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ECONOMIC OPERATION OF RENEWABLE DGS IN DISTRIBUTED NETWORKS

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ABSTRACT

The loads in distribution network are heterogeneous in nature and the fast growing electrical demand is due to manufacturing sector and domestic needs. The impact of load demand, affects the distribution network which leads to power interruptions and failures in the distribution system. To minimize theses problems, the decentralized generation by using distributed generators (DGs) is preferred. For optimal operation of distribution network, it is required to obtain optimal size and location of DGs. In this paper particle swarm optimization technique is implemented by considering economical and technical factors. The optimization technique is implemented on standard IEEE buses.

KEYWORDS: Distributed Generators (DGs), Distribution Generation, PSO (Particle Swarm Optimization) and Loss reduction.

I. INTRODUCTION

The entire power demand is in the distribution network is handled by distribution feeders. The increasing load demand causes heavy current which reduces the performance of the distribution network. Due to this the losses in the system will increases. To over this problem, the DGs are installed at load points is the alternate solution. This will reduces power loss, improving voltage profile and improves reliability of distribution network.

A multi-objective function is implemented for optimal size of DG with considering different performance indices and practical load modeling. The Genetic algorithm and particle swarm optimization method is used [1]. For DG size and allocation a genetic algorithm is developed to minimize power losses and DG cost different load model [6]. An evolutionary programming technique is implemented to the network by consider in uncertainties of load and demand by using probabilistic technique for power loss reduction. The solar and wind is considered in DGs [2]. In [3], an improved multi-objective harmony search is implemented for DG sizing and allocation for power loss reduction and voltage profile improvement of the system. In [17], by considering system operation and security constraints, a differential evolution algorithm is used for obtaining optimal sizing and allocation of DGs to reduced power losses and improves the performances of the system voltage. In [4], Particle Swarm Optimization with Genetic Algorithm is used for optimal size and allocation of DGs. In [5] PSO with clonal algorithm is implemented to increase the performance. In [7], the combination of loss sensitivity, index vector and voltage sensitivity index methods are used for optimal sizing of DG and allocation in distribution network. In [15], PSO technique is used for loss reduction and voltage profile improvement in radial distribution network. In [9], energy summation method is presented for Dg allocation in distribution network. Three algorithms Pro, rate, quadratic allocation and proportional are presented for DG allocation [10]. GA is presented for allocation of DG in radial distribution network for minimizing losses [16]. MPGSA algorithm is used with simultaneous reconfiguration and DG allocation in radial distribution system [11]. A mixed-integer linear programming approach is implemented for optimal size and allocation of DGs in radial distribution system [13]. In [18], a modified bare bone PSO method is presented for distributed generation planning under voltage stability consideration.

In this paper the renewable energy distributed generation networks are implemented to obtain optimal allocation and size using PSO technique by considering economical and technical aspects. The large size DGs are incorporated in this method yields efficient results. Cost break even analysis is carried out using solar DGs to achieve the optimal solution.

II. METHOD FOR LOAD FLOW CALCULATION OF RADIAL DISTRIBUTION NETWORK

For the given distribution network, load flow is carried out to compute the power loss and voltage profile. Standard IEEE network is considered. A multi-objective function is formulated to optimize location and size of DG's by considering cost parameters, voltage index and power loss. From the proposed method, the reduction in power loss which results cost benefit analysis for a standard IEEE buses.

II.I. Load Flow Algorithm

The complete algorithm for load flow calculation of radial distribution network is follows:

1. Read the total number nodes in a feeder(f), laterals(l) and sub lateral (s) respectively in a distribution network Then the total number of nodes in Feeder $Nt = f + l + s$.
2. The node number of feeder is stored in a matrix $Fn(i, j)$ where $i=1,2,3\ldots Nt$ and $j=1,2,3\ldots n(i)$ where n corresponds to the total number of nodes in the main feeder or corresponding lateral or sub laterals.
3. Read the common nodes to the feeder and laterals and store them.
4. Obtain the total number of branches equal to $n(i)-1$, where $n(i)$ is the number of nodes in the corresponding feeder lateral or sub lateral i, store the branch numbers in a matrix $Fb(i, j)$.
5. Read resistance and reactance of each branch as $R(Fb(i, j)$ and $X(Fb(i, j))$.
6. Initialize base kV, base MVA, Maximum iteration itmax and convergence factor ($\varepsilon = 0.0001$)
7. Assume voltage of each node of feeder as 1.000+ j0.000 p. u.
8. Initialize active power losses and reactive power losses of each branch is zero.
9. Calculate the current in each node

   $Il(Fn) = (P(Fn(i, j) - Q(Fn(i, j))/V^*(Fn(i, j))$ (1)

   2. Compute the current in each branch starting from the end node. Add current of the last branch I (n) to the current of preceding branch I (n-1).

