are using deregulated structure of power system in earlier days we were using regulated structure where all tasks were performed by same utility companies. Clearly we can see that the regulated structure of power system was not efficient and effective that's why we switched to deregulated PS structure The reasons for change have been many and have differed over regions and countries. For developing countries, the main issues have been a high demand growth coupled with inefficient system management and irrational tariff policies. This has affected the availability of financial resources to support investments in improving generation and transmission capacities. In such circumstances, many utilities were forced to restructure their power sectors under pressure from international funding agencies. In developed countries, on the other hand, the driving force has been to provide electricity at lower prices and offer them a greater choice in purchasing economic energy. The goal of changing the way of operation, i.e. re-regulation, or deregulation, as we say, is to enhance competition and bring consumers new choices and economic benefits. Under Deregulation, the former vertically integrated utility, which performed all the functions involved in power, i.e. generation, transmission, distribution and retail sales, is dis-aggregated into separate companies devoted to each function.

a)"OVERVIEW OF A DEREGULATED INDUSTRY"

Disaggregation of traditionally vertically integrated utility One of the principal characteristics of a competitive structure is the identification and separation of the various tasks which are normally carried out within the traditional organization so that these tasks can be open to competition whenever practical and profitable. This process is called *unbundling*. An unbundled structure contrasts with the so-called vertically integrated utility of today where all tasks are coordinated jointly under one umbrella with one common goal, that is, to minimize the total costs of operating the utility. One of the first steps in the restructuring process of the power industry has been the separation of the transmission activities from the electricity generation activities. The subsequent step was to introduce competition in generation activities, either through the creation of power pools, provision for direct bilateral transactions or bidding in the spot markets. On the other hand, the transmission system having significant economies of scale consequently had a tendency to become a monopoly. While in many instances, it started with the breaking up of a large vertically integrated utility, in certain other instances restructuring was characterized by the opening up of small municipal monopolies to competition. In brief, Electric utilities are expected to split apart into unbundled companies, with each utility re-aligning itself into several other companies that respectively focus on each part of the new industry, i.e., power delivery and retailing. This is known as Disaggregation. Under deregulation, the vertically integrated utility, one giant company that generates, transmits, distributes and sells electricity in coordinated manner will become thing of the past. To function in an open access system, such utilities will have to rearrange their operational organization to match the unbundled functions they must perform. Each part of the company will need to work in its new form. Generation will have to compete in the competitive power generation market place. T & D will have to operate as an open provider of delivery services. Competition will be present in retailing.

Generally, the governments advocating deregulation want competition in energy production, and they want to see significant levels of customer choice in the retail market for electricity. At the same time, it recognizes that it is best to have only one transmission and one distribution system in any one area. Therefore, the purpose of deregulation is to restructure the electric industry so that power production and retail sales are competitive, while delivery is still a regulated, monopoly franchise business.

Structure of deregulated industry Figure shows the typical structure of a deregulated electricity system with links of information and money flow between various players.

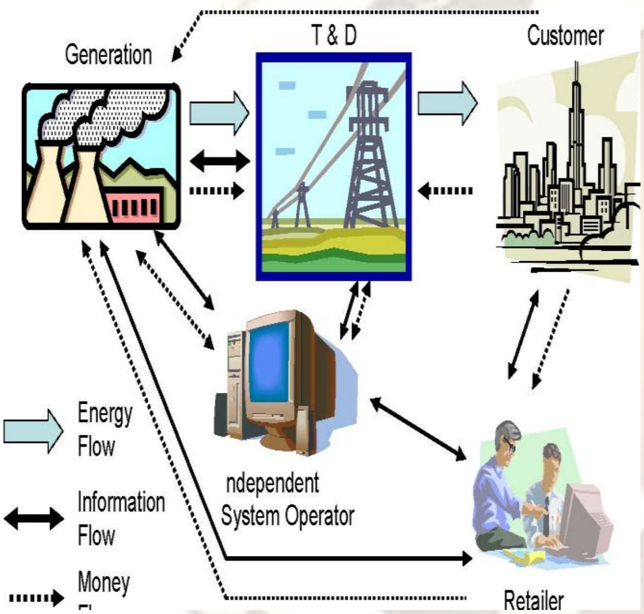

Figure 1: Typical structure of a deregulated electricity system

The configuration shown in the figure is not a universal one. There exist variations across countries and systems.

