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To Investigate the Effect in Loss Reduction by Optimum Size of DG Using BFO

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Abstract— ***Distribution system has to meet the demands and to secure sufficient power for all the consumers. This can be achieved by increasing the more number of power units. Distribution generation (DG) causes reduction in power losses, enhances power profile, decreases the cost of generation and also delays the deferring of existing substations. Therefore the future of power generation will be DG. DG at one point can provide solution to the growing problems of the power system and at the other hand they can lead to many problems of the power system. Therefore DG comes with both opportunities and challenges. The advantage and disadvantage of implementing DG in the distribution network depend upon the size and allocation of DG in the distribution system. DGs are of different capacities and are divided into micro, small, medium, and large. Location and size of DG are the two main concerns in installation of DG in the system. In this paper, investigation is done on optimal size of DG in order to obtain minimum losses.***

Index Terms—***BFOA, DG, Newton-Raphson method, DG installation cost.***

I. INTRODUCTION

Old concept of power system, in large power system electrical energy is produced. These are located far from the consumer areas and near to the primary sources. Here the flow of the power is unidirectional i.e. from generation to the consumers. It consists of three stages: first is the generation, second is transmission and third is distribution. From the past few years, power demand is increasing day by day because of increase in population and growing needs of people. This increase in demand may be due to increase local customer connected to the network or due to increase in the social welfare. Therefore due to this the distribution system has to meet the demands and to secure sufficient power for all the consumers. This is done by increasing the more number of power units i.e. increasing the power network capability which means deferring of cable sizes, medium voltage switchgear, Protection device setting, or by installing new small unit generators near the consumer site. This led to the introduction of new term called distribution generator. The lateral solution proved to be beneficial. Distribution generation causes reduction in power losses, enhances power profile, decreases the cost of generation and also delays the deferring of existing substations [1-2]. Therefore the future of power generation will be DG. DG at one point can provide solution to the growing problems of the power system and at the other hand they can lead to many problems of the power system. Therefore DG comes with both opportunities and challenges.

The advantage and disadvantage of implementing DG in the distribution network depend upon the size and allocation of DG in the distribution system.

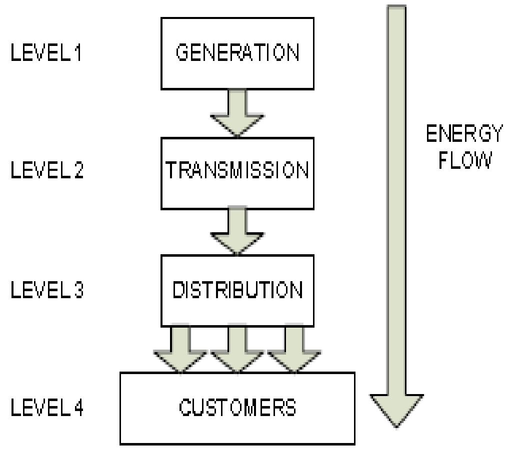

Fig. 1 Traditional industrial conception of electrical energy supply [1].

If DG are properly placed in the distribution network then it will lead to decrease in the system losses, improvement of voltage profile, improvement of power profile and by deferring distribution system upgrading cost saving is also expected. But if DGs are not properly placed in the distribution network then it will result in increase of losses. While designing and planning of distribution system losses are to be considered. Losses cannot be avoided in any network but depending upon the design of the network their amount varies. The level of losses is mainly linked to the power flow. Allocation of DG in the distribution network can reduce losses if they are properly allocated therefore tools are needed by the companies [3]. The impact of DG on distribution system is either positive or negative depending upon the distribution system operating characteristics and DG characteristic [4-5]. DG is a link between the consumers and high transmission lines, radial distribution system consist of main feeders and lateral distributors. The main feeder passes through various consumer loads and originates from the substation. Through individual loads lateral distributors are connected. Due to low voltage and high current, power loss in the system is higher. The overall efficiency can be increased by DG units [6]. Depending upon the operating characteristic of DG and distribution network the installation of DG in the network is either beneficial or disadvantageous.

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DG is beneficial if it meets the basic requirement of system and feeder design. DG may contribute to harmonic distortion in the system if it is installed in the system depending upon the type of DG unit and power converter technology.

