OPTIMIZATION OF MICRO GRID USING FUZZY TOOL

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ABSTRACT

Distributed generation (DG) are small scale power producers close to end user of power. Thisis having are many technical,environmental and economic benefits. By proper placement of DGs at optimal location with optimal size, benefits of DG can be maximized. In this paper the optimal capacity of distributed generation (DG) plant in a microgrid is determined to minimize the cost function. One case is considered to solve the cost function. Here the method is applied on diesel, wind and solar power unit. In this case uncertainty is considered in installation cost and no. of power units of DG. To deal with this uncertainty fuzzy logic is used and membership function made which defuzzified by fourdifferent methods and converted into linear mathematical programming.

Keywords: Distributed generation (DG), Microgrid (MG),Fuzzy linear programming (FLP), Defuzzification

I. INTRODUCTION

The best possible size and position of DG units in the area of the load causes a reduction in losses on the power networks and also the thermal losses at the power station and improves voltage profile [1], [2]. The generation sources driven by renewable resources are of great worth in MG, which holds DG along with other constituents. In actuality, as such generation sources delivers end consumers a better power quality, letfacility of higher reliability electric service, and decrease pollutant levels [3], [4]. It helps to reduce greenhouse gas emission. There has been a wide range of modular size from 5 KW to 500 MW [5]. Table 1 shows the available DG modular sizes. Storage devices, such as flywheels and batteries are used in improving the efficiency and stability of MG [6], [7].

The Control of frequency and voltage is done by local controllers. These controllers control inverters to produce the active power needed by demand side. It is to establish equilibrium between production and consumption [8], [9]. MGs central controller (MCC) determines the set point for each local controller. And MCC is controlled by the MGs operating system [10], [11].

In practical problem,the maximum time the information is unspecified. To deal this uncertainty fuzzy logic was introduced. Linear programming is one of most used techniques in operation research. Membership function

(MF) developed and various methods can be used to defuzzify it. MF can be of triangular shape, square, trapezoidal, depends on input quantity [12].

In this paper, focus is to find the optimal capacity of DG plant in a micro-grid to minimize the cost function. Uncertainty case istaken to determine the cost function. Here the method is applied on wind, diesel andsolar power unit. In this case uncertainty of installation cost and no of power units of DG has been involved. To deal with uncertainty fuzzy logic tool is used and membership function are generated which defuzzified by different methods and converted into linear mathematical programming.

TABLEI.

DG MODULAR SIZE [5]

SI NO.	DG TECHNOLOGY	AVAILABLE POWER MODULE SIZE
1	COMBINED CYCLE GAS TURBINES	35-400 MW
2	INTERNAL COMBUSTION ENGINES	5KW-10 MW
3	COMBUSTION TURBINE	1-250 MW
4	MICRO-TURBINE	35KW -1 MW
5	FUEL CELLS	200KW-2 MW
6	BATTERY STORAGE	0.5-5 MW
7	HYDRO POWER	1-25 MW
8	WIND TURBINES	200W-3 MW
9	SOLAR PV	20 W -100 KW
10	SOLAR THERMAL POWER PLANT	1-10 MW
11	BIOMASS GASIFICATION BASED	100KW-20 MW
12	OCEAN ENERGY	0.1-1 MW

II. PROBLEM STATEMENT

To determine the optimal capacity ofsolar power unit, wind power unit and diesel power unitunder fuzzy environment to minimize the cost function is considered. Some assumptions have been made to frame the model into mathematical form. The case leads to the fuzzy linear programming problem. Assumption while framing the model is given below for different case.

Problem statement

- Numbers of unit of DG is uncertain.
- Electricity Price of is uncertain.
- All three units should generate at least 1MW unit of power.
- Each plant should generate at least some electricity.

- Diesel engine should generate power at least twice of combination of wind and solar plant.
- Each plant must generate some least define amount of power and we kept varying minimum limit of generation of power.

