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Optimal Allocation and Sizing of Multi DG Units Including Different Load Model Using Evolutionary Programming

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Abstract. This paper presents the optimal allocation and sizing of multi distributed generation (DG) units including different load models using evolutionary programming (EP) in solving power system optimization problem. This paper also studies on the effect of multi DG placement in different load model. To optimize the power distribution system, multi DG units were used to reduce losses power distribution system. By using EP, the optimal allocation and sizing of multi-DG was determined in order to obtain maximum benefits from its installation. The propose technique was tested into IEEE 69-bus distribution system. The result shows the placement of DG can reduce power loss 89% to 98%. The placement of multi-DG unit has better performance compare to single DG.

1. Introduction

In the electrical engineering, the most importance consideration of the design is the efficiency. According to energy conservation law, the energy cannot be created or destroyed. From the law, as the efficiency decrease the more energy needed to operate same load because some of the energy had being converted to the unwanted form such as heat, magnetic and others. In distribution system the best system is the system with the optimum system that has the lowest losses.

To increase the efficiency of the distribution system the optimal location and size of multi DG is important. The optimal placement of multi DG will reduce the power losses in the system. The study shown the optimal location of multi DG is depending on the load model. In difference load model have difference load profile and voltage. However, in selection of optimize size and location of multi DG there are many considerations that need to be assume such as voltage profile, power flow, stability, short circuit level and quality of supply. There are many techniques to optimise the power distribution system such as Evolutionary Programming (EP), Genetic Algorithm (GA), and particle swarm optimization (PSO) [1]–[4]. The optimal placement of multi DG will produce the best DG sizing optimize to the distribution system.

However, the evolutionary programming (EP) is used in the study because the EP has been recently utilized with success to many numerical and combinatorial optimization troubles. Optimization by EP can be summarized into two major steps it is mutate the solutions in current population and select the next generation from the mutation and current solution. These two steps can be regarded as a population-based model of the classical generate-and-test technique.

The power distribution system is the system used to distribute the power from main transmission line to the final consumer. In larger distribution system some of the power transfer are loss due to impedance in distribution system. To increase the efficiency of the distribution system, the multi DG is used with suitable size and optimum location placement of DG. Taking consideration of difference load model the optimal placement and size of multi DG is essential to reduce power loss in distributions system [5]–[7].The implementation task will be tested into IEEE-69 bus system. This project using single and multi DG that connected with different load models. In this project DG type-2 is used to inject power at tested bus to optimize power distribution system with maximum of 2 DG. This project implement using Matlab simulation.

2. Distributed Generation

Distributed generator is define as small-scale electricity generator that the maximum power generated 50MW to 100MW that normally connected at the distributed network [8]. The main function of distributed generator is to reduce power loss in the distribution line system. The distributed generator control system beyond the grid system operator (GSO) that control the transmission and generation system of Malaysia.

According to Institute Electrical Electronic Engineering the distributed generation are define as Electricity generation through facilities that are sufficiently smaller than main generating plants to allow interconnection at almost any point in an electricity system. The size of DG not the main issue in define the DG but the size of DG has significant value to the effect of the placement of the DG. The DG must supply an active power to the system however the reactive power supply is not compulsory but accepted. The DG may also be grouped into four major types based on terminal characteristics in terms of real and reactive power delivery capability. For comparative studies, four major types are considered which are described as follows [9]:

Type1: This type DG can deliver only active power
Type2: DG able to deliver active as well as reactive power.
Type3: DG which can only deliver reactive power.
Type4: DG capable of delivering active power but having reactive power consumption.

Type of uses of the distributed generator is usually dependent on the load model type. In the residential sector, typical distributed generation systems are solar photovoltaic panels, small wind turbines, natural gas-fired fuel cells and emergency generators powered by gasoline or diesel fuel. However, the distributed generation used in the commercial and industrial sectors includes assets such as combined heat and power systems, solar photovoltaic panels, wind, hydropower, biomass combustion or co-firing, municipal solid waste incineration, fuel cells powered by natural gas or biomass, and reciprocal combustion engines like oil-fired backup generators.

