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Price Based Unit Commitment Problem Under Deregulation

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Abstract — The profit based unit commitment problem involves determining the time intervals at which a particular generating unit should be online and available for generation, and the associated generation or dispatch, the aim being to maximize its total profits based on a given price profile. This problem can be attacked by various techniques like single unit dynamic programming, lagrangian relaxation, genetic algorithm; particle swarm optimization etc. this paper describes how a dynamic programming optimization method is used to solve this complex optimization problem. All the usual unit constraints like minimum up time, minimum down time, and ramp up, ramp down limits are considered, after which results for the chosen 26 generating units are presented, and discussed.

***Index Terms*— unit commitment, deregulation, dynamic programming, mat lab.**

I. INTRODUCTION

Since most systems supplying services to the human population experience cyclical in nature like transportation systems, communication systems etc. Generally the total load is higher during day time and early evening when most of the industrial loads are high, lights are on, and lower during late evening and early morning when most of the population is asleep. In addition, the use of electric power has a weekly cycle, the load being lower over weekend than weekdays. Why is this problem in the operation of an electric power system? Why not just simply commit enough units to cover the maximum system loads and leave them running? Note that to "commit" a generating unit is to "turn it on", i.e. to bring the unit up to speed synchronize it to the system, and connect it so that it can deliver power to the network. The problem with "commit enough units and leave them on line" is one of economics. It is quite expensive to run too many generating units. Turning units off when they are not needed can save a great deal of money. Hence, electricity generating companies and power systems has the problem of deciding how best to meet the Varying demand for electricity.

II. UNIT COMMITMENT PROBLEM

The unit commitment problem is to schedule available generators (on or off) to meet the required loads at a minimum cost subject to system constraints which are.

1. The total output of all the generating units must be equal to the forecast value of the system demand at each time-point.
2. The total spinning reserve from all the generating units must be greater than or equal to the spinning-reserve requirement of the system. This can be either a fixed requirement in MW or a specified percentage of the largest output of any generating unit. (The purpose of the spinning-reserve requirement is to ensure that there is enough spare capacity from the units on-load or 'spinning' at any time to cover the accidental loss of any individual generating unit, or to meet higher than expected demands.)
3. Minimum up time: Once the unit is running, it should not be turned off immediately.
4. Minimum down time: Once the unit is decommitted (off), there is a minimum time before it can be recommitted.
5. The output power of the generating units must be greater or equal to the minimum power of the generating units.
6. The output power of the generating units must be smaller or equal to the Maximum power of the generating units.

III. COST CALCULATION

Mainly, the total power production can be separated into two parts that is start-up cost and operating cost.

1) Start-up cost is warmth-dependent, corresponding to the hot, warm or cold condition of each generating unit, as determined by the time that the unit has been off-loaded. Its value depends on the shutdown time; alpha, beta and τ which can be obtained from Unit Data. $SU_i^t = \alpha_i + \beta_i(1-\exp(-X_{off,i}^t/\tau_i))$ Where SU_i^t: Start-up cost of unit i at time interval t. α_i : Combined crew start-up

Costs and the equipment maintenance costs of unit i, β_i: Cold Start-up cost of unit i, τ_i: Cooling time constant of unit $X_{off,i}^{t}$: Continuous offline time of unit i at time interval t

2) Each generating unit has a 'no-load' or fixed operating cost and a number of incremental operating costs, which can define a non-linear profile of operating costs.