A system operator is appointed for the whole system and it is entrusted with the responsibility of keeping the system in balance, i.e. to ensure that the production and imports continuously match consumption and exports. Naturally, it was required to be an independent authority without involvement in the market competition nor could it own generation facilities for business. This system operator is known as Independent System Operator (ISO).

Referring to figure, there is no change as compared to figure so long as energy flow is concerned. Customer does its transactions through a retailer or transacts directly with a generating company, depending on the type of a model.

Different power sellers will deliver their product to their customers (via retailers), over a common set of T & D wires, operated by the independent system operator (ISO). The generators, T & D utility and retailers communicate ISO. Mostly, customer communicates with the retailer, demanding energy. The retailer contacts the generating company and purchases the power from it and makes it transferred to its customer's place via regulated T & D lines. The ISO is the one responsible for keeping track of various transactions taking place between various entities.

In the regulated environment, the electricity bill consisted of a single amount to be paid towards the generation, transmission and all other costs. But, in the restructured environment, the electricity price gets segregated into the following:

1 Price of electrical energy
2 Price of energy delivery (wheeling charges)
3 Price of other services such as frequency regulation and voltage control, which are priced separately and charged independently but may or may not be visible in the electricity bills.

b)"DIFFERENTENTITIESINDEREGULATEDENVIRONMENT."

The introduction of deregulation has brought several new entities in the electricity market place, while on the other hand redefining the scope of activities of many of the existing players. Variations exist across market structures over how each entity is particularly defined and over what role it plays in the system. However, on a broad level, the following entities can be identified as shown in the figure

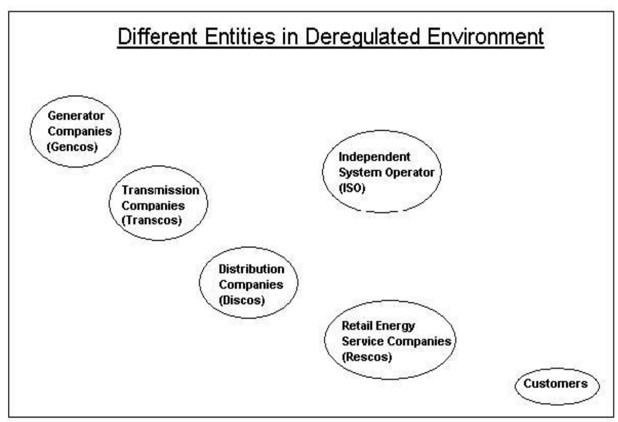

Figure 0-2: Different Entities in Deregulated Environment

1 Genco (Generating Company): Genco is an owner-operator of one or more generators that runs them and bids the power into the competitive marketplace. Genco sells energy at its sites in the same manner that a coal mining company might sell coal in bulk at its mine.

2 Transco (Transmission Company): Transco moves power in bulk quantities from where it is produced to where it is delivered. The Transco owns and maintains the transmission facilities, and may perform many of the management and engineering functions required to ensure the system can continue to do its job. In most deregulated industry structures, the Transco owns and maintains the transmission lines under monopoly franchise, but does not operate them. That is done by Independent System Operator

3 Disco (Distribution Company): It is the monopoly franchise owner-operator of the local power delivery system, which delivers power to individual businesses and homeowners. In some places, the local distribution function is combined with retail function, i.e. to buy wholesale electricity either through the spot market or through direct contracts with gencos and supply electricity to the end use customers..

