Comparative Analysis of Unit Commitment Problem of Electric Power System using Dynamic Programming Technique

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Abstract: In this paper shows a Dynamic programming based on algorithm to solve the (UCP) Unit commitment problem bookkeeping voltage security consideration and imbalance limitations. In the present electrical power system, where electricity demands are in its pinnacle, it has turned out to be extremely troublesome for administrators to satisfy the demand. There are numerous regular and transformative programming methods utilized for the solution of the unit (UCP) issue. Dynamic optimization is conventional algorithm used to take care of the deterministic issue. The created calculation has been executed on 4 and 10 unit's power system. The outcomes got from this strategy was approved with the accessible procedures and result discovered satisfactory. The responsibility such that aggregate cost of generation is reduced to minimize.

Keywords: **Dynamic optimization, Fuel cost, Voltage stability, Unit commitment and Economic dispatch.**

I. Introduction

Because of the idea of evolving innovation, (UC) unit commitment is likewise experiencing an adjustment in its answer strategy. This is on account of there must be a proficient technique to confer the generators to meet the load demand. Numerous strategies have been acquainted with understand (UC) unit commitment. Regardless of whether the techniques have favorable circumstances, the greater part of the strategies experiences the ill effects of nearby joining and revile of dimensionality.[1] While booking the activity of the generating units at least working expense or operating cost in the meantime satisfying the equality and inequality limits is the advancement emergency associated with commitment of the units. The high dimensionality and combinatorial nature of the unit commitment issue abridges the endeavors to build up any thorough scientific enhancement strategy equipped for solve of the entire issue for any genuine size of power system. For both deterministic and stochastic loads the (UCP) is relevant.[6] The deterministic approach gives us clear and interesting conclusions. Anyway the dependable outcomes are not gotten for stochastic loads. All things considered the imperatives are changed into controlling requirements in stochastic models and after that by any of the typical calculations the detailing can be worked out. In the UC issue is settled by itemizing every single plausible amalgamation of the producing units and afterward the combination that gives the littlest measure of the cost of activity is chosen as the most ideal arrangement. While considering the need list technique for the conferring the units, replication time and memory are spared, and it can likewise be related in a bona fide control power system. Conversely, the need list strategy has weaknesses that result into problematic arrangements since it won't consider every last one of the conceivable combinations of generation. Dynamic optimization computer programs are the one of the techniques which gives ideal arrangement. To give greatness answers for the UC issue various arrangement approaches are proposed. Despite the fact that the dictatorial strategies are basic and quick, they experience the suffer effects of numerical convergence and way out greatness issues. This paper gives a definite analysis's of the unit commitment issue arrangement utilizing Dynamic Programming technique, real commitment is assurance of UC plan with consideration towards what is known as power system voltage security. The endeavor is first of its kind in UC calculation.

II. PROBLEM FORMULATION OF (UCP)

The goal of the (UC) unit commitment is limiting the aggregate working expense keeping in mind the operating cost to meet the desire demand. [8] It is expected that the fuel cost, for unit 'i' in a given time interim is a quadratic function of the output power of the generators.

$$FC(P_{ih}) = \sum_{i=1}^{NG} (a_i P_{ih}^{2} + b_i P_{ih} + c_i) \qquad \$/hrs. \qquad (1)$$

Where ai, bi, ci are the comparing unit"s cost coefficients. For the booking time frame 'T' the total of the generation costs acquired from the comparing submitted units gives the aggregate working cost

$$Cost_{NH} = \sum_{h=1}^{H}\sum_{i=1}^{NG}[FC_i(P_{ih})*U_{ih} + STUC_{ih}*(1-U_{i(h-1)})*U_{ih} + SDC_{ih}*(1-U_{ih})*U_{i(h-1)}] \quad (2)$$

Where,

$Cost_{NH}$ is the total operating cost over the scheduled horizon

$FC_i(P_{ih})$ is the fuel cost function of units

$U_{i(h-1)}$ is the ON/OFF status of i^{th} unit at $(h-1)^{th}$ hour.

U_{ih} is the ON/OFF status of i^{th} unit at h^{th} hour.

U is the decision matrix of the U_{ih} variable. for i=1,2,3,........NG.