IV. UCP UNDER DEREGULATION

The unit commitment problem can be analyzed in two situations. The first one is the unit commitment before the restructuring of electric power systems, while the second one is based on the system after deregulation. Before the restructuring of electric power systems it is the point of generation part of utility and after deregulation it is the Point of Generation Company wishing to optimize their operation, which is minimum production cost for the first case and maximize profit for the second case. The restructuring and deregulation of electric power systems have resulted in market-based competition by creating an open market environment. A restructured system allows the power supply to function competitively, as well as allowing consumers to choose suppliers of electric energy. In a regulated framework, an electric utility serves the customers of a certain region under tariffs calculated to guarantee the recovery of its costs. In this situation, a power generating utility solves the UCP to obtain an optimal production schedule of its units to meet customer demand. The optimal schedule is found by minimizing the production cost over a given time interval while satisfying the demand and the set of operating constraints. The minimization of the production costs assures maximum profits because the power generating utility has no option but to reliably supply the prevailing demand. The price of electricity over this period is predetermined. Therefore; the decisions on the operation of individual units have no effect on the firms' revenues. Under deregulation the price of electricity is however no longer predetermined. The unit commitment decisions in this situation are based on the expected market price of electricity rather than on the demand although these variables are usually correlated. in a deregulated power systems there will be mainly three components exists .one is power producer and second is power consumers and last one is independent system operator which acts as a mediator between power producers and power consumers, usually the independent system operator will forecast the load demand at each and every instant of our and accepts the bids and prices from producers and consumers to meet this load demand.

V. PROBLEM FORMULATION

The unit commitment problem under deregulation can be stated as follows:

"For an electric utility or a power producer with M generating units, and given a certain market price profile it is required to determine the start-up/shut-down times and the power output levels of all the generating units at each time interval t over a specified scheduling period T. so that the generator's total profit is maximized, subject to the unit constraints."

The cost function will be given by the formula as below:-

$$F_{T,i}^{t} = [(inc_i^k * \sum_{ton}^{toff} P_i^t) + SU_i^{ton} + \sum_{ton}^{toff} nl_i^k]U_i^t$$

inc_i^k : Incremental cost of segment k of unit i [\$/MWh], k=1,2and 3;

nl_i^k : No-load cost of segment k of unit i [\$/h], k=1,2and 3;

$P_i^{\min}, P_i^{\max}$: The lower and upper generation limits of unit i respectively in [MW];

e_i^1, e_i^2 : The first and second elbow points of the piece-wise linear cost Function of unit i, respectively [MW].

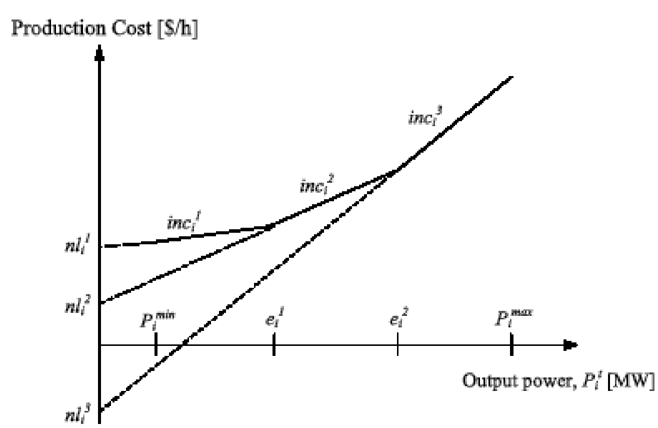

Fig.1 piece wise linear cost function

The UCP under deregulation can be formulated by first defining the following:

Let U_i^t =0 if unit i is offline during time interval t;

U_i^t =1 if unit i is online during time interval t;

X_i^t = Cumulative up time during time interval t if X_i^t >0;

X_i^t = Cumulative down time during time interval t if X_i^t <0;

Thermal units are subject to a variety of constraints. The unit constraints that must be satisfied during the maximization process are:

1. Unit limits-units can only generate between given limits:

$U_i^t\, P_i^{\min} \le P_i^t \le U_i^t\, P_i^{\max}$ For i=1, 2, 3…N and t=1, 2, 3…T

2. Unit minimum up time constraint:

$(X_i^{t-1} - T_i^{up})(U_i^{t-1} - U_i^t) \ge 0$ for i=1, 2, 3…N and t=1, 2, 3…T, Where T_i^{up} is the minimum up time constraint [h].

3. Unit minimum down time constraint:

$(-X_i^{t-1} - T_i^{down})(U_i^t - U_i^{t-1}) \ge 0$ for i=1, 2, 3…N and t=1, 2, 3…T Where T_i^{down} is the minimum down time constraint [h]

4. Unit ramp-up constraint- the amount a unit's generation can increase in an Hour. $P_i^t - P_i^{t-1} \le R_i^{up}$ For i=1,2…N and t=1,2… T, Where R_i^{up} is the ramp-up constraint [MW/h].