4 Resco (Retail Energy Service Company): It is the retailer of electric power. Many of these will be the retail departments of the former vertically integrated utilities. Others will be companies new to the electric industry that believes they are good at selling services. Either way, a resco buys power from gencos and sells it directly to the consumers.

5 Independent System Operator (ISO): The ISO is an entity entrusted with the responsibility of ensuring the reliability and security of the entire system. It is an independent authority and does not participate in the electricity market trades. It usually does not own generating resources, except for some reserve capacity in certain cases.

Customers: A customer is entity, consuming electricity. In deregulated markets, the customer has several options for buying electricity. It may choose to buy electricity from the spot market by bidding for purchase, or may buy directly from a genco or even from the local distribution company.

The competition in a deregulated environment, two levels of competition exist, rather, encouraged. The gencos bid their power at the marketplace so as to maximize their profits.

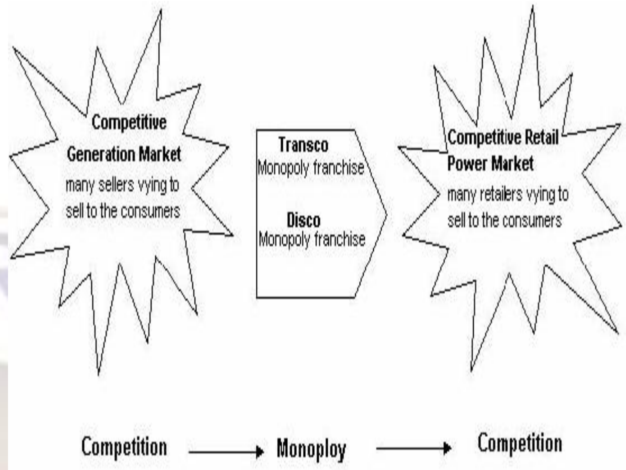

Figure 0-1: The competition

c)"THE WHOLESALE POWER MARKETPLACE":

In order for a deregulated power industry to work well, apart from the entities discussed earlier, two additional entities or functions must be created:

System Operation: The transmission system can move power from seller's site to the buyer's locations, but it must be kept under proper control on a real time basis.

Both of these functions must be accomplished in one form or another in every deregulated electric power industry. Both require objectivity and equality of operation towards all competitors. None of the competitive companies involved (Gencos, Rescos) can possibly serve either of these roles. System operation can be accomplished by Transco's and Discos, under some types of deregulated structure, but the power market is a concept that was completely unfamiliar to the power industry prior to deregulation. For this reason, deregulation usually requires that one or more new entities be created in one form or another.

d)"MARKET CLEARING PRICE"

Energy auction and competitive bidding in a competitive electricity market, the sellers and buyers submit bids for energy buy and sell. The bids are generally in the form of price and quantity quotations and specify how much the seller or buyer is willing to buy or sell and at what price. After the bids are available to the market operator, it settles the market based on some criteria. Once the market is cleared, all selling participants receive a uniform price for their power delivered, i.e., the market price from the buying participants. In case of an auction, where all winning bidders are offered the same price without discrimination, and regardless of their individual bid, is known as non-discriminated or second price auction. This is usually, the price of the highest priced bid that is cleared in the market. On the other hand, in a discriminated auction or first price auction, all bidders are not offered the same price after the market is settled. The bidders get the price that they had actually bid for, in the first place. A disadvantage of this system is that, it can give rise to gaming opportunities for the participants thereby providing ample scope for over-bidding and pushing up the market clearing price. Once the buyer and seller bid the amount of energy and the price, the power exchange forms an aggregate supply bid curve for suppliers and aggregate demand bid curve for consumers. The curves are plotted on the coordinates of, supply and demand energy and price as shown in the figure.The point of intersection of the two curves determines the market-clearing