2.1. Optimization technique

Mathematical optimization methods have been used in many power systems planning, operation, and control problems over the years. By using some assumption from the real situation in the real world a mathematical model has being derived to solving optimization of the system. However, with the assumption that has being consider the power system optimization quite difficult to solve because it has a large system, complicated and geographical widely distributed. In simple word the power system optimization using mathematical method is impossible to solve the power system optimization for the grid system that connected to the large system and complex system. It just suitable to solve locally optimization problem. By using artificial intelligence such as genetic algorithm, evolutionary programming, particle swarm optimization and other method the power system optimization are available to be analysis and calculated.

Practitioners are keen users of optimization techniques in the field of power systems operations. Several key issues in the area are solved daily using optimization algorithms as part of the power grid's real-time operation. One such fundamental problem is the problem of unit engagement, which involves scheduling the generation of electricity to meet demand at minimum cost. Realistic instances of unit engagement are typically large-scale, and since the real-time time available is limited, practitioners sometimes must settle for solutions that are not optimal globally. The advent of the smart grid introduces new challenges for power system researchers and optimizers beyond the well-known fundamental problems. It is expected that this combination will provide energy savings, cost reductions and increased reliability and safety. It also raises new problems in the management of the resulting system, however. These include integrating renewable energy sources such as wind and solar generation, managing power and information bidirectional flows, and incorporating demand response [10].

2.2. Evolutionary programming
Initially conceived by Lawrence J, evolutionary programming. Fogel in 1960 is a stochastic optimization technique similar to genetic algorithms, but instead emphasizes the social interaction between parents and their offspring instead of trying to emulate specific genetic operators as found in nature. Evolutionary programming (EP) is one of the approach in evolutionary computation under the artificial intelligent hierarchy that used for optimization technique [11].

In power system operation and planning especially in voltage stability study, optimization is the most importance issue because the optimize system will increase the efficiency of the power system. Evolutionary programming engine initially develop to solving real power planning for optimization of the optimal real power dispatch (ORPD) and optimal transformer tap changer setting.

2.3. Load model
The optimal allocation and sizing of DG units are to be investigated under scenarios of different voltage dependent load models. For investigations, practical voltage dependent load models, i.e. residential, industrial, and commercial, were adopted. The charging models can be expressed mathematically as

$$P_i = P_{oi} V_i^{\alpha} \tag{1}$$

$$Q_i = Q_{oi} V_i^{\beta} \tag{2}$$

where P_i and Q_i are real and reactive power at bus i, P_{oi} and Q_{oi} are active and reactive operating point at bus i, V_i is voltage at bus i, and α and β are real and reactive power exponents. In a constant power model conventionally used in power flow studies, $\alpha = \beta = 0$ is assumed. The values of the real and reactive exponents used in this project for industrial, residential and commercial loads are given in Table 1 below.

Table 1. Load types and exponent values [12].

Load model	**α**	**β**
Constant load	0	0
Residential load	0.92	4.04
Commercial load	1.51	3.40
Industrial load	0.18	6.00

3. Methodology
This project is developed to determine the optimal allocation and sizing of multiple DG unit in order to reduce power loss in distribution system. By placement multi DG at the suitable location and sizing, the losses in power system will be reduce. To identify the suitable position and size of multi DG, the evolutionary programming technique is used. The project also determines the size and location of multi-DG in difference load model of power system.