5. Unit ramp-down constraint-the amount a unit's generation can decrease in an Hour. $P_i^{t-1} - P_i^t \le R_i^{down}$ For i=1,2…N and t=1,2…T Where R_i^{down} is the ramp down constraint [MW/h].

The limit at start-up is given by

$P_i^t \le \text{Max}\,(R_i^{up}, P_i^{\min})$ for i=1,2…N and t=1,2…T

The limit at shut down is given by:

$P_i^t \le \text{Max}\,(R_i^{down}, P_i^{\min})$ for i=1,2…N and t=1,2…T

6. Unit status restrictions-certain units may be required to be online at certain time intervals (must run), or may become unavailable due to planned maintenance or forced outage (must not run), due to operating constraints, reliability requirements, or economic reasons.

7. The initial conditions of the units at the start of the scheduling period must be considered. Plant crew constraints were not considered (thermal plants may have limits on the number of units that can be committed or decommitted in a given time interval due to manpower limits). Also, units may be derated (i.e. have their generating limits reduced), or required to operate at pre-specified generation levels. These restrictions were also ignored. The start-up cost in any given time interval t depends on the number of hours a unit has been off prior to start-up. This can be modeled by an exponential function of the form:

$$SU_i^t = \alpha_i + \beta_i (1 - \exp(-X_{off,i}^t / \tau_i))$$

Where α_i : Combined crew start-up costs and equipment maintenance costs [$];

β_i : Cold start-up cost [$];

$X_{off,i}^t$: Number of hours the unit has been offline [h];

τ_i : Unit-cooling time constant [h].

The shutdown cost. SD_i^t, Is usually given a constant value for each unit per shutdown and in this dissertation is assumed to be zero. The total production cost, F_{Ti}^t, for each unit at each time interval is the sum of the running cost, start-up cost and shutdown cost during that interval.

$$F_{T,i}^t = [(inc_i^k \sum_{ton}^{toff} P_i^t) + SU_i^{ton} + \sum_{ton}^{toff} nl_i^k]U_i^t$$

The profit at each time interval is calculated by subtracting the total production cost during that interval from the revenue, a negative profit indicates a loss

$$\text{Pr}ofit_i^t = (\lambda^t * P_i^t)U_i^t - F_{T,i}^t$$

$(\lambda^t * P_i^t)U_i^t$ = Revenue at time interval t.

As mentioned previously, the prices, λ^t, can be actual market prices or an estimate of how they would fluctuate, and are given in [$/MWh]. The total profit for unit i is then given by

$$\textit{Total profit} = \sum_{t=1}^{T} \text{Pr}\,ofit_i^t$$

The main complication arises from the unit minimum up and down time constraints. When a unit is committed, it incurs a cost equal to its start-up cost. It then has to stay online until its minimum up time constraint has been satisfied before it can be shut down again. Similarly, once a unit is decommitted, it has to remain offline for as long as its minimum down time constraint requires before it can be recommitted.

Another difficulty lies in the time-dependent nature of the start-up cost. Although committing a unit at a particular point in the scheduling period may not be the most profitable choice at that instant, it may still yield a better solution over the entire study period compared to the case in which the unit remained offline at the aforesaid point in time. This option may have been totally lost during the optimization process though economic disqualification; i.e. if the feasible state associated with starting up the unit had been discarded because it incurred a loss during start-up.

Thus the utility has to decide whether to:

a) Keep a unit committed even when the price is low during a particular period, incurring fuel cost during that period with the hope that the profit made in the following period when the price is high, together with the savings achieved from not having to start up the unit at the start of or during the high-price period would offset the losses; or
b) Shut down the unit during the period of low price and incur a cost when starting up the unit for the following high-price period.

Note that in the second case, the unit might have to forfeit any profit it would otherwise have been able to attain in the period of high price if its minimum down time constraint required that it remained offline during that period (or part of it). Similar decisions must be considered when moving from a high-price period to a low –price period.