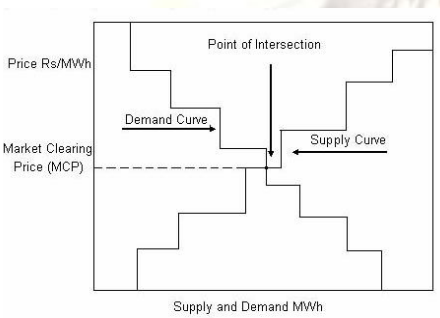

Fig 1.Market Equilibrium Point

The MCP is the price of electric energy that is paid by consumers at all the places. The sellers are also paid the price equal to the MCP. Consider the power exchange auction. MCP is the highest sell bid or lowest buy bid accepted in the auction. Thus, a seller is certain he will be paid no less than its cost of production if he bids its marginal cost, and may be paid more. If a seller bids less than his marginal cost, he would lose money because his bid may set the MCP. If he bids more than his marginal cost, he may bid more than other sellers and fail to be selected in the auction. If the seller's bid sets the MCP then he would recover his running cost and if the MCP is higher than his marginal cost, then he would earn profit or contribution to fixed cost. Buyer itself makes similar considerations.

II.OPTIMAL BIDDING STRATEGY

Power system deregulation is designed to allow competition among market participants, leading to a higher efficiency. In general, oligopoly market model is used to represent the competitive electricity market behavior, which is dominated by large sellers whose decisions affect the market price. For inelastic demand, dominant sellers can use a strategy to raise their supply curve and increase the market price to gain a higher profit. This ability is called market power. The objective of the firms in oligopoly market is to maximize its own profit and this lead to the optimal bidding strategy problem. There are many ways to find the optimal bidding strategy. In, Monte Carlo Simulation was used to find the optimal bidding strategy. It repeatedly calculates the optimal bidding strategy for one player with randomly opponent bidding. The average of bidding parameter was calculated to be the optimal strategy. In Reinforcement Learning was used to find the optimal bidding strategy. In this method, artificial agent will decide what price should be bidden in the next round of auction corresponding to load forecast and previous experience. If the agent has enough learning, decision of the agent is called the optimal bidding strategy. In, particle swarm optimization algorithm was used to find the optimal bidding strategy in the auction market.

a)"Major Responsibilities of ISO"

The independent system operator (ISO) is the central entity to have emerged in all deregulated markets with the responsibility of ensuring system security and reliability, fair and equitable transmission tariffs and providing for other system services. With differing market structures evolving in various countries, it has been noticed that based on the responsibilities assigned to them and their functional differences, ISOs could be placed in two categories. The first and the most common one is the pool structure in which the ISO is responsible for both market settlement including scheduling and dispatch, and transmission system management including transmission pricing, and security aspects. Here, ISO is also known as Poolco Operator. In this system, bulk of the energy transactions are directly organized between the generator and the customer, and the ISO has no role in generation scheduling or dispatch and is only responsible for system operation. The role of ISO is minimal and limited to maintenance of system security and reliability functions. In any market structure, the ISO has following basic functions laid out for it:

System security: Operator must assure that the power system continues to operate in a stable, economical manner.

b)"MARKET STRUCTURE":

Market structure used consists of m number of sellers or IPP and n number of large consumer. These two groups of market participant submit linear demand and supply curves to power exchange

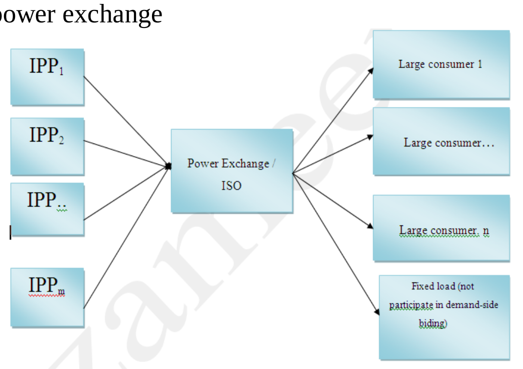

Fig 2.Market power

(PX) and try to maximize its profit by developing an adaptive strategy. This market also includes aggregated load model for small consumers whose consumption is not varied by market price. The aggregate load is represented by $Q=Q_0-KR$ when K is the price elasticity of small customer.