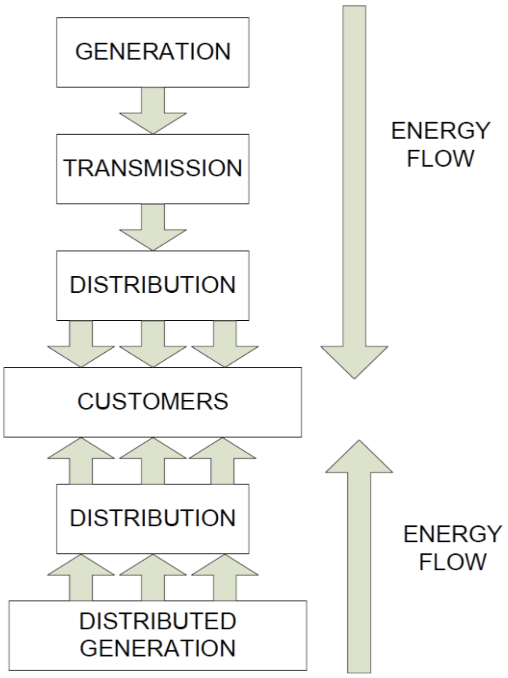

Fig. 2 New industrial conception of electrical energy supply [1].

DGs are classified into two types depending upon the interfacing of DG. First is the inverter based DG and second is the non inverter based DG. Photovoltaic cells, wind turbine, micro-turbine, fuel cells, these DG uses interfacing device called power converter to the grid. On the other hand non inverter DG includes small hydro synchronous generators and induction generators. Before connecting DG to the distribution system the effect of DG on power loss, voltage profile, short circuit current, power system reliability and harmonic distortion is considered separately. DG should be installed near the load centre. The benefits from the DG depend upon how optimally they are installed. About 13% of generated power is consumed as losses. The voltage profile tends to drop below operating levels in the feeder with increase in load. This is due to the rising demand day by day [7]. The advantages of distribution generation comprises of technical, economical and environmental advantages. Voltage support and improved power quality, Loss reduction, Transmission and distribution capacity release, Lowering of cost by avoiding long distance high voltage transmission, Use renewable sources of energy therefore it has positive impact on environment, With use of renewable sources, running cost is more or less constant over the period of time [8-9]. At feeders, radial distribution network has to face voltage instability. Therefore the voltage at the end of the feeder is boosted by DG [10]. To achieve these advantages DG must be of appropriate size, should be reliable, dispatch able and should be connected at appropriate locations [11]. The disadvantage of DG includes harmonics injected by DG, reverse power flow, rise in the fault current depending upon the location of DG in the distribution system. Increase in size of DG reduces the losses but if the size of DG is increased above the limits then the losses again increases and the losses may likely to overshoot the losses of the base case [12-13].

The objective of this paper is to investigate the effect optimal size of DG in order to obtain minimum losses as increase in size of DG does not mean decrease in losses. The information about the size and cost of DG are given in section II. The methodology is given in section III, results and discussions in section IV along with conclusions in section V.

II. SIZE AND COST OF DISTRIBUTED GENERATION

For solving the problem of power flow we use power flow analysis also called load flow study. The benefit of power flow analysis is future expansion of power system and it also has the advantage that it provides the best operation of existing system. It makes use of per unit system and one line diagram and focuses on real, reactive and apparent power of AC. The load is kept constant and is defined by their consumption of real and reactive power. There are three buses specified in the load flow study. First is the load bus second is the generator bus and third is the slack bus. For solving the load flow problem Newton-Raphson method is used. The variables are shown in polar coordinates. It is advantageous as compared to other methods. The number of iterations is independent of the size of the system. The selection of the slack bus is arbitrary [14].

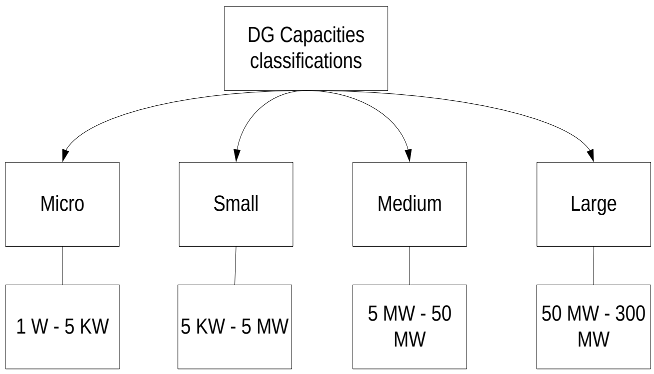

Fig. 3 Different capacities of DG

DGs are of different capacities and are divided into micro, small, medium, and large. Micro DG ranges from 1W to 5 KW capacity. Small DG ranges from 5 KW to 5 MW. Medium DG ranges from 5 MW to 50 MW capacities. Large DG ranges from 50 MW to 300 MW capacities. In this paper, DG size lies in medium range i.e. between 5 MW to 50 MW. The main consideration is to reduce losses in the distribution system by installation of DG in the system.