The optimization starts with calculate power flow solution to determine the nominal voltage at each bus before load model implement. The voltage for each bus is used to calculate new active power (P_{new}) and reactive power (Q_{new}) of the load. The active and reactive power of the load at busdata will be replace with new active and reactive power. After the new busdata generate the program will continues as constant load model program. For initialization of the EP, two random variables are generated as initial population. After completing generate population, the fitness of data will be calculated according to objective. Next, the data will be mutated. The mutation of the data X_m will be generate. x(i) and n(i) are random variable.

$$p = \tau \times nr + \tau \times nr \tag{3}$$

$$nm(i) = n(i) \times e^{p} \tag{4}$$

$$xm(i) = x(i) + nm(i) \times nr \tag{5}$$

By using mutation formula in equation (3), (4) and (5), new value will be calculated. The parent or the initial data and mutation data will be combined in array. The combine data will be rearranged in ascending or descending order of fitness value. The maximum and minimum value are tested for convergence test. If the maximum and minimum value data indicates the different less than 0.0001 the program will be terminated. Otherwise, if the convergence test fail and the program will be repeated until the value of maximum and minimum data will be less than 0.0001.

In this project, the program starts with the generation of two variable as the value of the DG size (P_{DG}). Next, the program will calculate the losses for the system with DG placement and generate data for different DG size. In this study, the population size is set to 20 population. Then, the mutation data will be calculated as fitness value for each offspring. After that, the parent and first-generation of mutation data will be combined. The combination data will be sorting in ascending order to determine the lower value of power losses. Then, the next step is convergence test. This procedure is to determine the stopping criterion of the optimisation process. If the convergence condition is not satisfied, the mutation, combination and selection processes will be repeated until the convergence criterion is met. The flowchart of EP programming is presented in Figure 1.

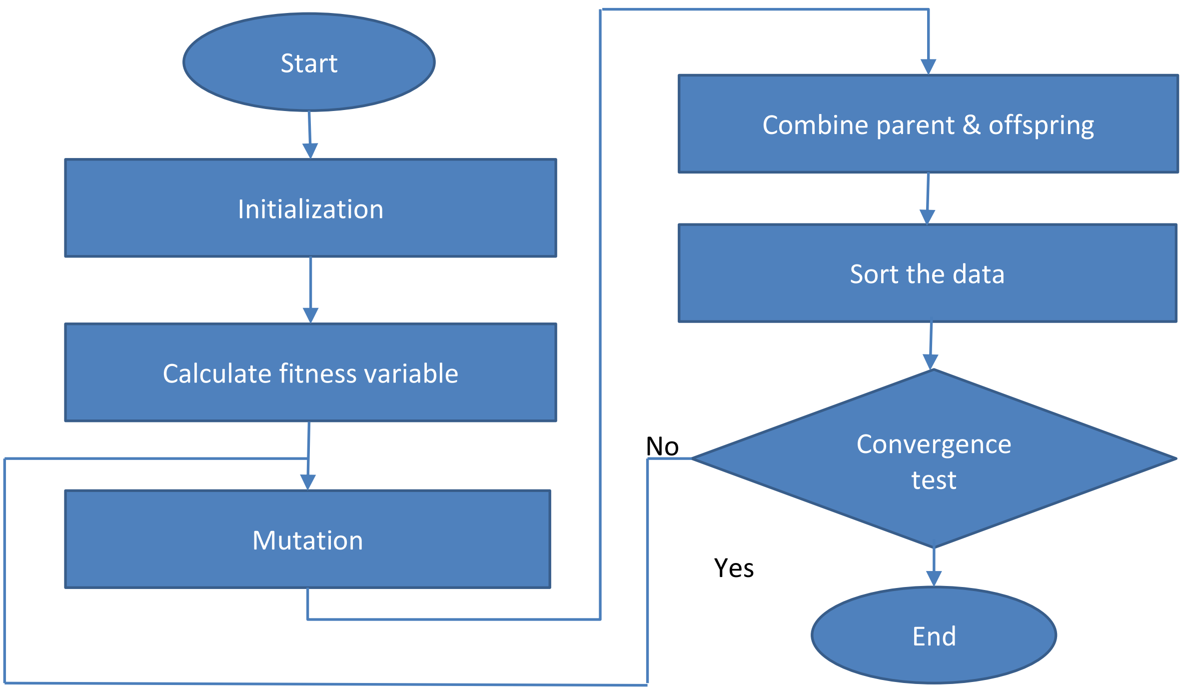

Figure 1. Flowchart for implementation of evolutionary programming

3.1. Case Study
From the base system, three different cases are formed and shall be analyzed for their power loss reduce and efficiency improvement of the distribution system by using EP. The list of cases is:

Case 1: This distribution system is the original IEEE-69 bus test system without any change
Case 2: This configuration of IEEE-69 bus test system with placement single DG unit with different load model.
Case 3: This configuration of IEEE-69 bus test system with placement 2 DG unit with different load model.