These considerations, compounded with the other unit constraints discussed above. Clearly render this a very complex problem, as making the wrong decisions could significantly reduce the profitability of the unit. Fortunately, there are several possible techniques that can be used to solve this problem.

VI. APPLICATION OF DP METHOD

VI.I SINGLE UNIT DYNAMIC PROGRAMMING

In determining an optimal commitment schedule, there are two decision variables P_i^t and U_i^t where P_i^t denotes the amount of power to be generated by unit i at time t and U_i^t is the control variable whose value is chosen to be “1” if the generating unit i is committed at hour t and “0” otherwise (of course if U_i^t =0,then P_i^t =0) the cost of the power produced by the generating unit i depends on the amount of fuel consumed and is typically approximated by a quadratic cost function and later it was approximated by piece wise linear cost function. The startup cost can be calculated using equation 4.9. In addition to startup cost the generating unit must satisfy all the constraints (minimum up time, minimum down time, ramp up and ramp down, minimum power and maximum power generation) as discussed in the previous chapter.

VI.II DECOMPOSITION INTO SUB-PROBLEMS

The objective function is total profit, revenue minus cost over the interval [1, T]. The revenue during hour t is obtained from supplying the quantity stipulated under the long-term bilateral contracts and by selling surplus energy (if any) to the power pool at the market price, λ^t ($/MWh). The cost includes those of producing the energy, buying short falls (if needed) from the power pool, and the start-up costs. Defining the amount to be sold under the bilateral contract by l_t (MWh), the contract price by R ($/MWh), and the amount of energy bought or sold from the market by E_t, we solve the optimization problem by maximizing the expected profit over the period [1, T]. (A positive value of E_t indicates that E_t (MWh) is bought from the power poll and a negative value indicates that

$-E_t$ (MWh) is sold to the pool. The objective function is given by:

Max

$$E\{\sum_{t=1}^{T}\{l_t R-\lambda^t E_t-\sum_{i=1}^{M}F_{T,i}^t\}$$

This is under the case that the cost function is represented by piece wise linear cost characteristics. If cost function is same as in the form of quadratic cost function then the objective function will become

Max

$$E\{\sum_{t=1}^{T}\{l_t R-\lambda^t E_t-\sum_{i-1}^{M}[CF_i(P_i^t)+SU_i^t(X_i^{t-1})(1-U_i^{t-1})]U_i^t\}$$

Where $CF_i\ (P_i^t)=F_{T,i}^t(P_i^t)=a_i\ (P_t^t)^2+b_i P_i^t+c_i$ but we usually consider that the cost function will be represented by piece wise linear cost characteristics because this representation will fetch us to take the values of cost function as discrete values. And hence the objective function will be given by **Max** $E\{\sum_{t=1}^{T}\{l_t R-\lambda^t E_t-\sum_{i=1}^{M}F_{T,i}^t\}$ since the quantity $l_t R$ is a constant, the optimization problem reduces to:

Max $$E\{\sum_{t=1}^{T}\{-\lambda^t E_t-\sum_{i=1}^{M}F_{T,i}^t\}$$

Where $F_{T,i}^t=[(inc_i^k\sum_{ton}^{toff}P_i^t)+SU_i^{ton}+\sum_{ton}^{toff}nl_i^k]U_i^t$ Subject to the following constraints (for t=1…T, i=1…M)

1) Load: $E_t+\sum_{i=1}^{M}P_i^t=l_t$

2) Capacity limits: $U_i^t\ P_i^{\min}\le P_i^t\le U_i^t\ P_i^{\max}$

3) Minimum up time: $U_i^t\ge I(1\le X_i^{t-1}\le t_i^{UP}-1)$

4) Minimum down time: $U_i^t\le 1-I(-t_i^{down}+1\le X_i^{t-1}\le -1)$ Where $I(X)$=0 if X is false, =1 if X is true. And U_i^t=1 if X_i^t>0, 0 if X_i^t<0

