Proc. of Int. Conf. on Current Trends in Eng., Science and Technology, ICCTEST

Fuzzy Logic Solution for Unit Commitment

Akshay S Aspalli[1], Raveendra R[2] and Anita I Patil[3]
[1-3]Assistant Professor /Don Bosco Institute of Technology/EEE, Bangalore, India
[1]Email: aspalliakshay@gmail.com, [2]Email: ravi73193@gmail.com, [3]Email: mrs.anitaravi@gmail.com

***Abstract*—This paper presents fuzzy logic solution to unit commitment and economic dispatch. Unit commitment is aimed to a proper generator commitment schedule for a power system over a period of one day to one week. The main objective of unit commitment is to minimize the total production cost over the study period and to satisfy the constraints imposed on the system such as power generation-load balance, spinning reserve, operating constraints, minimum up time and minimum down time, etc. In this, fuzzy logic approach is described which achieves a logical and feasible economic cost of operation of power system without the need of exact mathematical formulation.**

***Index Terms*— Fuzzy logic, unit commitment, defuzzification fuzzy rules.**

I. Introduction

The use of fuzzy logic has received increased attention in recent years because of its usefulness in reducing the need for complex mathematical models in problem solving. Rather, fuzzy logic employs study of terms which deal with the causal relationship between input and output variables. For this reason, the approach makes it easier to manipulate and solve many problems, particularly where the mathematical model is not explicitly known, or is difficult to solve. Furthermore, fuzzy logic is a technique which approximates reasoning, while allowing decisions to be made efficiently.

II. Existing Methods

A. Priority List Method

A simple shutdown rule or priority list schemes could be obtained after an exhaustive enumeration of all units combinations of each load level. Priority list methods are easy fast but they are highly heuristic and give schedules with relatively highly production cost.

B. Lagrangean Relaxation Method

In this method minimization cost function decomposed into N smaller minimization problems one for each unit takes more time for solution by
Iteration procedure. And in this method used to concept of equal incremental cost which will also give high production cost.

C. Dynamic Programming Method

The main limitation of the dynamic programming method is in treating time dependent constraints such as

Grenze ID: 02.ICCTEST.2017.1.74

unit minimum up and down time, start-up cost etc. It causes the dimensionality and gives sub-optional solution.

III. UNIT COMMITMENT PROBLEM

Shifting load demands on the power supply system require that a sufficient number of generating units be committed to supply the required load. Because of the tremendous expense involved in unit commitment, the electric utility must determine which generators are the most economical to operate and the combinations of units that should be committed to meet a given load demand.

Problems associated with unit commitment have generally been difficult to solve because of the uncertainty of particular aspects of the problem. For instance, the availability of fuels, imprecise load forecasts variable costs affected by the loading of generating units of different fuels or water rates, and losses caused by reactive flows are some of the unpredictable issues. These and other problems of inconsistency affect the overall economic operation of the electric power system. In order to reach a feasible solution to this economic enigma, different constraints must be considered, such as spinning reserve, thermal unit constraints, must-run units, fuel constraints, power generation-load balance, and other operating constraints.

Must-run constraints are included because those units placed on must-run status during particular periods throughout the year are needed as voltage support on the transmission network or to supply process steam. Further, fuel constraints are essential in deriving an optimal energy mix in order to achieve the lowest total fuel cost.

Fuzzy logic represents an effective alternative to conventional solution methods It attempts to quantify linguistic terms so that the variables can be treated as continuous rather than as discrete. In this process, the qualitative behavior of a system, the system's characteristics and response may be described without the need for exact mathematical formulations.

IV. FUZZY-LOGIC-BASED UNIT COMMITMENT

FUZZY logic is a mathematical theory, which encompasses the idea of vagueness when defining a concept mining. For example, there is uncertainty are ‘fuzziness’ in expressions like ‘large’ or ‘small’, since these expressions are imprecise or relative variables considered thus are termed ‘fuzzy.’ Fuzziness is simply one means of describing uncertainty. Such ideas are readily applicable to unit problem.