P_{ih} is the generation output of i^{th} unit at h^{th} hour.

$STUC_{ih}$ is the start-up cost of the i^{th} generating unit at h^{th} hour.

SDC_{ih} is the shut-down cost of the i^{th} generating unit at the h^{th} hour.

NG is the number of thermal generating units

$U_{ih} \in \{0,1\}$ and $U_{i(h-1)} \in \{0,1\}$

The accompanying imperatives are incorporated:

a. Power Balance Constraint

The aggregate produced power and load at comparing hours must be equivalent.

$$\sum_{i=1}^{ng} P_{gi} = P_d \quad (3)$$

b. Power generation limit

The produced power of the units should be within max. and min. power limits.

$$P_{gimin} \le P_{gi} \le P_{gimax} \quad (4)$$

III. DYNAMIC PROGRAMMING OPTIMIZATIO

The reason for Dynamic Programming (DP) is the hypothesis of optimality illustrated by Bellman in 1957. This strategy can be utilized to clarify emergencies in which numerous sequential conclusions are to be taken in characterizing the ideal activity of a power system, which comprises of particular number of stages. The seeking might be in forward or in reverse heading. Inside a day and generation the combinations of units are known as the states. In Forward dynamic programming a superb monetary calendar is acquired by beginning at the starter arrange gathering the aggregate costs, at that point backtracking from the combination of minimum amassed cost beginning at the last stage and completing at the underlying stage. The phases of the DP issue are the times of the investigation skyline. Each stage as a rule compares to one hour of activity i.e., mixes of units ventures forward one hour on end, and target plans of the units that are to be booked are put away for every hour. At long last, by retreating from the plan with littlest measure of aggregate cost at the last hour all through the finest way to the course of action at the fundamental hour the most temperate timetable is obtained. The estimation of every last mix isn't helpful clearly. Furthermore, a few of the combinations are restricted because of lacking existing limit.

The well ordered method for dynamic programming approach is as per the following:

1) Begin haphazardly by considering any two units.

2) Assemble the aggregate output of the two units as discrete load levels.

3) Determine the most temperate combination of the two units for all the load levels. It is to be watched that at each load level, the monetary activity might be to run either a unit or the two units with a specific load sharing between the two units.

4) Obtain the more practical cost curve for the two units in discrete frame and it can be dealt with as cost curve of single proportional unit.

5) Add the third unit and the cost curve for the combination of three units is acquired by rehashing the system.

6) Unless all the current units are viewed as the system is rehashed.

The advantage of this technique is that having the most ideal method for running N units, it is easy to discover the most ideal route for running N + 1 units. The DP approach based on the subsequent recurring equations.

$$F_M(P) = \min[F_M(Q) + F_{M-1}(P - Q)] \quad (5)$$

Where FM(P) is the base cost in $/hr of generation of P MW by M generating units. FM(Q) is the cost of generation of Q MW by Mth unit. FM-1(P-Q) is the min. cost of generation of (P-Q) MW by the rest of the (M - 1) units. In its essential shape, the dynamic programming calculation for (UCP) assesses each conceivable state in each interim. The dimensionality of the issue is essentially declined which is the main preferred standpoint of this strategy. The hypotheses for organizing the well ordered strategy for dynamic programming technique are followed underneath.

1) A state comprises of a gathering of units with just exact units in benefit at once and the remaining disconnected.

2) While the unit is in off state the start-up cost of a unit is autonomous of the time particularly it remain fixed.

3) For shutting the unit there will be no cost included.

4) The request of priority is firm and a little amount of power must be in task in every interim.