The objective of IPP is to maximize its profit. Suppose the power producer i has cost function denoted by $C_i(P_i)=e_iP_i+f_iP_i^2$ and market use uniform pricing scheme. The objective of power producer can be defined as:

$$\text{Max } F_i(a_i, b_i)=RP_i - C_i(P_i) \quad (1)$$

Similarly, the objective of large consumer is to maximize its benefit. Suppose the large consumer j has revenue function denoted by $B_j(L_j)=g_jL_j-h_jL_j^2$.The objective of large consumer can be defined as:

$$\text{Max } F_i(c_i, d_i)= B_j(L_j)-RL_j \quad \mathbf{(2)}$$

Subject to power balance constraint neglecting loss:

$$\sum_{i=1}^{m} P_i = Q + \sum_{j=1}^{n} L_j \quad (3)$$

Where $P_i = \dfrac{R-a_i}{b_i}$ fors upply curve (4)

$L_j = \dfrac{c_j - R}{d_j}$ for demand curve (5)

Power generation and consumption limit constraints:

$$P_{\min,i} \le P_i \le P_{\max,i} \quad (6)$$

$$L_{\min,j} \le L_j \le L_{\max,j} \quad (7)$$

Market clearing price (MCP) is determined from (3), (4) and (5)

$$R = \frac{\sum_{i=1}^{m} \frac{a_i}{b_i} + \sum_{j=1}^{n} \frac{c_i}{d_i}}{K + \sum_{i=1}^{m} \frac{1}{b_i} + \sum_{j=1}^{n} \frac{1}{d_i}} \quad (8)$$

Using R from (8) in (4) and (5), if P_i or L_j is below its limit, remove that generator or consumer from the system and calculate R again. Similarly, if P_i or L_j is greater than its limit, set P_i or L_j at its upper limit and calculate R again by ignoring that generator or consumer since it is no longer a marginal unit. Continue this process until all power produced and consumed by each firm is within the limit, MCP is finally obtained. It is clear that market participants can set MCP at the level that returns the maximum profit to them if they know bidding strategy of other firms. But in sealed bid auction based electricity market, information for the next bidding period is confidential in which IPPs and large consumers cannot solve optimization problem (1) and (2)directly.. However, bidding information of previous round will be disclosed after ISO decide MCP and everyone can make use of this information to strategically bid for the next round of auction.

c)"PROBLEM FORMULATION"

The optimal bidding problem is defined as maximizing the profit of every committed generators and loads
n-total no of plants.
P_i Generation / Load of 'i'th plant.

$$F_i = R * P_i - (e_iP_i + f_iP_i^2)$$

Where $K * R = Q_0 - \sum_{i=1}^{n} P_i$

The total profit of all plants is to be maximized so the problem is defined like this
Maximize

$$F = R * \sum_{i=1}^{n} P_i - \sum_{i=1}^{n} (e_iP_i + f_iP_i^2) \quad (9)$$

Subject to the constraints (7)

$Q_o - \sum_{i=1}^{n} P_i - K * R = 0,$

and the limits.

For generators $P_i^{min} \le P_i \le P_i^{max}$

For loads $-P_i^{max} \le P_i \le -P_i^{min}$

Solution procedure

1. The loads are considered as negative generators.
2. The maximization problem is converted as a minimization problem.

Minimize

$$-F = -R * \sum_{i=1}^{n} P_i + \sum_{i=1}^{n} (e_i P_i^2 + f_i P_i)$$

Subject to the constraints

$$Q_o - \sum_{i=1}^{n} P_i - K * R = 0,$$

and the limits.