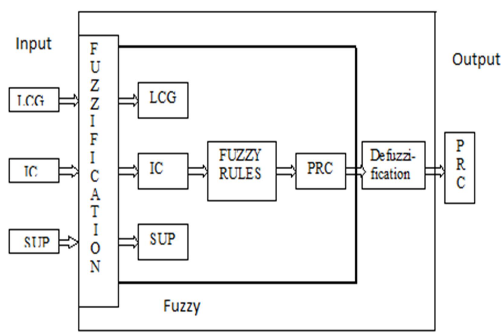

Fig.1. The overall block diagram of unit commitment using fuzzy logic

LCG: Load Capacity Of Generator;
IC: Incremental Cost
PRC: Production Cost.
SUP: Start Up Cost;

A. Fuzzy Variables

Fuzzy input variables

- Load capacity of generator(LCG)
- Incremental cost(IC)
- Start up cost(SUP)

Fuzzy output variables

- Production cost (PRC)

Load capacity of the generator is considered to be fuzzy, as it is based upon load to be served. Incremental cost is taken to be fuzzy, because the cost of fuel for each unit may be different. Further, the startup cost of unit is assumed to fuzzy, because some units more time than others to be placed on line. Finally, production cost of the system (which includes no load cost of the system) is treated as fuzzy variable since it is directly proportional to the hourly load. Certain other variables, such as minimum up time, minimum down time and generator limitation, are considered to be crisp variables in the unit commitment problem.

B. Fuzzy Sets Associated With Unit Commitment

After identifying the fuzzy variables associated with the unit commitment, the fuzzy sets defining these variables are selected and normalized between 0 and 1. This normalized value can be multiplied by a selected scale factor to accommodate any desired variable. The sets defining the load capacity of generator (LCG) are as follows

LCG (MW) = {Low (Lo), Below Average (Bav), Average (Av), Above Average (AAV), High (H)}

The incremental cost (IC) is stated by the following sets,

IC (Rs) = {Least, Small, Large}

The Startup cost (SUP) is defined by the following sets,

SUP (Rs) = {Low, Medium, High}

The production cost, chosen as the objective function is given by,

PRC (Rs) = {Low (Lo), Below Average (Bav), Average (Av), Above Average (AAV), High (H)}

Suitable ranges are selected for the fuzzy sets selected from the given problem

C. Membership Function

Based on the fuzzy sets, the membership functions are chosen for each fuzzy input and output variables. Triangular membership function is chosen for all the fuzzy variables.

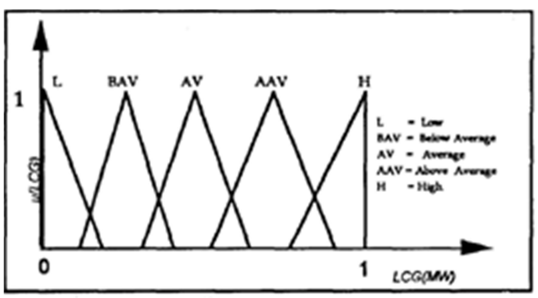

Fig. 2. Membership Function of Load Capacity of Generator

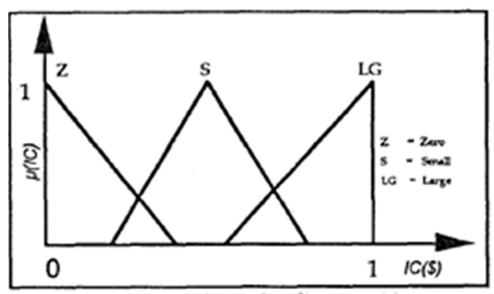

Fig. 3. Membership Function of Incremental Cost

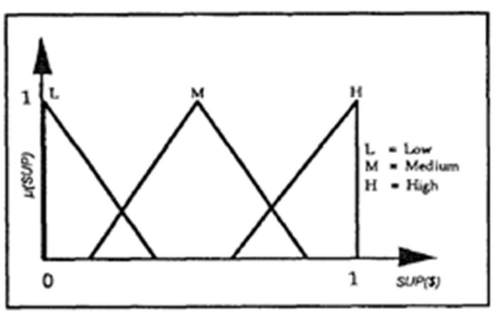

Fig. 4. Membership Function of Start-up Cost

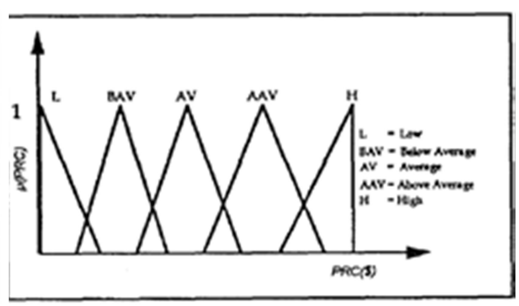

Fig. 5. Membership Function of Production Cost

Fuzzy If - Then Rules

In a fuzzy-logic-based approach, decisions are made by forming a series of rules that relate the input variables to the output variable using gif-then statements. The If (condition) is an antecedent to the Then (consequence) of each rule. Each rule in general can be represented in the following manner:

If (antecedent) Then (consequence)

Load capacity of generator, incremental cost, and startup cost are considered as input variables and production cost is treated as the output variable. This relation between the input variables and the output variable is given as:

Production Cost = {Load Capacity of Generator) and {Incremental Cost} and (start-up Cost}

In fuzzy set notation this is written as

PRC = LCG n IC n SUP

Using the above notation, fuzzy rules are written to associate fuzzy input variables with the fuzzy output variable. Based upon these relationships, and with reference to Figs. 2-5, a total of 45 rules can be composed (since there are 5 subsets for load capacity of generator, 3 subsets for incremental cost, and 3 subsets for start-up cost (5+3*3 = 45)). Fig. 6 shows the relationships for some of the rules, and can be applied to all 45.

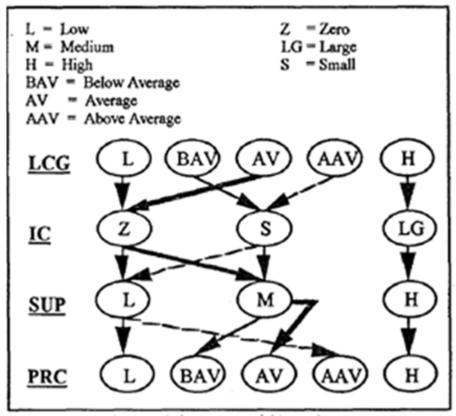

Fig. 6. Relating Input Variables to Output

These rules are composed in the following manner.

If LCG is (·), IC (·) and SUP cost is (·), then production cost is (·).For example, using figure above 5 rules for the LCG can be written as follows;

Rule 1

If Load Capacity of Generator is Low,
Incremental Cost is Least and
Start up cost is Low, then the production cost is Low.

Rule 2

If Load Capacity of Generator is BAV,
Incremental Cost is small and
Start up cost is Medium, and then the production cost is BAV.

Rule 3

If Load Capacity of Generator is AV,
Incremental Cost is Least and
Start up cost is Medium, then the production cost is AV.

Rule 4

If Load Capacity of Generator is AAV,
Incremental Cost is small and
Start up cost is Low, then the production cost is AAV.

Rule 5

If Load Capacity of Generator is High,
Incremental Cost is Large and
Start up cost is high, then the production cost is High.

In similar manner total 45 rules can be formed.

V. Case Study And Simulation

A. Results

Fuzzy logic simulations are obtained through MATLAB. The result obtained by the fuzzy logic approach (FLA) is compared with solution obtained from Lagrangean Relaxation Method.

TABLE I. THREEUNIT SYSTEM

S.N	Pmax (MW)	Pmin (MW)	a (Rs/hr)	b (Rs/MWhr)	c (RS/MW^{2}hr)
1	450	200	500	5.3	0.004
2	350	150	400	5.5	0.006
3	225	100	200	5.8	0.009