III. METHODOLOGY

To solve case I linear programing is used to frame and solve mathematical model, while case II is solved using fuzzy logic. By which mathematical model is framed. The fuzzy logic phases is shown in Fig 1

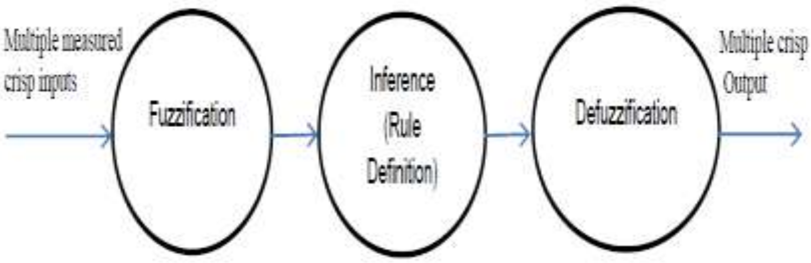

Fig 1. Fuzzy Logic Phases

IV. ASSOCIATED COST OF DG's PLANT

R. Banerjee and A. Nayak reviewed the different technological options available for DG; their current status and evaluated them based on the generation cost and India's future potential [6-7] .The generation cost is dependent on load factor and discount rate. It includes cost of operation and maintenance. Installation cost for different plant taken in Rs / KW and as follows

1. Cost of wind power generator (C_w) =50,000 Rs /kW
2. Cost of diesel power generator (C_c) = 25000 Rs /kW
3. Cost of solar power generator (C_s) =144,000 Rs/kw

V. MATHEMATICAL MODEL

Based on the above problem statement objective function and subject to constraints are made and framed in mathematical form which is given below.

Objective function- here objective is to minimize the cost function.Cost coefficients of the objective function are crisp value i.e. single valued [13]. Mathematically objective function can be represented as-

$$Min\ \Sigma(C_w N_w X_w + C_c N_c X_c + C_s N_s X_s)$$

Subject to constraints

1. $N_w X_w + N_c X_c + N_s X_s \geq 1000kW$
2. $X_w \geq 100kW$
3. $X_c \geq 100kW$

4. $X_s \geq 100kW$
5. $N_w X_w + N_s X_s \leq 0.5 N_c X_c$

Where

C_w: cost of wind power generator (Rs/kw)

C_s: cost of solar power generator (Rs/kw)

C_c: Cost of diesel engine generator (Rs/kw)

X_w: Capacity of wind power generator unit (kW)

X_s: Capacity of solar power generator unit (kW)

X_c: Capacity of diesel power generator unit (kW)

N_w : No. of Wind Units.

N_s : No. of Solar Units.

N_c : No. of Diesel Units.

VI. MEMBERSHIP FUNCTION

Figure 2-7 represents membership function of Wind, Solar and Diesel Power Plant. It is required to solve the linear programing using simplex method.

Cost range of wind power plant is from Rs 144000 to Rs 520000 where membership function is 1 from 144000 to 350000 and decreases continuously and becomes 0 at 520000. Similarly Cost range of solar and diesel power plant range from Rs 426000 to Rs 1460000 and Rs 46000 to Rs 216000 respectively. Their membership function remains 1 up to 1015000 and 150000 respectively and becomes 0 at 1460000 and 270000 respectively.

No. of units for wind power plant is from 3 to 10 where membership function is increasing from 0 to 1 from 3 to 7 and decreasing again to 0 from 7 to 10. Similarly for solar and diesel plant range is from 3to 10 and 2 to 8 respectively.

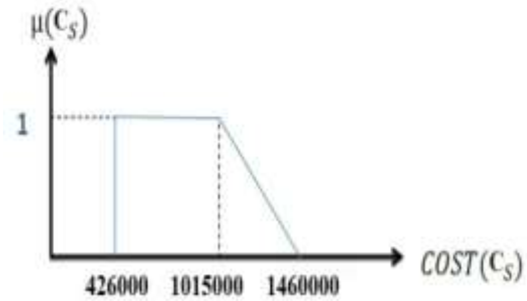

Figure:2 Cost of Solar Power Plant

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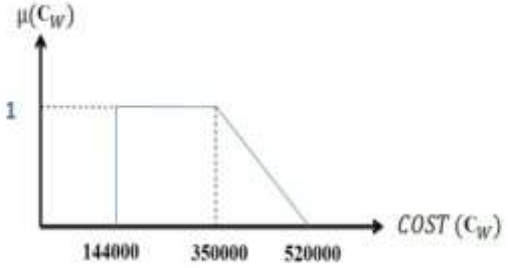