For generators $P_i^{min} \le P_i \le P_i^{max}$

For loads $-P_i^{max} \le P_i \le -P_i^{min}$

3. The R value is taken as constant.R is 16.35.

For comparison, the case study is taken from. The problem consists of 6 IPPs who supply electricity to aggregate load and 2 large consumers. The generator and large consume data are shown in given below table. Q_0 is 300 and K is 5

GENERATOR LARGE CONSUMER DATA:

IPP no	e	f	P_{min}	P_{max}
1	6.00	0.01125	40	160
2	5.25	0.0525	30	130
3	3.0	0.1375	20	90
4	9.75	0.02532	20	120
5	9.0	0.075	20	100
6	9.0	0.075	20	100
Con no.	**g**	**h**	**L_{min}**	**L_{max}**
1	30	0.04	0	200
2	25	0.03	0	150

iii)*GENETIC ALGORITM BASED BIDDING STRATEGY*

1. [Start] Generate random population of n chromosomes
2. [Fitness] Evaluate the fitness f(x) of each chromosome x in the population
3. [New population] Create a new population by repeating following steps until the new population is complete

3.1. [Selection] Select two parent chromosomes from a population according to their fitness (the bigger fitness, the higher chance to be selected)

3.2. [Crossover] With a crossover probability, crossover parents to form new off springs (children). If no crossover is performed, offspring is the exact copy of parents.

3.3. [Mutation] With a mutation probability, mutate new offspring at each locus (position in chromosome).

3.4. [Accepting] Place new offspring in the new population

4. [Replace] Use new generated population for a further run of the algorithm
5. [Test] If the end condition is satisfied, stop, and return the best solution in current population
6. [Loop] Go to step 2

In this paper, genetic algorithm is applied by using Genetic Algorithm Toolbox which is one of MATLAB toolboxes developed by Math Works,. For this application, it need proper input objective function to find optimal solution when the parameter such as size of population, number of generation, crossover fraction, etc can be controlled through "gaoptiomset function" in toolbox. Auction is an important mechanism to make a transaction between suppliers and consumers. With the proposed algorithm, market is efficient because the valuation of electric is widely known. In fact, the valuation may be known from trade paper, daily newspaper or online communication service. Players will consider their status whether current profit is acceptable or not. If any players deem that they can gain more profit, they can make a new round of auction. This process will continue until nobody wants to change their bid

Agent will determine its optimal bidding strategy based on the latest bidding information. In this proposed algorithm, agent will expect certain profit if other players do not change their strategy. But other players may change their strategy, so the real profit those agents receive may differ from the expected one. If the changes in strategy of any players reduce profit that the agent will receive; the difference between exact-profit and expected-profit will be negative and agent will need to change their bid to handle the affected strategy. On the other hand, if changing of opponent strategy contributes to agent's current strategy, the difference between real-profit and expected-profit will be positive and agent will not be interested in changing the bid. For this case, expected profit for the next round should be higher than the current expected-profit but less than current exact-profit.

iv)*PSO BASED BIDDING STRATEGY*:

PSO an Optimization Tool:

Particle swarm optimization (PSO) is a population based stochastic optimization technique developed by Dr. Ebehart and Dr. Kennedy in 1995, inspired by social behavior of bird flocking or fish schooling. PSO shares many similarities with evolutionary computation techniques such as Genetic Algorithms (GA). The system is initialized with a population of random solutions and searches for optima by updating generations. However, unlike GA, PSO has no evolution operators such as crossover and mutation. In PSO, the potential solutions, called particles, fly through the problem space by following the current optimum particles. The detailed information will be given in following sections. Compared to GA, the advantages of PSO are that PSO is easy to implement and there are few parameters to adjust. PSO has been successfully applied in many areas: function optimization, artificial neural network training, fuzzy system control, and other areas where GA can be applied.

Algorithm of PSO:

PSO simulates the behaviors of bird flocking. Suppose the following scenario: a group of birds are randomly searching food in an area. There is only one piece of food in the area being searched. All the birds do not know where the food is. But they know how far the food is in each iteration. So what's the best strategy to find the food? The effective one is to follow the bird, which is nearest to the food. PSO learned from the scenario and used it to solve the optimization problems. In PSO, each single solution is a "bird" in the search space. We call it "particle". All of particles have fitness values, which are evaluated by the fitness function to be optimized, and have velocities, which direct the flying of the particles. The particles fly through the problem space by following the current optimum particles.