IV. FLOW CHART FOR DYNAMIC PROGRAMMING STRATEGY

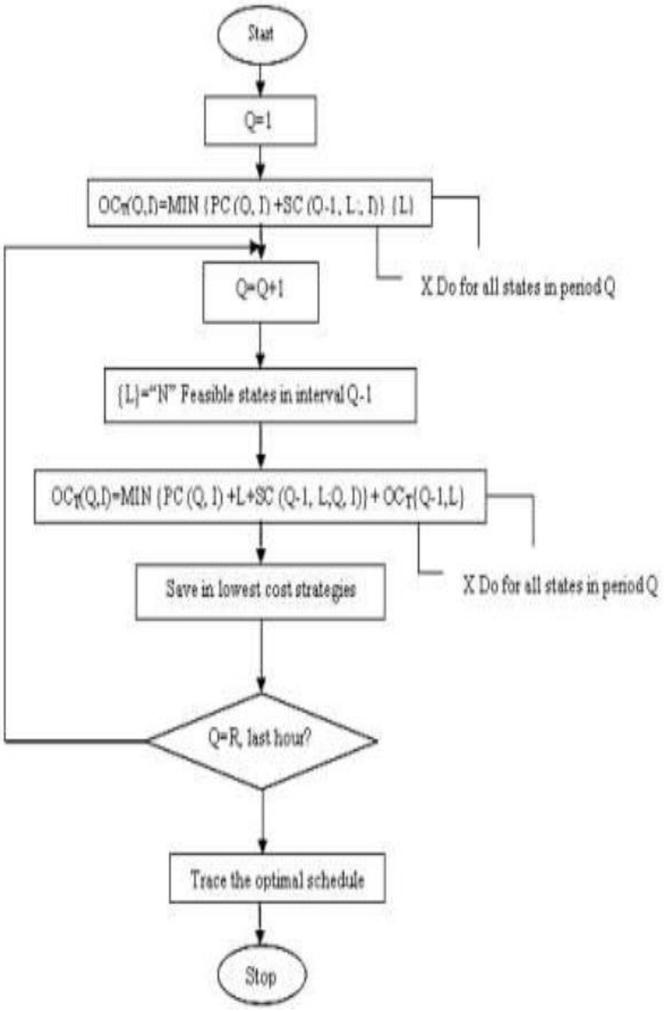

Fig.1 Flow chart for Dynamic Programming strategy

The major skilled cost effective combination of units can be all around decided utilizing the recursive connection. Impressive computational cost minimize can be achieved by utilizing this strategy. It isn't compulsory to tackle the co-ordination equation. The aggregate figure of units easy to get to, their individual cost attributes and load cycle should be known. Just when the operations at the prior stages are not influenced by the choices at the later stages this strategy is suitable.

V. TEST POWER SYSTEM AND MATLAB RESULTS

The unit (UCP) arrangement strategy is actualized in Matlab R2010a. A generation organization with 4 and 10 generating units to outline the proposed technique. In our execution, energy balance and power reserve are considered at the same time in the detailing

8 hours and 24 hours scheduling period is considered. Fuel cost function of each unit is evaluated into quadratic equation .Unit information, load demand, fuel cost coefficient and market costs are given in Tables I and IV.

Table: I Generating Unit characteristics-4 Unit Model

UNITS	P_{min}	P_{max}	MU_i	MD_i	H_{cost}	C_{cost}	C_{hour}	Initial State
Unit 1	25	80	4	2	150	350	4	-5
Unit 2	60	250	5	3	170	400	5	+8
Unit 3	75	300	5	4	500	1100	5	+8
Unit 4	20	60	1	1	0	0.02	0	-6

Table: II Time varying load demand of 4 unit system

Load Demand (MW)	450	530	600	540	400	280	290	500
Time in Hour	1	2	3	4	5	6	7	8

Table: III Result of 04 units system using proposed technique

Hour Demand Tot.Gen Min MW Max MW ST-UP Cost Prod.Cost F-Cost State Units ON/OFF
0 - - 135 550 0 0 0 13 0 1 1 0
1 450 450 135 550 0 9208 9208 13 0 1 1 0
2 530 530 135 550 0 10648 19857 13 0 1 1 0
3 600 600 155 610 0 12450 32307 14 0 1 1 1
4 540 540 135 550 0 10828 43135 13 0 1 1 0
5 400 400 135 550 0 8308 51444 13 0 1 1 0
6 280 280 135 550 0 6192 57635 13 0 1 1 0
7 290 290 135 550 0 6366 64002 13 0 1 1 0
8 500 500 135 550 0 10108 74110 13 0 1 1 0