Figure:3 Cost of Wind Power Plant

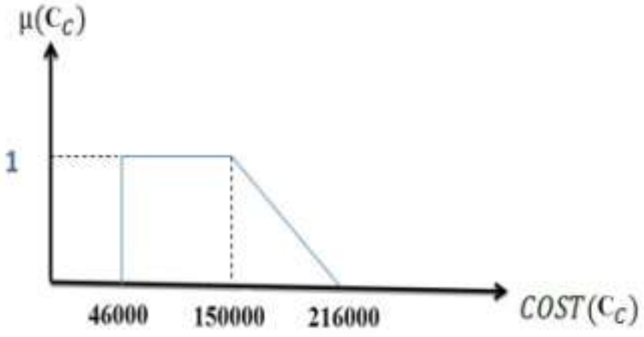

Figure:4 Cost of Diesel Power Plant

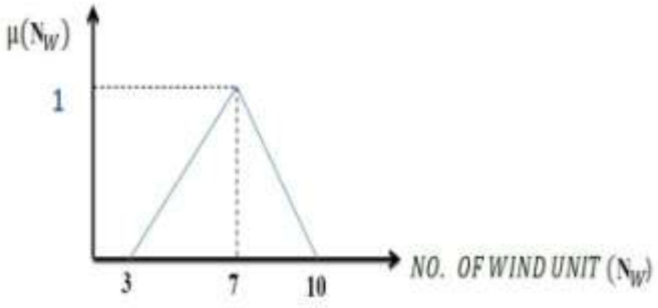

Figure:5 No. of Wind Unit

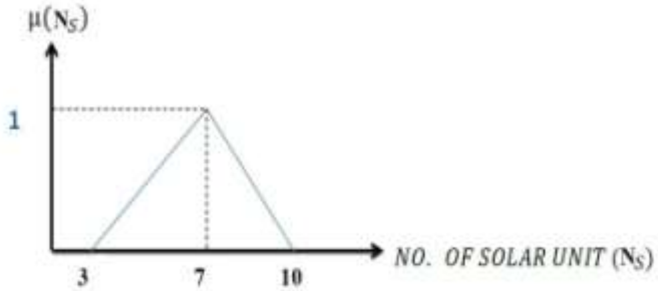

Figure:6No. of Solar Unit

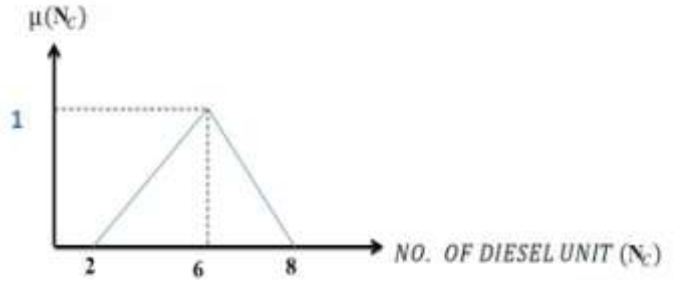

Figure: 7 No. of Diesel Unit

VII. RESULT

For problem Statement Table II represents defuzzified values which are obtained after defining membership function and different techniques by this we can get modified objective function for different techniques which can be solved by simplex algorithms.

TABLE II.
DEFUZZIFIED VALUE FOR DG

Source	Price Range	Centroid	Max Mean	First Or Last Maxima	Bisector
Wind	144000-520000	293610	247000	144000	289500
Solar	426000-1460000	841890	720500	426000	831700
Diesel	46000-216000	115800	98000	46000	114500

Table III represents optimal capacity of DG with fuzzy objective using mean-max method for problem statement .Here mean max method is used in defuzzification to get the objective constraint after that Simplex algorithm is used to find the capacity of DG plant. Optimum Value and minimum cost are shown in tabular form for different generation ability. From the table it can be witnessed that optimal value of diesel engine is highest among three and optimal value of solar and wind are minimum of its generation capacity. And also as the value of each DG unit is increased optimal value is also increased in the same proportion for wind and solar plant, but diesel plant produces large power since it involves less cost. So it is increases in large proportion.

Table IV represents optimal capacity of DG with fuzzy objective using Centroid method for problem statement .Here centroid method is used in defuzzification to get the objective constraint after that Simplex algorithm is used to find the capacity of DG plant. Comparing mean max and centroid method we find that mean max give better result. Optimum Value and minimum cost are shown in tabular form for different generation ability. From the table it can be witnessed that optimal value of diesel engine is highest among three and optimal value of solar and wind are minimum of its generation capacity. And also as the value of each DG unit is increased optimal value is also increased in the same proportion for wind and solar plant, but diesel plant produces large power since it involves less cost. So it is increases in large proportion.

Table V represents optimal capacity of DG with fuzzy objective using bisector method for problem statement .Here bisector method is used in defuzzification to get the objective constraint after that Simplex algorithm is used to find the capacity of DG plant. Comparing mean max, centroid & bisector method we find that mean max give better result. Optimum Value and minimum cost are shown in tabular form for different generation ability. From the table it can be witnessed that optimal value of diesel engine is highest among three and optimal value of solar and wind are minimum of its generation capacity. And also as the value of each DG unit is increased optimal value is also increased in the same proportion for wind and solar plant, but diesel plant produces large power since it involves less cost. So it is increases in large proportion.