PSO is initialized with a group of random particles (solutions) and then searches for optima by updating generations. In every iteration, each particle is updated by following two "best" values. The first one is the best solution (fitness) it has achieved so far. (The fitness value is also stored.)This value is called p-best. Another "best" value that is tracked by the particle swarm optimizer is the best value, obtained so far by any particle in the population. This best value is a global best and called g-best. When a particle takes part of the population as its topological neighbors, the best value is a local best and is called p-best. After finding the two best values, the particle updates its velocity and positions with following equation

$V_i^{(u+1)} = w * V_i^{(u)} + C_1 * rand\,(\,) * (pbest_i - P_i^{(u)}) + C_2 * rand\,(\,) * (gbest_i - P_i^{(u)})$

$P_i^{(u+1)} = P_i^{(u)} + V_i^{(u+1)}$

In the above equation,

The term rand ( )*(pbest $_i$ -$P_i^{(u)}$) is called particle memory influence The term rand ( )*(gbest$_i$ -Pi$^{(u)}$) **is** called swarm influence. $\mathbf{V}_i^{(u)}$ which is the velocity of ith Particle at iteration 'u' must lie in the range $V_{min} \le V_i^{(u)} \le V_{max}$

- The parameter V_{max} determines the resolution, or fitness, with which regions are to be searched between the present position and the target position
- If Vmax is too high, particles may fly past good solutions. If V_{min} is too small, particles may not explore sufficiently beyond local solutions.
- In many experiences with PSO, V_{max} was often set at 10-20% of the dynamic range on each dimension.
- The constants $C_1$and C_2 pull each particle towards p-best and g-best positions.
- Low values allow particles to roam far from the target regions before being tugged back. On the other hand, high values result in abrupt movement towards, or past, target regions.
- The acceleration constants C1 and C2 are often set to be 2.0 according to past Experiences.
- Suitable selection of inertia weight 'ω' provides a balance between global and local explorations, thus requiring less iteration on average to find a sufficiently optimal solution.
- In general, the inertia weight w is set according to the following equation,

$$w = w_{max} - \left[\frac{w_{max} - w_{min}}{ITER_{max}} \right] \times ITER$$

Where w -is the inertia weighting factor
W_{max} - maximum value of weighting factor
W_{min} - minimum value of weighting factor
$ITER_{max}$ - maximum number of iteration

RESULTS:

TABLE1:OPTIMAL BIDDING STRATEGY BY PSOALGORITHM

METHOD	GENERATION (MW)		PROFIT	LOAD (MW)		BENEFIT	MCP	TOTAL PROFIT	TIME ELASPED (SEC)
PSO	Genco 1	160.0	1370.12	Load 1	171.46	1162.32	16.37	4858.1	3.465 1565
	Genco 2	105.83	588.12						
	Genco 3	48.592	324.80						
	Genco 4	120.00	428.90	Load 2	143.95	621.73			
	Genco 5	49.08	180.71						
	Genco 6	49.085	180.71						
GA	Genco 1	160.00	1370.10	Load 1	170.46	1162.31	16.36	4857.1	4.895 242
	Genco 2	105.8	588.10						
	Genco 3	48.59	324.70						
	Genco 4	120.00	428.90	Load 2	143.95	621.71			
	Genco 5	49.085	180.70						
	Genco 6	49.085	180.70						
Monte Carlo	Genco 1	160.0	1367.99	Load 1	139.70	1126.26	16.35	4723.7	--------
	Genco 2	89.37	572.69						
	Genco 3	45.67	322.90						
	Genco 4	88.79	386.40	Load 2	112.06	592.60			
	Genco 5	43.09	177.45						
	Genco 6	43.09	177.45						

