

# Optimal Allocation of Distributed Energy Resource in Distribution System Using Genetic Algorithm

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**Abstract:** This paper is proposed to find the optimal allocation of DER systems to losses reduce, improve voltage profile. To demonstrate the validity of the proposed algorithm, computer simulations are carried out on 69-bus simulation results are presented and discussed. To obtain these goals the resources capacity and the installation place are of a crucial importance. The expected energy, economic, and environmental benefits may not be achieved and a deficit in energy supply may occur if the uncertainties are not handled properly.

**Key words:** Distribution Networks, planning, DG, Losses Reduce, Genetic algorithm.

## INTRODUCTION

The Distributed generations (DGs) are small-scale power generation technologies of low voltage type that provide electrical power at a site closer to consumption centers than central station generation. It has many names like Distributed energy resources (DER), onsite generation, and decentralized energy. Expansion planning of distribution network generally static definitions, such as restructuring, reconfiguration, rewiring, installation of new feeders, installed new posts, install normal opened (NO) and normal closed (NC) switches and installing new distributed generation (DG) as well as issues related to the electricity market in energy sold to the grid and purchased energy from load growth can be named. Dynamic programming to include different stages looking for the best time and place to strengthen the system to grow with the lowest cost and best quality done that's why we have distribution networks in transition from passive network with unidirectional flow supplied by transmission grid to active distribution network with integration DG [1]. In previous works, based on pseudo-dynamic algorithm have been done [2] on the basis of this algorithm was built dynamic method [3] and using genetic algorithm interconnected [4] shown, and without the control of sequential genetic algorithm for scheduling development is done in this paper to consider improving reliability and reducing cost efficient method genetic algorithm by backward and forward [1] used taking losses and market presence that is the power of innovation in this article we have tried to improve the situation with regard to the algorithm flowchart maximize profits and minimize losses, along with dynamic scheduling 5 years ahead with genetic algorithm to develop new feeders and installation in distribution network, rewiring, reconfiguration and restructuring, change switch status and installation new switches and energy purchased from DG can be named. In this paper is proposed to find the optimal allocation of DER systems to losses reduce, improve voltage profile.

## I. Objective Function

A structure model is developed to optimally design a DER system at the building level under purely deterministic conditions. The structure of the DER system. The active and reactive losses are greatly depending on the proper location and size of the DGs. The indices are defined as

$$ILP = \left( \frac{TS_{loss}^{withDER}}{TS_{loss}^{withoutDER}} \right) \quad (1)$$

Where,  $TS_{loss}^{withDER}$  is the power losses of the distribution system with DER.  $TS_{loss}^{withoutDER}$  is the power losses of the system without DER. Expansion planning model in this paper based on genetic algorithm is pseudo-dynamic multi-objective function with the aim of optimizing the objective function alongside the existing restrictions in the planning and development is taking uncertainties which the objective function can be expressed as follow:

$$OF = C_{Loss} + (C_{Grid} - C_{Pool}) + ECOST + C_{INV} \quad (2)$$

$$ECOST = \sum C_i L_i U_i \quad (3)$$

The value of losses and energy imported from transmission system are calculated by non-linear optimal power flow (NLP) and power flow solved by the Newton-Raphson method. In active distribution networks operation, active management (AM) is applied with real time control and management of DG units and distribution network devices based on real time measurements of primary system parameters (voltage and current) [5]. Constraint in this article are as active and reactive power balance

$$\begin{aligned} P_{gi} - P_{li} - \sum_{ij \in \Omega_i} P_{ij} &= 0 \\ Q_{gi} - Q_{li} - \sum_{ij \in \Omega_i} Q_{ij} &= 0 \end{aligned} \quad (4)$$

Bus voltage limit

$$V_i^{min} \leq V_i \leq V_i^{max} \quad (5)$$

Power flow limit

$$P_{ij}^{min} \leq P_{ij} \leq P_{ij}^{max} \quad (6)$$

Line loading constraint

$$S_{ij}^{min} \leq S_{ij} \leq S_{ij}^{max} \quad (7)$$

DG penetration level constraint

$$PL_i \leq PL_i^{max} \quad (8)$$

## II. Genetic Algorithm

GA's are generalized search algorithms based on the mechanics of natural genetics [14]. GA maintains a population of individuals that represent the candidate solutions to the given problem. Each individual in the population is evaluated to give some measure to its fitness to the problem from the objective function. GA's combine solution evaluation with stochastic operators namely, selection, crossover and mutation to obtain optimality.