   $I(Fb(i, j)) = Il(Fn(i, j+1))$ for end nodes

   $I(Fb(i, j)) = I(Fb(i,j+1)) + Il(Fn(i, j+1))$ for other nodes.

   3. Compute the voltage at each node using equation

   $V(Fn(i,j)) = V(Fn(i, j-1)) - I(Fn(i,j-1))Z(Fn(i,j-1))$ (2)

   4. Compute $\Delta V(Fn(i,j)) = V(Fn(i,j)) - V1(Fn(i, j))$ (3) for each node and find $\Delta V\max$

   5. Check if $\Delta V\max$ is greater than tolerance. Then increment the iteration, count iter = iter+1 else converge solution

   6. Compute active power loss (Lp) and reactive power loss (Lq) for each branch

   $Lp(Fb(i,j)) = I(Fb(i, j))^2 R(Fb(i, j))$ (4)

   7. Print Solution.

III. PARTICLE SWARM OPTIMIZATION TECHNIQUE

PSO is based on stochastic processes, like evolutionary programming for optimal solution. This algorithm executes in finding optimal values from swarm of particles through two essential reasoning capabilities like local best and global best. Each particle of swarm flies in search space or changes its position with a velocity and remembers its best position which gives minimum of objective function termed as pbest particle (local best or individual best) and the gbest (global best particle) which gives minimum of objective function among all pbest particles. Each particle decides its velocity according to its distance from personal best particle, global best particle and its previous velocity.

III.I Algorithm for PSO technique:

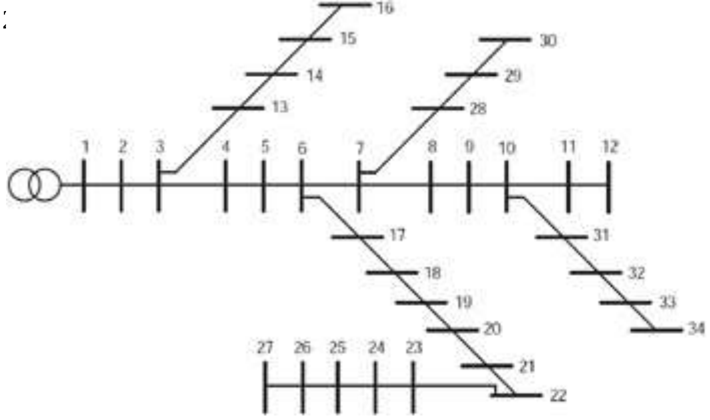
1. The location of DGs has to select, where the voltage profile is less than prescribed limits.
2. Initialize the swarm by initializing random particles**.** Where each particle represents size of the DG to be placed at the selected location. Particle (n, m) = [DG1 DG2 …DGm].

   Where DG is the size of DG located at the sensitive location m is the total number of location where DG is to be allocated.

3. Initialize the PSO weight factors wo, w1, w2, W. where wo is the weight factors for previous velocity, w1& w2 is the weight factor for movement of particle towards pbest and gbest respectively.
4. Initiate random velocity for each particle in algorithm.
5. For each particle if the voltage and line loading are in limits. Calculate the active power loss and objective function and determine its fitness.
6. Store the best fitness so far reached by each particle as its pbest value and the particle associated with as pbest particle.
7. Store the best fitness among all pbest as gbest and the particle associated with gbest particle.
8. Update the particle velocity and particle positions by equation
   Velocity [n, m] =W*(w0*Velocity [n, m] + w1* ([pbestparticle [n, m] – particle [n, m]) + w2*(gbestparticle [n] – particle [n, m]))
9. Update particles by adding the velocity particle (n, m)= particle(n, m) + velocity(n, m)
10. Evaluate and compare the objective function value with updated particles with pbest value. If the objective functions value is less than the pbest value set this value as current pbest. And the corresponding particle position as pbest particle.
11. Set the minimum pbest value and its corresponding position as current gbest and gbest particle.
12. Increment the iteration count. If iteration count is not reached to maximum count then go to step. 8.
13. gbest particle gives the best optimal sizes of DG for selected n locations.
14. Reduction in loss is obtained after DG allocation.
15. Cost benefit ratio is computed to carry out the cost break even analysis.