TABLE 2: OPTIMAL BIDDING STRATEGY WITH NEW ENTRY OF GENERATOR

METHOD	GENERATION (MW)		PR0FIT	LOAD (MW)		BENEFIT	MCP	TOTAL PROFIT	TIME ELASPED (SEC)
PSO	Genco 1	160.00	948.5	Load 1	200.0	1654.4	13.72	5424	4.2269
	Genco 2	80.745	342.3						
	Genco 3	39.011	209.3						
	Genco 4	78.559	156.3	Load 2	150.0	1015.8			
	Genco 5	31.521	74.5						
	Genco 6	31.521	74.5						
	Genco 7	160.00	948.5						
GA	Genco 1	160.00	948.5	Load 1	200.0	1654.4	13.72	5424	4.2226
	Genco 2	80.74	342.3						
	Genco 3	39.011	209.3						
	Genco 4	78.559	156.3	Load 2	150.0	101.58			
	Genco 5	31.521	74.5						
	Genco 6	31.521	74.5						
	Genco 7	160.00	948.5						
Monte Carlo	Genco 1	160.00	948.5	Load 1	168.7	1700.10	13.17	5205.	--------
	Genco 2	67.26	29.57						
	Genco 3	35.60	187.9						
	Genco 4	50.46	108.3	Load 2	150.0	1098.70			
	Genco 5	39.79	47.41						
	Genco 6	39.80	47.38						
	Genco 7	160.00	860.1						

CONCLUSION:

Genetic algorithm, PSO with multi-round auction bidding is efficiently used to solve the optimal bidding strategy problem. This proposed algorithms results in the same solution as Monte Carlo Simulation with much less computing effort and much less computing time and also better benefits. Here GA is take less computing time and better benefit compare to Monte Carlo method. And PSO is better than GA. The total benefit is 4857.1 using GA method, Where 4723.74 by using Monte Carlo method. By using PSO it is 4858.1 .The proposed algorithms can be easily used to determine the optimal bidding strategy in different market rule, different fixed load, different capacity of buyers and sellers or different number of buyers and sellers. For future research, here plan to expand this algorithm to cover 24 hours for competitive day-ahead auction problem considering minimum up and down times.

REFERENCES

[1] A**. Kumar David & Fushuan Wen** 2001. Market Power in Electricity Supply.IEEE Transactions on Energy Conversion, 16 (4), 352-360

[2] A**. Kumar David & Fushuan Wen** 2000. Strategic Bidding in Competitive Electricity Market: a Literature Survey. Proceedings of IEEE PES 2000 Summer Meeting, Seattle, 2168-2173

[3] **Fushuan Wen & A.K.David** 2001. Optimal bidding strategy for competitive Generators and large consumers. Electric Power and Energy System, 23, 37-43

[4] **Fushuan Wen & A.K.David** 2001. Optimal Bidding Strategy and Modeling of Imperfect Information among Competitive Generators. IEEE Transactions on Power Systems, 16(1), 15-21

[5] **Rajkumar Ragupathi & Tapas K.Das** 2004. A Stochastic Game Approach for Modeling Wholesale Energy Bidding in Deregulated Power Markets. IEEE Transactions on Power Systems, 19(2), 849-856

[6] The Math Works, Inc. 2005. Genetic Algorithm and Direct Search Toolbox: For Use with MATLAB.

[7] **M.Shahidehpour,H.Yamin,Z.Li**, Market Operation in Electric Power systems, Forecasting, Scheduling and Risk Management, JohnWiley&Sons,2002

. [8] **LoiLaiLei Power** System Restructuring and Deregulation, (Edited), John Wiley & Sons Limited, 2001

[9] **AJ Wood, Woolen berg**, Power Generation Operation and Control, John Wiley and Sons, 1996

[10] **D. Karaboga and B. Basturk**. On the performance of artificial bee colony (ABC) algorithm. Applied Soft Computing, 8(1):687–

[11] **Steven Stoft** Power System Economics Designing Markets for Electricity IEEE Press & wiley-interscience a john wiley & sons, inc., publication