The project tested at the IEEE 69-bus test system. Figure 2 below shown the single line diagram of IEEE 69-bus test system

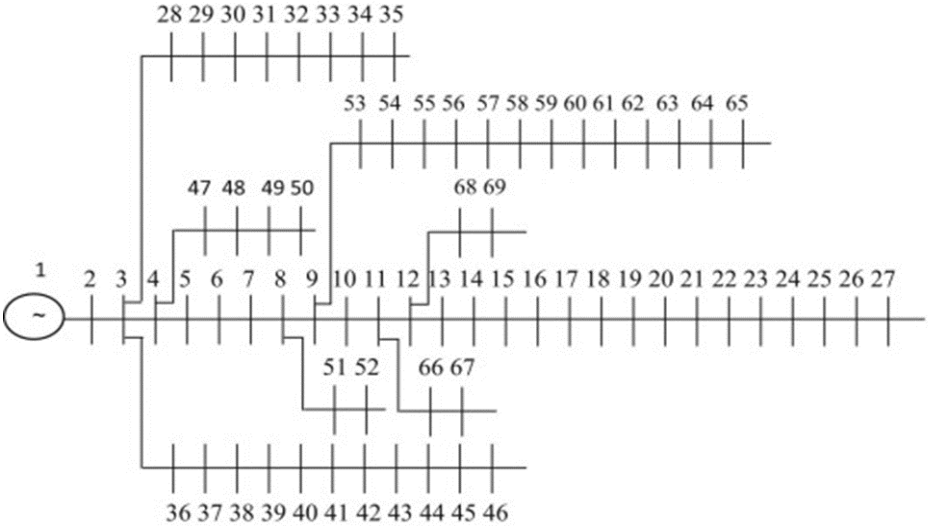

Figure 2. Single-line diagram of IEEE 69-bus test system

4. Results and discussion
This section discusses the data from the simulation result. the result has been analyzed according to the case of study. Below the result for each case study.

4.1. Without DG
Figure 3 shown the value of losses for IEEE 69-bus test system without placement of DG

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Base Case of 69-Bus Test System
Total Power Losses : P = 0.225 MW
                     Q = 0.102 MVar
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Figure 3. The losses for IEEE 69-bus test system without DG

4.2. Single DG
There are a few types to r optimization, one of the techniques for power optimization are by placement of distributed generator (DG). There are 4 type of load model are tested in this project. Table 2 to Table 5 below show the result for 20 best location and size for optimum single DG placement in different load model.

Table 2. Best 20 location and size of a DG placement in constant load model

DG location	P_{DG} size (MW)	Q_{DG} size (MVar)	Total losses(MW)	Minimum voltage	Maximum voltage
61	1.83705	0.96552	0.02317	0.97256	1
62	1.80943	0.95101	0.02512	0.97234	1
63	1.76979	0.93017	0.02808	0.97201	1
60	1.8773	0.98668	0.03465	0.97281	1
64	1.60751	0.84488	0.04076	0.97059	1
59	1.91174	1.00478	0.04352	0.973	1
58	1.93538	1.0172	0.05172	0.97313	1
65	1.39559	0.7335	0.0617	0.96873	1
57	2.01062	1.05675	0.07339	0.97105	1
56	2.28081	1.19876	0.1193	0.94885	1
55	2.38448	1.25324	0.12755	0.9444	1
54	2.51732	1.32306	0.13604	0.9398	1
53	2.66876	1.40266	0.14216	0.93644	1
9	2.81013	1.47696	0.14714	0.93353	1
8	2.82922	1.48699	0.15072	0.93233	1
51	2.56591	1.3486	0.15737	0.93021	1
7	2.8372	1.49119	0.15805	0.93	1
10	1.9083	1.00297	0.1615	0.92584	1
11	1.80757	0.95003	0.16274	0.92492	1
66	1.65674	0.87076	0.16817	0.92357	1