IV. IMPLEMENTATION OF PROPOSED TECHNIQUE

The proposed method is carried out on IEEE 34[10]. The 11 kV IEEE with 34 nodes and 33 branches with 4 laterals is shown in Fig.1 The minimum voltage and active power loss is obtained. The values are 0.9417 p. u (bus no 27) and



For IEEE 34 bus, the power loss location and size of DGs are obtained by the proposed method are shown in table 1. The voltage profile is shown in figure.2.

Table 1. Power loss and DG allocation for a IEEE 34 bus network.

Bus Type	DG Location	DG Size	Base Case		Optimal Case	
			Active Power loss(KW)	Reactive power loss (KVAR)	Active Power loss(KW)	Reactive power loss (KVAR)
IEEE 34 bus	22	27.5	220.6	66.8	201.15	59.41
	23	39.5				
	24	26.5				
	25	39.4				
	26	38.8				
	27	28.6				

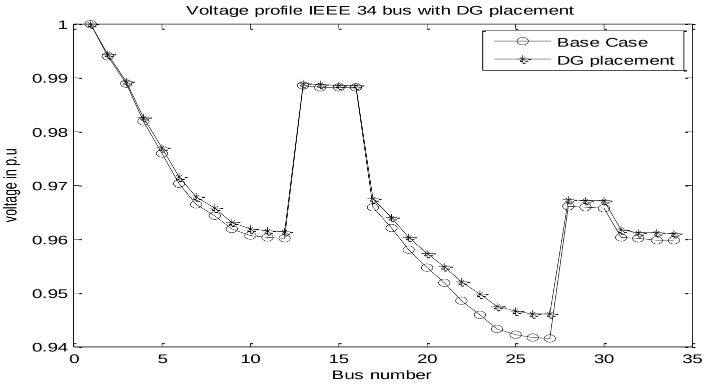


Fig. 2. Voltage profile of IEEE 34 bus

For IEEE 34 bus, the effectiveness of the proposed approach is verified according to the algorithm the power loss, location and size of DGs are shown the table 2&3 for IEEE 69 and EPDCL 29 bus. For the networks IEEE 69 bus and EPDCL 28 bus, the voltage profiles are shown in figures 3&4 respectively.

Table 2. Power loss and location of DGs of IEEE 69 bus

Bus Type	DG Location	DG Size	Base Case		Optimal Case	
			Active Power loss(KW)	Reactive power loss (KVAR)	Active Power loss(KW)	Reactive power loss (KVAR)
IEEE 69 bus	58	28.0	224.22	101.87	183.86	84.7
	59	40.0				
	60	31.4				
	61	40.0				
	62	37.2				
	63	40.0				
	64	29.4				
	65	38.7				