After substituting in the objective function $E_t+\sum_{i=1}^{M}P_i^t=l_t$

Max $$E\{\sum_{t=1}^{T}\{-\lambda^t(l_t-\sum_{i=1}^{M}P_i^t)-\sum_{i=1}^{M}F_{T,i}^t\}$$

Which after removing the constant term is equivalent to

Max $$E\{\sum_{t=1}^{T}\ \sum_{i=1}^{M}\lambda^t P_i^t-F_{T,i}^t\}$$

Subject to the operating constraints, the optimization problem is now separable by individual units. The optimal solution can be found by solving M-decoupled sub problems. Thus the sub problem for the i th unit is

Max $$E\{\sum_{t=1}^{T}\lambda_t P_i^t-F_{T,i}^t\}$$

Subject to the operating constraints of the i[th] unit. The main problem is similar to the sub-problem obtained in the standard version of the UCP using the lagrangian relaxation method; except that the values of Lagrange multipliers are now replaced by the market price of electricity λ^t and the expected value is being maximized. When the optimization sub-problem is solved for a particular unit, we assume that the market consists of *N* generating units (*N* will be much larger than *M*). The generating unit for which the sub-problem is solved is excluded from the market. Excluding a unit from the market does not influence the spot price because of the existence in all likelihood of a number of generating units with almost equal marginal costs, ready to produce if any of The infra-marginal (or marginal) units are unavailable.

VII.SINGLE UNIT DYNAMIC PROGRAMMING

Dynamic programming (DP) was the earliest optimization-based technique to be applied to the UC problem and is still used extensively all over the world. The DP technique employs a systematic searching algorithm that tries to achieve the optimal solution without having to access all the possible combinations. The unit commitment problem can be solved using a dynamic programming algorithm. This technique can be applied because:

1) The problem satisfies the principle of optimality if all parts of an optimal solution are themselves optimal solutions to sub-problems.
2) The number of relevant sub-problem depends on a limited number of smaller sub-problems.
3) The number of relevant sub-problems is limited by the unit constraints.

VII.I THE DYNAMIC PROGRAMMING ALGORITHM

The unit commitment problem can be solved in a bottom-up manner, whereby:

1) The smallest sub-problems are solved first. This corresponds to finding the feasible states (whether 0 or 1), the associated nominal generation or dispatch. And the profit that it would entail for each unit at each time interval.
2) These solutions are then combined to solve larger sub-problems. In this case the individual profits of each feasible solution path are added together to give the total Profit over the scheduling period, after which the path with the highest total profit is determined. This gives the optimal schedule for that unit for a given price profile.
3) Finally, the individual maximum total profits are summed over all the units in the utility to give its maximum total profit for a given price profile.

The dynamic programming algorithm is given as follows:

- Specify the rule that relates large problems to small problems.
- Store the partial feasible solutions of each sub problem.
- Extract the final solution for main problem considering all solutions from sub problems.