Table 3. Best 20 location and size of a DG placement in residential load model

DG location	P_{DG} size (MW)	Q_{DG} size (MVar)	Total losses(MW)	Minimum voltage	Maximum voltage
61	1.6963	0.89155	0.0203	0.97418	1
62	1.67457	0.88013	0.02175	0.97398	1
63	1.63631	0.86002	0.02393	0.9737	1
60	1.73228	0.91046	0.02849	0.9744	1
64	1.48555	0.78078	0.03329	0.97249	1
59	1.76446	0.92737	0.0348	0.97458	1
58	1.78367	0.93747	0.04065	0.9747	1
65	1.28668	0.67626	0.04858	0.9709	1
57	1.84816	0.97136	0.05602	0.97494	1
56	2.10181	1.10468	0.08808	0.95577	1
55	2.19965	1.1561	0.09369	0.95202	1
54	2.33249	1.22592	0.09941	0.94814	1
53	2.45409	1.28983	0.10348	0.9453	1
9	2.61531	1.37456	0.10673	0.94285	1
8	2.6097	1.37162	0.10939	0.94181	1
51	2.38076	1.25129	0.11439	0.93996	1
7	2.62944	1.38199	0.1149	0.93978	1
10	1.77696	0.93394	0.11622	0.93625	1
11	1.67855	0.88222	0.11695	0.93547	1
12	1.38245	0.72659	0.12081	0.9331	1

Table 4. Best 20 location and size of a DG placement in commercial load model

DG location	P_{DG} size (MW)	Q_{DG} size (MVar)	Total losses(MW)	Minimum voltage	Maximum voltage
61	1.61341	0.84798	0.01993	0.97455	1
62	1.5896	0.83547	0.02132	0.97436	1
63	1.5554	0.81749	0.0234	0.97408	1
60	1.64909	0.86674	0.02769	0.97477	1
64	1.40932	0.74071	0.03232	0.9729	1
59	1.6755	0.88061	0.03366	0.97495	1
58	1.70065	0.89383	0.03919	0.97506	1
65	1.22498	0.64383	0.04687	0.97134	1
57	1.76171	0.92593	0.05372	0.97546	1
56	2.01164	1.05729	0.08389	0.95734	1
55	2.10229	1.10493	0.08915	0.9537	1
54	2.2281	1.17106	0.0945	0.94994	1
53	2.35047	1.23537	0.09831	0.9472	1
9	2.50053	1.31424	0.10132	0.94482	1
8	2.51025	1.31935	0.10386	0.94381	1
51	2.2813	1.19902	0.10864	0.942	1
7	2.52458	1.32688	0.10913	0.94182	1
10	1.71452	0.90112	0.11017	0.93844	1
11	1.62351	0.85329	0.11084	0.93767	1
12	1.33994	0.70425	0.11448	0.93536	1

Table 5. Best 20 location and size of a DG placement in industrial load model

DG location	P_{DG} size (MW)	Q_{DG} size (MVar)	Total losses(MW)	Minimum voltage	Maximum voltage
61	1.80599	0.9492	0.02041	0.9739	1
62	1.78064	0.93588	0.02192	0.9737	1
63	1.7411	0.9151	0.02419	0.97341	1
60	1.84456	0.96947	0.029	0.97412	1
64	1.5798	0.83032	0.0339	0.97219	1
59	1.87624	0.98612	0.03562	0.9743	1
58	1.89561	0.9963	0.04175	0.97442	1
65	1.37409	0.7222	0.04981	0.97057	1
57	1.96184	1.03111	0.05787	0.97417	1
56	2.22586	1.16988	0.09161	0.95431	1
55	2.32287	1.22086	0.09754	0.95047	1
54	2.45818	1.29198	0.1036	0.9465	1
53	2.59381	1.36327	0.10792	0.9436	1
9	2.74564	1.44306	0.11138	0.9411	1
8	2.76182	1.45157	0.11413	0.94004	1
51	2.49424	1.31093	0.11929	0.93816	1
7	2.77011	1.45592	0.11981	0.93797	1
10	1.85599	0.97548	0.12144	0.93431	1
11	1.75542	0.92262	0.12224	0.93351	1
12	1.43573	0.7546	0.12628	0.93112	1