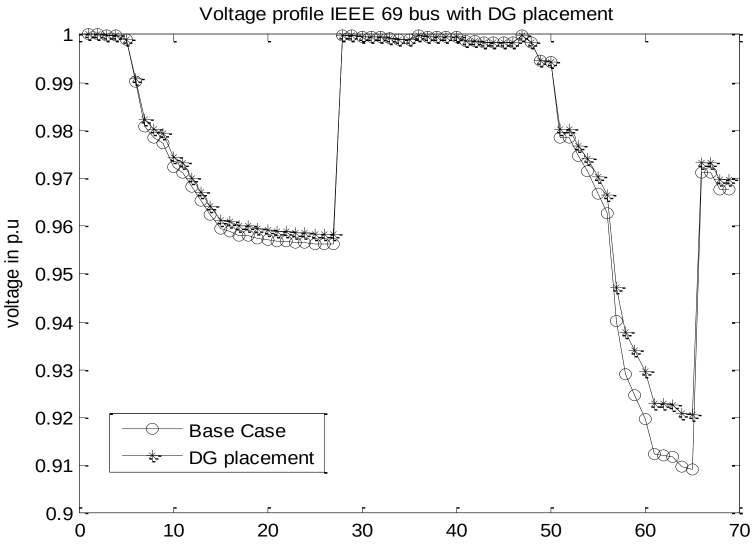


Fig. 3. Voltage profile of IEEE 69 bus

Table 3. power loss and location of DGs of EPDCL 28 bus

Bus Type	DG Location	DG Size	Base Case		Optimal Case	
			Active Power loss(KW)	Reactive power loss (KVAR)	Active Power loss(KW)	Reactive power loss (KVAR)
EPDCL 28 bus	7	31.4	66.6	44.23	38.57	25.35
	8	37.7				
	9	40.0				
	10	29.5				
	22	40.0				
	23	33.2				
	24	40.0				
	25	40.0				
	26	31.7				
	27	24.1				
	28	27.2				

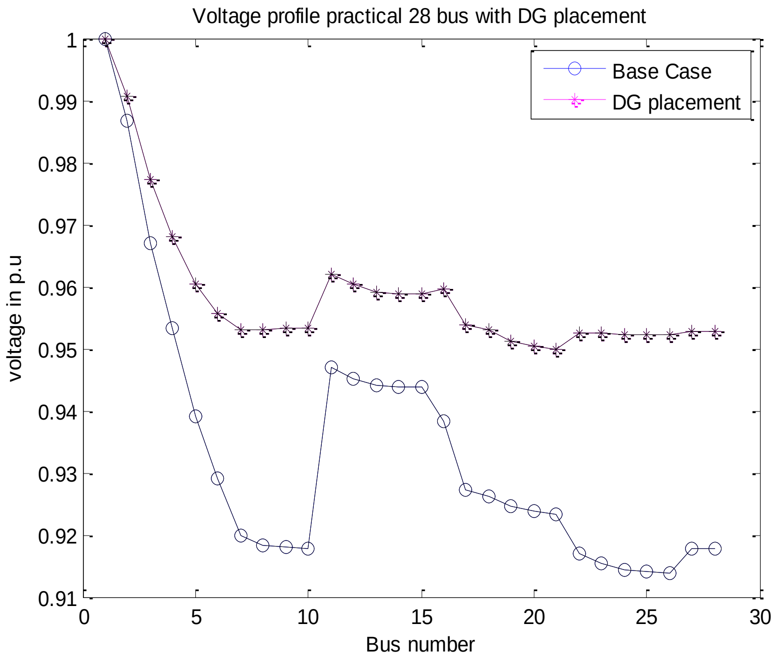


Fig. 4 Voltage profile of EPDCL 28 bus

Table 4. Cost and Cost benefit Ratio

Bus Type	IEEE 34 bus	IEEE 69 bus	EPDCL 28 bus
Base network power loss(KW)	220.67	224.22	66.6061
Optimal case power loss(KW)	201.1597	184.2709	38.5717
Reduction in power loss(KW)	19.5103	39.95	28.03
Benefit (Rs)	305044.8	3696980	2747360
Cost of DG (Rs)	9213800	13096200	5520000
Cost benefit retio	3.02	3.5	2

V. RESULTS

For IEEE 34 bus, 69 bus and EPDCL 28 bus, networks, the proposed method is implemented. From the table 4, after allocating optimal DG, power losses are reduced as 15%, 18% and 53.46% respectively. The average power loss reduction is 33.15%. Cost benefit ratio is also computed. In IEEE 34 bus, based on optimal DG allocation, the reduction in power loss is 19.51KW. The annual benefit obtained is Rs.3050448/-. The investment for the new DG allocation is Rs. 9213800/-. From table 4, within three months the break even occurs. Similarly for IEEE 69 bus and EPDCL 28 bus, the break even occurred within four months and two months respectively. The proposed method gives the cost break even time, effective cost and technically feasible operation.

VI. CONCLUSION

The proposed method is executed on IEEE 34 bus, 69 bus and EPDCL 28 bus to obtain reduction in power loss, optimal location and sizing of DG. Solar power is considered during sunny hours of the day and rest has been met through utility grid. The cost benefit analysis is carried out to obtain the cost break even in all the three networks. Allocations of DG units of higher size are also beneficial for improvement in the system. The average power loss reduction is 22.90% and the average cost break even period is 2.84 years. The profit will be gained in the rest of period over 30 years. The proposed method is cost viable and technically feasible for economic operation.

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