VIII. RESULTS

STATES (U) FOR 1-26 UNITS

Unit	t=1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	0	0	0	1	1	1	1	1	1	1	1	1	1	1
2	0	0	0	1	1	1	1	1	1	1	1	1	1	1
3	0	0	0	1	1	1	1	1	1	1	1	1	1	1
4	0	0	0	1	1	1	1	1	1	1	1	1	1	1
5	0	0	0	1	1	1	1	1	1	1	1	1	1	1
6	0	0	0	1	1	1	1	1	1	1	1	1	0	0
7	0	0	0	1	1	1	1	1	1	1	1	1	0	0
8	0	0	0	1	1	1	1	1	1	1	1	1	0	0
9	0	0	0	1	1	1	1	1	1	1	1	1	0	0
10	1	1	1	1	1	1	1	1	1	1	1	1	0	0
11	1	1	1	1	1	1	1	1	1	1	1	1	0	0
12	1	1	1	1	1	1	1	1	1	1	1	1	0	0
13	0	1	1	1	1	1	1	1	1	1	1	1	0	0
14	0	0	1	1	1	1	1	1	1	1	1	1	1	1
15	0	0	1	1	1	1	1	1	1	1	1	1	1	1
16	0	0	1	1	1	1	1	1	1	1	1	1	1	1
17	0	0	1	1	1	1	1	1	1	1	1	1	1	1
18	0	0	1	1	1	1	1	1	1	1	1	1	1	1
19	0	0	1	1	1	1	1	1	1	1	1	1	1	1
20	0	0	1	1	1	1	1	1	1	1	1	1	1	1
21	0	0	0	1	1	1	1	1	1	1	1	1	1	1
22	0	0	0	1	1	1	1	1	1	1	1	1	1	1
23	0	0	0	1	1	1	1	1	1	1	1	1	1	1
24	0	0	1	1	1	1	1	1	1	1	1	1	1	1
25	1	1	1	1	1	1	1	1	1	1	1	1	1	1
26	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Unit	T=1	2	3	4	5	6	7	8
1	0.0	0.0	0.0	4.0	8.0	12.0	12.0	12.0
2	0.0	0.0	0.0	4.0	8.0	12.0	12.0	12.0
3	0.0	0.0	0.0	4.0	8.0	12.0	12.0	12.0
4	0.0	0.0	0.0	4.0	8.0	12.0	12.0	12.0
5	0.0	0.0	0.0	4.0	8.0	12.0	12.0	12.0
6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.0
7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.0
8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.0
9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.0
10	15.2	30.2	45.2	60.2	75.2	76.0	76.0	76.0
11	15.2	30.2	45.2	60.2	75.2	76.0	76.0	76.0
12	15.2	30.2	45.2	60.2	75.2	76.0	76.0	76.0
13	0.0	20.0	40.0	60.0	76.0	76.0	76.0	76.0
14	0.0	0.0	25.0	50.0	75.0	100.0	100.0	100.0
15	0.0	0.0	30.0	60.0	90.0	100.0	100.0	100.0
16	0.0	0.0	30.0	60.0	90.0	100.0	100.0	100.0
17	0.0	0.0	100.0	155.0	155.0	155.0	155.0	155.0
18	0.0	0.0	150.0	155.0	155.0	155.0	155.0	155.0
19	0.0	0.0	150.0	155.0	155.0	155.0	155.0	155.0
20	0.0	0.0	150.0	155.0	155.0	155.0	155.0	155.0
21	0.0	0.0	0.0	197.0	197.0	197.0	197.0	197.0
22	0.0	0.0	0.0	197.0	197.0	197.0	197.0	197.0
23	0.0	0.0	0.0	197.0	197.0	197.0	197.0	197.0

24	0.0	0.0	200.00	350.00	350.00	350.00	350.00	350.00
25	250.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00
26	250.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00

1	T=9	10	11	12	13	14
2	12.0	12.0	12.0	12.0	12.0	12.0
3	12.0	12.0	12.0	12.0	12.0	12.0
4	12.0	12.0	12.0	12.0	12.0	12.0
5	12.0	12.0	12.0	12.0	12.0	12.0
6	12.0	12.0	12.0	12.0	12.0	12.0
7	16.0	20.0	20.0	10.0	0.0	0.0
8	16.0	20.0	20.0	10.0	0.0	0.0
9	16.0	20.0	20.0	10.0	0.0	0.0
10	16.0	20.0	20.0	10.0	0.0	0.0
11	76.0	76.0	76.0	76.0	76.0	76.0
12	76.0	76.0	76.0	76.0	76.0	76.0
13	76.0	76.0	76.0	76.0	76.0	76.0
14	76.0	76.0	76.0	76.0	76.0	76.0
15	100.0	100.0	100.0	100.0	100.0	100.0
16	100.0	100.0	100.0	100.0	100.0	100.0
17	155.0	155.0	155.0	155.0	155.0	155.0
18	155.0	155.0	155.0	155.0	155.0	155.0
19	155.0	155.0	155.0	155.0	155.0	155.0
20	155.0	155.0	155.0	155.0	155.0	155.0
21	197.0	197.0	197.0	197.0	197.0	197.0
22	197.0	197.0	197.0	197.0	197.0	197.0
23	197.0	197.0	197.0	197.0	197.0	197.0