Table: IV Generating unit characteristic-10 unit system

UNITS	P_{max}	P_{min}	A	B	C	MU_i	MD_i	H_{cost}	C_{cost}	C_{hour}	IniState
Unit1	455	150	1000	16.19	0.00048	8	8	4500	9000	5	8
Unit2	455	150	970	17.26	0.00031	8	8	5000	10000	5	8
Unit3	130	20	700	16.6	0.002	5	5	550	1100	4	-5
Unit4	130	20	680	16.5	0.00211	5	5	560	1120	4	-5
Unit5	162	25	450	19.7	0.00398	6	6	900	1800	4	-6
Unit6	80	20	370	22.26	0.00712	3	3	170	340	2	-3
Unit7	85	25	480	27.74	0.00079	3	3	260	520	2	-3
Unit8	55	10	660	25.92	0.00413	1	1	30	60	0	-1
Unit9	55	10	665	27.27	0.00222	1	1	30	60	0	-1
Unit10	55	10	670	27.79	0.00173	1	1	30	60	0	-1

Table: V Time varying load demand of 10 unit system

Hour Demand Tot.Gen Min MW Max MW ST-UP Cost Prod.Cost F-Cost State
0 - - 300 910 0 0 0 615
1 700 700 300 910 0 13683 13683 615
2 750 750 300 910 0 14554 28238 615
3 850 850 325 1072 900 16809 45947 764
4 950 950 345 1202 560 19146 65653 838
5 1000 1000 345 1202 0 20020 85673 838
6 1100 1100 365 1332 1100 22387 109160 924
7 1150 1150 365 1332 0 23262 132422 924
8 1200 1200 365 1332 0 24150 156572 924
9 1300 1300 410 1497 860 27251 184683 1006
10 1400 1400 420 1552 60 30058 214801 1018
11 1450 1450 430 1607 60 31916 246777 1023
12 1500 1500 440 1662 60 33890 280727 1024
13 1400 1400 420 1552 0 30058 310785 1018
14 1300 1300 410 1497 0 27251 338036 1006
15 1200 1200 365 1332 0 24150 362186 924
16 1050 1050 365 1332 0 21514 383700 924
17 1000 1000 365 1332 0 20642 404341 924
18 1100 1100 365 1332 0 22387 426728 924
19 1200 1200 365 1332 0 24150 450879 924
20 1400 1400 420 1552 920 30058 481856 1018
21 1300 1300 410 1497 0 27251 509107 1006
22 1100 1100 370 1237 0 22736 531843 868
23 900 900 320 990 0 17645 549488 701
24 800 800 300 910 0 15427 564916 615

Table: VI Result of 10 units system using proposed dynamic optimization

Time in Hour	Load Demand (MW)
1	700
2	750
3	850
4	950
5	1000
6	1100
7	1150
8	1200
9	1300
10	1400
11	1450
12	1500
13	1400
14	1300
15	1200
16	1050
17	1000
18	1100
19	1200
20	1400
21	1300
22	1100
23	900
24	800

Table: VII Turn on/off status of 10 units system using proposed dynamic optimization

Load Demand (MW)	U1	U2	U3	U4	U5	U6	U7	U8	U9	U10
700	1	1	0	0	0	0	0	0	0	0
750	1	1	0	0	0	0	0	0	0	0
850	1	1	0	0	0	0	0	0	0	0
950	1	1	0	0	1	0	0	0	0	0
1000	1	1	0	1	1	0	0	0	0	0
1100	1	1	0	1	1	0	0	0	0	0
1150	1	1	1	1	1	0	0	0	0	0
1200	1	1	1	1	1	0	0	0	0	0
1300	1	1	1	1	1	0	0	0	0	0
1400	1	1	1	1	1	1	1	0	0	0
1450	1	1	1	1	1	1	1	1	0	0
1500	1	1	1	1	1	1	1	1	1	0
1400	1	1	1	1	1	1	1	1	1	1
1300	1	1	1	1	1	1	1	1	0	0
1200	1	1	1	1	1	1	1	0	0	0
1050	1	1	1	1	1	0	0	0	0	0
1000	1	1	1	1	1	0	0	0	0	0
1100	1	1	1	1	1	0	0	0	0	0
1200	1	1	1	1	1	0	0	0	0	0
1400	1	1	1	1	1	1	1	1	0	0
1300	1	1	1	1	1	1	1	0	0	0
1100	1	1	1	0	0	0	1	0	0	0
900	1	1	0	0	0	1	0	0	0	0
800	1	1	0	0	0	0	0	0	0	0
Total Cost ($)							**564916**			