.Table VI represents optimal capacity of DG with fuzzy objective using First or Last maxima method for problem statement .Here First or Last maximamethod is used in defuzzification to get the objective constraint after that Simplex algorithm is used to find the capacity of DG plant. Comparing mean max, centroid, First or last maxima & bisector method we find that First or last maxima give better result. Optimum Value and minimum cost are shown in tabular form for different generation ability. From the table it can be witnessed that optimal value of diesel engine is highest among three and optimal value of solar and wind are minimum of its generation capacity. And also as the value of each DG unit is increased optimal value is also increased in the same proportion for wind and solar plant, but diesel plant produces large power since it involves less cost. So it is increases in large proportion.

TABLE III.

OPTIMAL CAPACITY OF DG WITH FUZZY OBJECTIVE USING MEAN-MAX METHOD

S.No.	(X) Capacity (kW) (X 100)			(X) Optimal Value (kW) (X 100)			Minimized Cost (Rs) (X 10^5)
	W	S	C	W	S	C	FLP (max mean)
1	1	1	1	1	1	4.7	1424.84
2	2	1	1	2	1	7	1900.5
3	3	1	1	3	1	9.3	2376.16
4	1	2	1	1	2	7	2374
5	2	2	1	2	2	9.3	2849.66

6	1	3	1	1	3	9.3	3323.16
7	3	2	1	3	2	11.7	3325.36
8	2	3	1	2	3	11.7	3798.86
9	3	3	1	3	3	14	4274.5

TABLE IV.

OPTIMAL CAPACITY OF DG WITH FUZZY OBJECTIVE USING CENTROID METHOD

S.No.	(X) Capacity (kW) (X 100)			(X) Optimal Value (kW) (X 100)			Minimized Cost (Rs) (X 10^5)
	W	S	C	W	S	C	FLP (Centroid)
1	1	1	1	1	1	5	1714.89
2	2	1	1	2	1	7.5	2298.19
3	3	1	1	3	1	10	2881.53
4	1	2	1	1	2	7.5	2846.48
5	2	2	1	2	2	10	3429.81
6	1	3	1	1	3	10	3978.09
7	3	2	1	3	2	12.5	4013.03
8	2	3	1	2	3	12.5	4561.31
9	3	3	1	3	3	15	5144.65

TABLE V.

OPTIMAL CAPACITY OF DG WITH FUZZY OBJECTIVE USING BISECTOR METHOD

S.No.	(X) Capacity (kW) (X 100)			(X) Optimal Value (kW) (X 100)			Minimized Cost (Rs) ($X 10^5$)
	W	S	C	W	S	C	FLP (Bisector)
1	1	1	1	1	1	4.9	1679.12
2	2	1	1	2	1	7.3	2247.59
3	3	1	1	3	1	9.7	2816.05
4	1	2	1	1	2	7.3	2789.79
5	2	2	1	2	2	9.7	3358.25
6	1	3	1	1	3	9.7	3900.45
7	3	2	1	3	2	12.2	3926.73
8	2	3	1	2	3	12.2	4468.93
9	3	3	1	3	3	14.6	5037.36

TABLE VI.

OPTIMAL CAPACITY OF DG WITH FUZZY OBJECTIVE USING FIRST OR LAST MAXIMA METHOD

S.No.	(X) Capacity (kW) (X 100)			(X) Optimal Value (kW) (X 100)			Minimize d Cost (Rs) ($X 10^5$)
	W	S	C	W	S	C	FLP (FOLM)

1	1	1	1	1	1	4.7	784.66
2	2	1	1	2	1	7	1036
3	3	1	1	3	1	9.3	1287.33
4	1	2	1	1	2	7	1318
5	2	2	1	2	2	9.3	1569.33
6	1	3	1	1	3	9.3	1851.33
7	3	2	1	3	2	11.7	1820.68
8	2	3	1	2	3	11.7	2102.68
9	3	3	1	3	3	14	2354

VIII. CONCLUSION

Four different approaches have been applied to find the optimum capacity of DGs so as the cost function is minimized. It can be concluded that diesel engine have to generate most of the power in order to minimize the cost function whereas since cost of solar and wind are high hence it have generate less power as shown in the result. FLP problem with fuzzy objective function is studied in which price of electricity and no of unit was uncertain. From the result we can judge that different defuzzification techniques will give approx. same optimal value, as it is depends on membership function. First or Last Maxima gives improved optimal value among other methods.

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