Final Solution (For All (26) Units)

UNIT	**TOTAL PROFIT FOR (T=14)**
	HOURS
1	1414.134
2	1396.929
3	1377.049
4	1359.646
5	1342.546
6	151.066
7	140.274
8	129.071
9	118.107
10	19122.986
11	19084.224
12	19047.897
13	19207.385
14	18663.634
15	18795.565
16	18696.600
17	44956.134
18	45002.021
19	44936.085
20	44875.456
21	29841.747
22	29614.585
23	29377.709
24	103351.435
25	132119.379
26	132066.055
TOTAL PROFIT	**776190.00($/MWh)**

XI. CONCLUSION

The profit based unit commitment problem under deregulated environment has been solved using single unit dynamic programming and lagrangian relaxation technique. The algorithm has been developed for 26 generating unit system and profit is obtained for each generator for the scheduled time period.

X. REFERENCES

[1] J. Valenzuela & M. Mazumdar, "Commitment of Electric Power Generators under Stochastic Market Prices," (2001) accepted for publication in *Operations Research.*

[2] J. Valenzuela & M. Mazumdar,"Probabilistic Unit Commitment under a Deregulated Market," a chapter for the book on *The Next Generation of Unit Commitment Models,* B. Hobbs, M. Rothkopf, R.O'Neill, and H. Chao, ed.s, Kluwer Academic Publisher, Boston, (2001), 139 - 152.

[3] WOOD A AND B.WOLLENBERG, 1996.power generation operation and control. Second edition, Wiley & Sons, New York.

[4] A.I Cohen," modeling unit ramp limitations in unit commitment" proceedings of the 10th power systems computations conference, Graz, Austria, (1990) August 19-24, pp.1107-1114.

[5] Wang, C and Shahidehpour, S.M,"effects of ramp rate limits on unit commitment and economic dispatch " IEEE transactions on power systems, vol.8, no.3, August 1993,pp.1341-1350.

[6] J. Valenzuela & M. Mazumdar "Monte Carlo Computation of Power Generation Production Costs under Operating Constraints," IEEE Transactions on Power Systems, vol.16 (2001), 671-677.

[7] Kothari, D.P; Ahmad, A "an expert system approach to unit commitment problem"; TENCON 93. Proceedings. Computer, communication, control and power engineering.1993 IEEE region 10 conference on issue:19-21 Oct,(1993), vol.5, pp.5-8

[8] Sasaki, H; watanabe, M; kubokawa, J; yorino, N; yokoyama, R; a "solution method of unit commitment by artificial neural networks "IEEE transactions on power systems, Aug, (1992), vol.7 pp.974-981.

[9] Kazarlis, S.A; Bakirtzis, A.G; Petridis, V "A genetic algorithm solution to the unit commitment problem"IEEE transactions on power systems, Issue 1, Feb (1996), vol.11.pp: 83-92.

[10] Mantawy, A.H; Abdel-Magid, Y.L; Selim, S.Z "unit commitment by tabu search" generation, transmission and distribution, IEE proceedings vol-145 issue: 1, Jan (1998) pp: 56-64.

[11] Baldick, R, "the generalized unit commitment problem"IEEE transactions on power systems, vol: 10 issue: 1, Feb. (1995) pp: 465-475.

[12] Sheble, G.B; Fahd, G.N "unit commitment literature synopsis", IEEE transactions on Power systems, vol: 9 issue: 1,Feb (1994) pp: 128-135.

[13] Cohen, A.I; Brandwahjn, V; Show-kan Chang "security constrained unit commitment for open markets" power industry computer applications, PICA proceedings of the 21st IEEE international conference, 16-21 may (1999) pp: 39-44.

[14] Bellman, R.E.and Dreyfus, S.E.:'applied dynamic programming,' (Princeton university press, Princeton, NJ, 1962), pp.15

[15] Kazarlis, S.A; bakirtzis, A, G; petridis, V "a genetic algorithm solution to the unit commitment problem,'IEEE transactions on power systems, vol.11, no.1, February (1996), pp.83-90

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