The size of DG used should be of proper value. The value of the DG must be kept within its specified value. Therefore PD_i must be kept within its maximum and minimum values.

$PD_{i\max}$ = the maximum value of the DG and

$PD_{i\min}$ = the minimum value of DG.

If the DG capacity is less than the specified value i.e. $PD_{i\min}$, then the type and the cost of the particular DG is to be varied. DG capacity limit is given

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as $PD_{i\min} \le PD_i \le PD_{i\max}$. Therefore the value of DG should be within the capacity limits. The cost of distribution system mainly consists of two terms: energy loss cost and DG cost.

Energy loss cost (EL_C),

$$EL_C = (EC * GE)$$

$$EL = [PL_i] * t$$

Where, t = no. of hours in the specified period

PL = power loss in KW

GE = energy loss rate in \$/KWhr. Other one is the DG cost, it consist of installation cost and variable cost.

$$DG_c = \sum_{i=1}^{NDG} GI_c + \left(\sum_{i=1}^{NDG} (P_{DG1} * DG_R) \right)$$

where, P_{DG} = Power generated from DG in KW

DG_R = rate of DG/KW

GI_c = DG installation cost.

Therefore, total cost = $EL_c + DG_c$

Percent net saving = (energy lost cost without DG – energy lost cost with DG + DG_c))/ (energy lost cost with DG) [15].

III. METHODOLOGY

In order to investigate the effect of DG of appropriate sizes with minimum losses, on the percent losses reduction and also comparison of the losses with and without using DG in 14 bus system, BFOA and Newton-Raphson methods are applied. A load flow approach based on Newton-Raphson method is applied to calculate loss without inserting DG. For estimating overall minimum losses by using Newton-Raphson method, by inserting two DGs of different sizes manually in the system is a complex, lengthy and unsuitable situation.

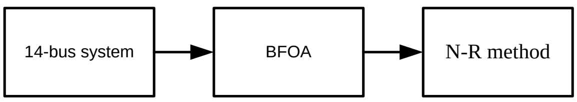

Fig. 4 Improved load flow study system

Thus Fig. 4 shows improved load flow system used in this paper. BFOA is used in such situation to estimate to optimal size of DG. In BFOA, Bacteria moves in random direction (random size of DG) in its specified limits form 10 to 50 MW for both DGs. Point where minima loss is obtained by the bacteria are plotted in form of 3 dimensional plot. This process is repeated until all bacteria die. It is important to note that bacteria don't move at all points but follow minima path only. Points where minima is estimated by BFOA, real losses are calculated by Newton-Raphson method (N-R method). In the experiment active value is always double than reactive value of DG.

Further study is done on the percent loss reduction which occurs between the system before installation of DG and with installation of DG of different sizes estimated by BFOA. The size of DG is the main consideration to have beneficial effect of DG in the distribution system.

IV. RESULT AND DISCUSSION

Analysis were carried out using 14 bus data system to find the optimized size of DG. The valley in the plot in Z axis shown in Fig. 5 display the minima obtained by the BFOA. DG_1 and DG_2 on the X and Y axis respectively represent different sizes. The range of The minima are the location in which bacteria E. coli find the food and for us these are the following minima where the losses are reduced and from these minima we can find the optimum size of DG where the losses are minimum.