### Concept of Genetic Algorithm

The genetic algorithm is a method for solving optimization problems that is based on natural selection, the process that drives biological evolution. The genetic algorithm repeatedly modifies a population of individual solutions. At each step, the genetic algorithm selects individuals at random from the current population to be parents and uses them to produce the children for the next generation. Over successive generations, the population "evolves" toward an optimal solution. You can apply genetic algorithm to solve a variety of optimization problems that are not well suited for standard optimization algorithms, including problems in which the objective function is discontinuous, non-differentiable, stochastic, or highly nonlinear [17].

### Genetic Operators

1) Selection: Select two parent chromosomes from a population according to their fitness. Chance for the better fitness individual to be selected is higher to produce the next generation with the higher fitness value.

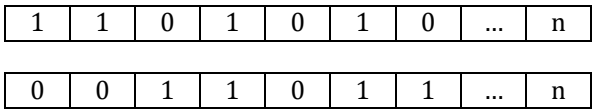


Figure 1: Single point crossover

2) Crossover: The crossover operator involves the exchange of genetic material between chromosomes (parents), in order to create new chromosomes (offspring). Various forms of this operator have been developed. The simplest form, single point crossover, is shown in Fig 3. This operator selects two parents, chooses random position in the genetic coding, and exchanges genetic information to the right of this point, thus creating two new offspring.

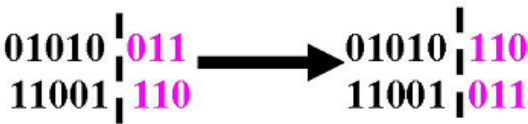


Figure 2: Single point crossover

3) Mutation: The mutation operator, in its simplest form, makes small, random, changes to a chromosome. For a binary encoding, this involves swapping gene 1 for gene 0 with small probability for each bit in the chromosome, as illustrated in Fig 4.



Figure 3: Binary mutation operators

The flow chart of proposed GA is depicted in Fig. 4.

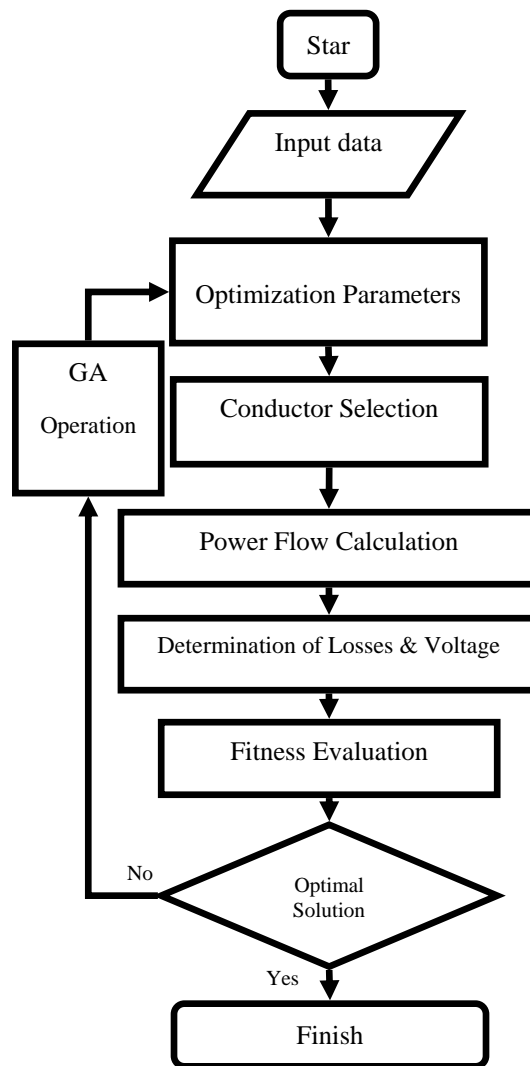


Figure 4: Flowchart of the proposed GA algorithm

### III. Modeling

The design variables include the selection of the types and capacities of equipment, the number of equipment, and the capacities of the storages. The operation variables include the load allocation of equipment, the amount of energy stored or released by the storages, and the amount of electricity purchased from the external grid. The constraints can be grouped into three categories: selection and availability of equipment, performance characteristics of equipment, and energy balance and supply-demand relationships. Other constraints such as specific legislation constraints (e.g., special tariffs or tax abatements for fuel allocated to DER systems, operational restrictions, and other constraints are considered if they are necessary. The main objective of this paper is to study the effect of placing and sizing the DG in all system indices given previously. Also observe the study with renewable bus available limits.

The methods proposed for solving distribution power flow analysis can be classified into three categories: Direct methods, Backward-Forward sweep methods and Newton-Raphson (NR) methods. The Backward-Forward Sweep method is an iterative means to solving the load flow equations of radial distribution systems which has two steps. The Backward sweep, which updates currents using Kirchhoff's Current Law (KCL), and the Forward sweep, which updates voltage using voltage drop calculations [12].