TABLE II. LOAD

SL.NO	Load(MW)
1.	848
2.	890
3.	931
4.	966
5.	1025
6.	1000
7.	950

Simulation Results

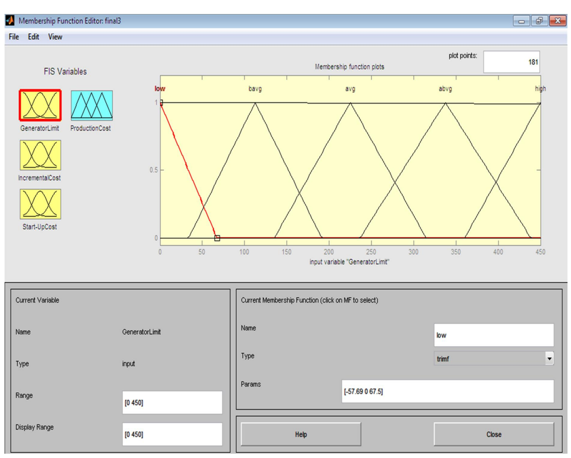

Fig.7 Feeding values to the variables

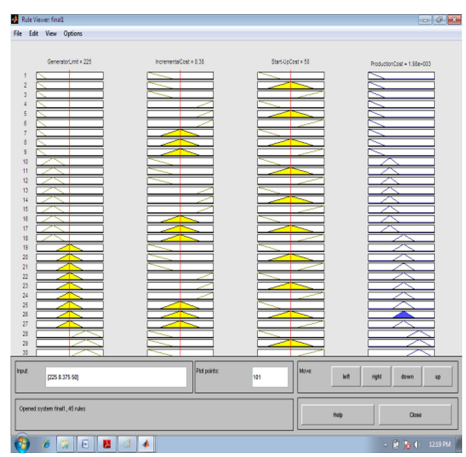

Fig.8 Output of fuzzy in terms of production cost

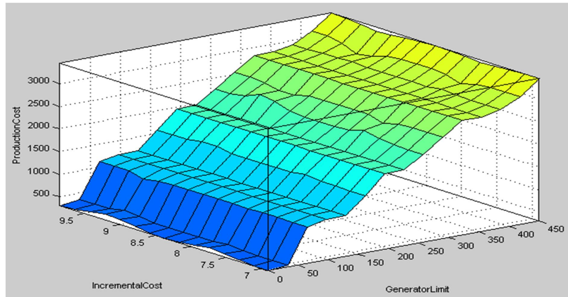

Fig.9 Incremental Cost Vs Production cost considering Generator limit Fuzzy

TABLE III. COMPARISON BETWEEN PRODUCTION COST IN RS OBTAINED FROM FUZZY LOGIC WITH LR METHOD

SL. NO	LOAD (MW)	Unit combination	Production Cost in Rs	
			LR Method	Fuzzy Method
1	848	111	7095	7080
2	890	111	7463	7520
3	931	111	7830	7570
4	950	111	8004	7970
5	966	111	8147	8220
6	1000	111	8474	8220
7	1025	111	8716	8220
		TOTAL	**Rs 55,730**	**Rs 54,800**

VI. CONCLUSION

The unit commitment and economic dispatch calculations can be solved by using fuzzy logic and this method can be applied to any number of units, each with different operating costs from this approach; we can also conclude that the outcomes are easily understood in terms of the logical representation of the rules. The feasibility of using this method to solve a combinational problem has been demonstrated. The unit commitment schedule is obtained by considering equal incremental criterion. The unit commitment can be described linguistically then such linguistic description can be translated to a solution that yields similar results compared to conventional method.

REFERENCES

[1] Ahmed Yousuf Saber , Tomonobu Senjyu, Naomitsu Urasaki *"*Fuzzy Unit Commitment Scheduling Using Absolutely Stochastic Simulated Annealing" IEEE transactions on power systems, VOL. 21, NO. 2, MAY 2006, pp 953-964.

[2] Dr. K. Duraiswamy, S. Chenthur Pandian **"**Fuzzy Logic Implementation for Solving the Unit Commitment Problem" 2004 International Conference on Power System Technology - POWERCON 2004 Singapore, 21-24 November 2004, pp 413-418

[3] D.P.Kadam, P. M. Sonwane, V. P. Dhote, B. E. Kushare "Fuzzy Logic Algorithm for Unit Commitment Problem" International Conference on "Control, Automation, Communication and Energy Conservation -2009, 4th-6th June 2009.

[4] Seyedrasoul, Saneifard Nadipuram, R. Prasad Howard and Smolleck “A Fuzzy Logic approach to Unit Commitment” IEEE Transactions on Power Systems, Vol. 12, No. 2, May 1997, pp 986-995.
[5] Allen J Wood and Bruce F Wallenberg, “power generation,operation and Control", John Wiley and sons, New York.

BIOGRAPHY

Rudresh.B.magadum was born in Karnataka,India in 1987.He is currently studing for M.Tech Degee in Power and energy systems Electrical and electronic Engineering inBasaveshwar engineering college (Autonomous) ,Bagalkot.