In Table 2, the suitable location for single-DG placement for constant load model are at bus 61 with size 1.8371MW and 0.96552MVar. The losses reduce from 225kW to 23.17kW. The percentage power loss reduction is 89.70%. Table 3 list the suitable location for single-DG placement for residential load model are at bus 61 with size 1.6962MW and 0.89155MVar. The losses reduce from 225kW to 20.3kW. The percentage power loss reduce is 90.97%. In Table 4, the suitable location for single-DG placement for commercial load model are at bus 61 with size 1.61341MW and 0.84798MVar. The losses reduce from 225kW to 19.93kW. The percentage power loss reduction is 91.14%. Result in Table 5 tabulate the suitable location for single-DG placement for industrial load model are at bus 61 with size 1.80599MW and 0.9492MVar. The losses reduce from 225kW to 20.41kW. The percentage power loss reduction is 90.93%. The finding shows the suitable location is almost similar to all cases of load model. However, the results tabulated the different DG size, but the total loss is nearly the same for every load type.

4.3. Multi-DG

To increase efficiency and reduce more losses, the multiple units of DG are added to other location in the same test system. Table 6 to Table 9 show the result for 20 best location and size for optimum 2 DG placement in different load model. The first location of DG placement is fix as the best location and sizing which is at bus 61 with size according to Table 2 to Table 5. The suitable location and sizing for second DG are determine based on the ranking of lowest losses. In Table 6 for constant load model, second DG placement are at bus 18 with size 0.52707MW and 0.27702MVar. The losses reduce from 225kW to 9.44kW. The percentage power loss reduction is 95.80%. Table 7 tabulate the result for residential load model. The results indicate second DG placement are at bus 17 with the sizing is 0.5088MW and 0.26741MVar. The losses reduce from 225kW to 6.49kW. The percentage loss reduction is 97.11%. In Table 8 for commercial load model, second DG placement are at bus 18 with size 0.49388MW and 0.25958MVar. The losses reduce from 225kW to 8.32kW. The percentage power loss reduce is 96.30%. In Table 9 for residential load model, second DG placement are at bus 18 with size 0.5192MW and 0.27288MVar. The losses reduce from 225kW to 8.6kW. Result shows the percentage power loss reduction is 96.18%. From the result, the best power loss reduction is by installing two DG placement in residential load model which is located at bus 61 and 17 with size 0.5088MW and 0.26741MVar respectively.