The Backward Sweep calculates the current injected into each branch as a function of the end node voltages. It performs a current summation while updating voltages. Bus voltages at the end nodes are initialized for the first iteration. Starting at the end buses, each branch is traversed toward the source bus updating the voltage and calculating the current injected into each bus. These calculated currents are stored and used in the subsequent Forward Sweep calculations. The calculated source voltage is used for mismatch calculation as the termination criteria by comparing it to the specified source voltage. The Forward Sweep calculates node voltages as a function of the currents injected into each bus. The Forward Sweep is a voltage drop calculation with the constraint that the source voltage used is the specified nominal voltage at the beginning of each forward sweep. The voltage is calculated at each bus, beginning at the source bus and traversing out to the end buses using the currents calculated in previous the Backward Sweep [12]. Single line diagram of main feeder depicted in Fig 5.

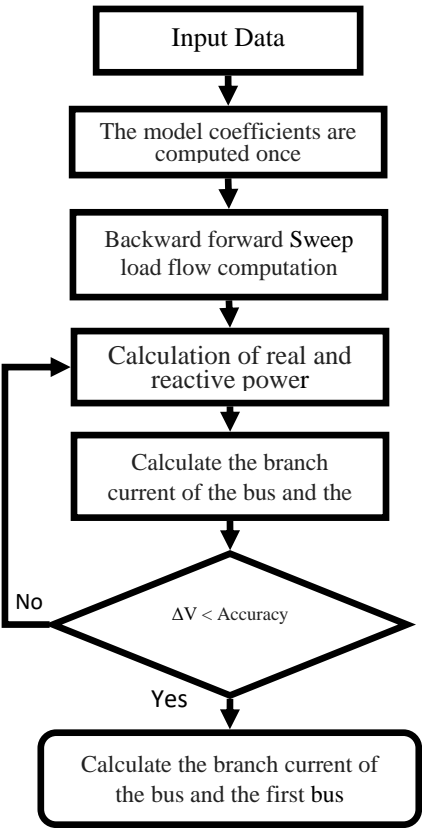


Figure 5: Single line diagram of main feeder

**IV. Tests and Results**

The case study is a network has a substation, 33 buses, 35-line, 32 NC-switches , 3 NO switches and 12.66 KV nominal system voltage, complete data are given in [6]. The single line diagram for proposed radial distribution systems is shown in Fig 6. Length of all branches is considered to be equal to 60m. The properties of the three conductors used in the analysis of this system are given in Table 1.

Table 1: Conductor properties

Type	R [ $\Omega/\text{km}$ ]	X [ $\Omega/\text{km}$ ]	Cmax [A]	A [mm <sup>2</sup> ]	Cost [Toman/m]
Hyena	0.1576	0.2277	550	126	2075
Dog	0.2712	0.2464	440	120	3500
Mink	0.4545	0.2664	315	70	2075

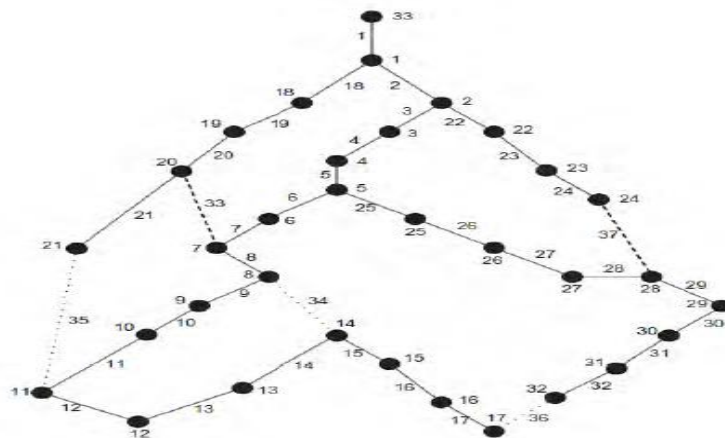


Figure 6: Single line diagram of main feeder

The Table 2 shows the methods which are compared, location (bus number), DG capacity, and real power loss in fig 4 shows which are basic columns.

Table 2: Optimal Place and Size of the DG in 33 Bus systems using Genetic Algorithm

Bus Location	Capacity [MW]	type
5	0.3	micro turbine
17	1.05	wind
26	1.35	PV
33	0.5	PV
49	0.15	PV
64	1.15	wind

## V. CONCLUSION

This paper is proposed to find the optimal allocation of DER systems to losses reduce, improve voltage profile using GA algorithm to expansion planning active distribution network. This optimization help to improve reliability and loss reduction and then simulate this method on 33 busses case study. The total annual cost is underestimated if the DER system is designed without considering the uncertainties. The uncertainty in energy prices has the significant and greatest effect on the total annual cost, the next is the uncertainty in load demands, and the last is the uncertainty in renewable energy intensity which has little effect.

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