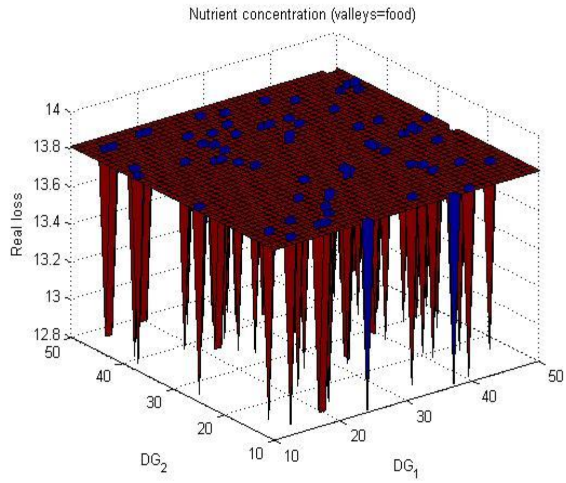

Fig.5 Minima obtained by BFOA

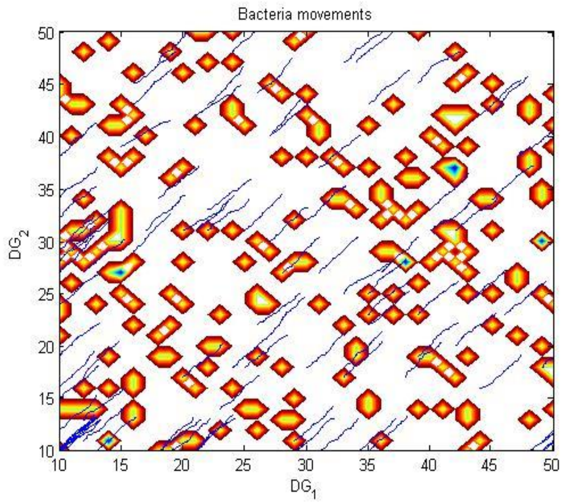

Fig.6 Random movement of bacteria

The Fig. 6 shows the movement of E. coli bacteria. The bacterium moves in specified area in the search of food. Some bacteria may die out in their path and some may die out after reaching their minima i.e. after reaching to their food. Thus the minima i.e. optimum size of DG opted for the reduction of losses is obtained. The appropriate size of DG are placed which improves active power, reactive power and reduces real losses and increased efficiency with a small amount of investment.

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Table.1 Corresponding percentage loss reduction on the minima obtained by BFOA

Value of DG obtained by BFOA (MW)		Active losses	Loss reduction percentage
Real value of DG_1	Real value of DG_2	(MVA)	
11	19	10.92	20.93
11	23	10.60	23.24
11	34	9.96	27.88
12	18	10.88	21.22
12	29	10.08	27.01
13	49	9.51	31.14
14	12	11.24	18.61
14	15	10.94	20.78
14	16	10.84	21.51
14	20	10.48	24.11
15	46	9.30	32.66
16	23	10.04	27.30
17	23	9.93	28.10
18	15	10.50	23.97
19	35	9.09	34.18
21	29	9.16	33.67
22	44	8.66	37.29
22	46	8.66	37.29
23	33	8.80	36.28
26	32	8.58	37.87
26	37	8.42	39.03
27	20	9.21	33.31
27	28	8.69	37.07
27	47	8.26	40.19
28	18	9.28	32.80
30	38	8.10	41.35
30	49	8.07	41.56
31	18	9.04	34.54
31	46	7.98	42.22
33	41	7.87	43.01
35	18	8.76	36.57
36	20	8.53	38.23
37	35	7.72	44.10
37	36	7.69	44.32
38	34	7.69	44.32
39	16	8.66	37.29
39	26	7.97	42.29
40	26	7.91	42.72
42	23	7.97	42.29
42	36	7.42	46.27
46	15	8.34	39.61
47	30	7.36	46.71
47	35	7.21	47.79
47	47	7.17	48.08
48	13	8.41	39.10
48	40	7.10	48.59

Loss in the system without using DG is about 13.81 MVA. Table.1 demonstrates active value of the two DGs at which the corresponding minima are obtained by BFOA. The reactive value of DG is kept constant and Newton-Raphson approach is applied at these values and corresponding active losses are obtained. Percent loss reduction is calculated along with it. The results may further be enhanced by using different DGs locations. Best size of DG is obtained, where the losses are reduced i.e. maximum loss reduction.

V. CONCLUSION

This paper proposed the use of BFOA method for obtaining the optimum size of DG for reduction of losses in the distribution system. The capability of this method is experimented on 14 bus system in which two DG are inserted at particular location. The size of DG is the main consideration in reducing the losses of the system. The installation DG of any size can increase the losses of the system, which leads to non beneficial characteristic of installed DG and increase in the cost of the system. So BFOA method is used to obtain optimum size of DG to increase the benefits of DG in the distribution system. This method is simple and less lengthy with additional computational complexity.

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