Table 6. Best 20 location and size for 2 DG placement in constant load model

DG1 location	P_{DG1} size (MW)	Q_{DG1} size (MVar)	DG2 location	P_{DG2} size (MW)	Q_{DG2} size (MVar)	Total losses (MW)	Minimum voltage	Maximum voltage
61	1.8371	0.9655	18	0.52707	0.27702	0.00944	0.99425	1
61	1.8371	0.9655	19	0.50792	0.26696	0.00953	0.99401	1
61	1.8371	0.9655	20	0.49703	0.26123	0.00959	0.99381	1
61	1.8371	0.9655	21	0.49703	0.26123	0.00959	0.99381	1
61	1.8371	0.9655	22	0.49703	0.26123	0.00959	0.99381	1
61	1.8371	0.9655	16	0.53851	0.28303	0.00967	0.99425	1
61	1.8371	0.9655	17	0.53851	0.28303	0.00967	0.99425	1
61	1.8371	0.9655	23	0.47289	0.24854	0.00986	0.99331	1
61	1.8371	0.9655	24	0.47289	0.24854	0.00986	0.99331	1
61	1.8371	0.9655	25	0.47289	0.24854	0.00986	0.99331	1
61	1.8371	0.9655	26	0.47289	0.24854	0.00986	0.99331	1
61	1.8371	0.9655	27	0.47289	0.24854	0.00986	0.99331	1
61	1.8371	0.9655	14	0.5908	0.31052	0.0109	0.9942	1
61	1.8371	0.9655	15	0.5908	0.31052	0.0109	0.9942	1
61	1.8371	0.9655	12	0.77384	0.40672	0.01337	0.98853	1
61	1.8371	0.9655	13	0.77384	0.40672	0.01337	0.98853	1
61	1.8371	0.9655	68	0.62077	0.32627	0.01443	0.9852	1
61	1.8371	0.9655	69	0.61952	0.32561	0.01443	0.98519	1
61	1.8371	0.9655	11	0.84627	0.44479	0.01607	0.98543	1
61	1.8371	0.9655	66	0.77483	0.40724	0.01627	0.98423	1

Table 7. Best 20 location and size for 2 DG placement in residential load model

DG1 location	P_{DG1} size (MW)	Q_{DG1} size (MVar)	DG2 location	P_{DG2} size (MW)	Q_{DG2} size (MVar)	Total losses (MW)	Minimum voltage	Maximum voltage
61	1.8371	0.9655	17	0.5088	0.26741	0.00649	0.99435	1
61	1.8371	0.9655	18	0.50712	0.26654	0.00649	0.99435	1
61	1.8371	0.9655	16	0.52189	0.2743	0.00659	0.99435	1
61	1.8371	0.9655	19	0.49097	0.25805	0.00669	0.99435	1
61	1.8371	0.9655	15	0.52899	0.27803	0.00671	0.99435	1
61	1.8371	0.9655	20	0.4809	0.25276	0.00681	0.99419	1
61	1.8371	0.9655	21	0.46745	0.24568	0.00698	0.9939	1
61	1.8371	0.9655	22	0.46496	0.24438	0.007	0.99389	1
61	1.8371	0.9655	23	0.45679	0.24008	0.00721	0.99372	1
61	1.8371	0.9655	14	0.57589	0.30268	0.00731	0.99435	1
61	1.8371	0.9655	24	0.43844	0.23044	0.00765	0.99337	1
61	1.8371	0.9655	13	0.64022	0.33649	0.00783	0.99192	1
61	1.8371	0.9655	12	0.75998	0.39943	0.00823	0.98925	1
61	1.8371	0.9655	25	0.40329	0.21196	0.00863	0.99267	1
61	1.8371	0.9655	26	0.39002	0.20499	0.00899	0.99242	1
61	1.8371	0.9655	27	0.38298	0.20129	0.00919	0.99228	1
61	1.8371	0.9655	11	0.84171	0.44239	0.01007	0.98632	1
61	1.8371	0.9655	68	0.6058	0.3184	0.01012	0.98613	1
61	1.8371	0.9655	69	0.60776	0.31943	0.01013	0.98611	1
61	1.8371	0.9655	66	0.76497	0.40205	0.01069	0.9852	1