Table: VIII Comparison of result of UCP using proposed algorithm

S.NO	METHOD	UNIT	TOTAL COST($)
1	EGA	4	77628.91
2	DP	4	74110.00
3	EGA	10	563937.57
4	DP	10	564916.00

VI. CONCLUSION

This mathematical optimization technique has been displayed to take care of thermal unit (UCP) by utilizing dynamic programming approach. For singular sub problem dynamic programming without discrediting power generation levels ended up being a proficient approach. [11] This strategy gives the advantage of non-discretization of generation levels and is turned out to be effective for power system with a couple of incline rate constrained units. The heuristic technique created to get achievable arrangements is powerful and close ideal arrangements are gotten.

REFERENCES

[1] Titti Saksornchai, Wei-Jen Lee, Kittipong Methaprayoon, James R. Liao and Richard J. Ross (2005), ‘‘Improve the Unit Commitment Scheduling by using the Neural-Network-Based Short-Term Load Forecasting’’ IEEE Transactions on Power Systems,Vol. 41, Year 2005 , pp. 169 – 179.

[2] Shantanu Chakraborty,Tomonobu Senjyu, Atsushi Yona, Ahmed Yousuf Saber and Toshihisa Funabashi (2009), “Generation Scheduling of Thermal Units Integrated with Wind-Battery System Using a Fuzzy Modified Differential Evolution”, Year 2009 , pp. 1-6

[3] Morteza Eslamian, Seyed Hossein Hosseinian, and BehroozVahidi (2009), ''Bacterial Foraging-Based Solution to the Unit-Commitment Problem '' IEEE transactions on power systems, vol.24, No.3 year Aug. 2009, pp. 1478-1488.

[4] Yare Y., Venaya gamoorthy G. K., and Saber A. Y. (2009), "Economic Dispatch of A Differential Evolution Based Generator Maintenance Scheduling of A Power System", IEEE Transactions on Power Systems, Vol. 12 July 2009, pp. 1-8.

[5] S.O. Orero and M.R. Irving (2002), ''A Genetic Algorithm Modeling Power system and Solution Technique for Short Term Optimal Hydrothermal Scheduling'' IEEE Transactions on Power Systems, Vol. 13, May 1998, pp 501-518.

[6] Gary W. Chang, Mohamed Aganagic, James G. Waight, José Medina, Tony Burton ,Steve Reeves, and M. Christoforidis (2001), "Mixed Integer Linear Programming Based Approaches on Short- Term Hydro Scheduling" IEEE Transactions ON power systems, vol. 16, No. 4, November 2001 pp.743-749.

[7] G. K. Purushothama and Lawrence Jenkins (2003), ''Simulated Annealing With Local Search A Hybrid Algorithm for Unit Commitment '' IEEE Transactions on Power Systems, Vol.18, No. 1, Year feb. 2003, pp.273-278.

[8] Ebrahimi, J.Hosseinian, S.H.(2011),''Unit Commitment Problem Solution using Shuffled Frog Leaping Algorithm''IEEE Transactions on Power Systems, Vol. 26, Year 2011, pp. 573 -581.

[9] Ioannis G. Damousis, Anastasios G. Bakirtzis and Petros S. Dokopoulos (2004), "A Solution to Unit Commitment Problem Using Integer Coded Genetic Algorithm '' IEEE Transactions on Power Systems,Vol.19, No. 2, May 2004, pp. 1165- 1172

[10] Navpreet Singh Tung, Ashutosh Bhadoria, Kiranpreet Kaur, Simmi Bhadauria." Dynamic programming model based on cost minimization algorithms for thermal generating units", International Journal of Enhanced Research in Science Technology & Engineering, Vol 1, issue 3,Dec 2012 pp.2319-7463.

[11] R.H. Kerr, J.L. Scheidt, A.J. Fontana and J.K. Wiley, "Unit Commitment", IEEE Transactions on Power Apparatus and Systems, vol.PAS-85, No.5,May 1966, pp.417-421,