Table 8. Best 20 location and size for 2 DG placement in commercial load model

DG1 location	P_{DG1} size (MW)	Q_{DG1} size (MVar)	DG2 location	P_{DG2} size (MW)	Q_{DG2} size (MVar)	Total losses (MW)	Minimum voltage	Maximum voltage
61	1.8371	0.9655	18	0.49388	0.25958	0.00832	0.99434	1
61	1.8371	0.9655	17	0.49396	0.25962	0.00832	0.99434	1
61	1.8371	0.9655	19	0.47631	0.25034	0.0084	0.99434	1
61	1.8371	0.9655	20	0.46799	0.24597	0.00845	0.99417	1
61	1.8371	0.9655	16	0.50737	0.26667	0.00851	0.99434	1
61	1.8371	0.9655	21	0.45333	0.23826	0.00852	0.99389	1
61	1.8371	0.9655	22	0.45313	0.23816	0.00853	0.99387	1
61	1.8371	0.9655	15	0.51436	0.27034	0.00867	0.99434	1
61	1.8371	0.9655	23	0.4438	0.23326	0.00869	0.9937	1
61	1.8371	0.9655	24	0.42483	0.22328	0.009	0.99336	1
61	1.8371	0.9655	14	0.56057	0.29463	0.00955	0.99434	1
61	1.8371	0.9655	25	0.39561	0.20793	0.00971	0.99266	1
61	1.8371	0.9655	26	0.37968	0.19955	0.00997	0.99241	1
61	1.8371	0.9655	27	0.3733	0.1962	0.01013	0.99227	1
61	1.8371	0.9655	13	0.62338	0.32764	0.0105	0.99206	1
61	1.8371	0.9655	12	0.73511	0.38636	0.01163	0.98943	1
61	1.8371	0.9655	68	0.5866	0.30831	0.01249	0.98633	1
61	1.8371	0.9655	69	0.58683	0.30843	0.01249	0.98631	1
61	1.8371	0.9655	11	0.80263	0.42185	0.01395	0.98655	1
61	1.8371	0.9655	66	0.73441	0.38599	0.01409	0.98543	1

Table 9. Best 20 location and size for 2 DG placement in industrial load model

DG1 location	P_{DG1} size (MW)	Q_{DG1} size (MVar)	DG2 location	P_{DG2} size (MW)	Q_{DG2} size (MVar)	Total losses (MW)	Minimum voltage	Maximum voltage
61	1.8371	0.9655	18	0.5192	0.27288	0.0086	0.99438	1
61	1.8371	0.9655	17	0.51927	0.27292	0.0086	0.99438	1
61	1.8371	0.9655	19	0.50151	0.26358	0.00868	0.99426	1
61	1.8371	0.9655	20	0.49301	0.25912	0.00872	0.99406	1
61	1.8371	0.9655	21	0.47661	0.2505	0.00879	0.99377	1
61	1.8371	0.9655	16	0.5346	0.28098	0.0088	0.99438	1
61	1.8371	0.9655	22	0.47347	0.24885	0.0088	0.99376	1
61	1.8371	0.9655	23	0.46553	0.24467	0.00895	0.99359	1
61	1.8371	0.9655	15	0.53992	0.28377	0.00897	0.99438	1
61	1.8371	0.9655	24	0.45005	0.23654	0.00926	0.99323	1
61	1.8371	0.9655	14	0.58639	0.30819	0.0099	0.99438	1
61	1.8371	0.9655	25	0.41299	0.21706	0.00998	0.99252	1
61	1.8371	0.9655	26	0.4008	0.21066	0.01025	0.99226	1
61	1.8371	0.9655	27	0.39317	0.20665	0.0104	0.99212	1
61	1.8371	0.9655	13	0.65365	0.34355	0.01093	0.99181	1
61	1.8371	0.9655	12	0.76851	0.40391	0.01218	0.9891	1
61	1.8371	0.9655	68	0.61319	0.32228	0.01296	0.98592	1
61	1.8371	0.9655	69	0.6118	0.32155	0.01296	0.9859	1
61	1.8371	0.9655	11	0.8437	0.44344	0.01461	0.98613	1
61	1.8371	0.9655	66	0.76861	0.40397	0.0147	0.98499	1

5. Conclusion

In conclusion, the study on the optimal allocation and sizing of multi distributed generation (DG) units including different load models using evolutionary programming (EP) is successfully tested in IEEE 69-bus test system. By using evolutionary programming, the impact of multi-DG placement in IEEE 69-bus distribution system has being analysed. The data from analysis of optimization has being used to determine the suitable location and size for multi-DG placement in different load model. The placement of DG in IEEE-69 bus test system can reduce power loss 89% to 98%. It can be concluded by placement suitable size and location of DG placement will reduce power loss in power distribution system. The finding shows the suitable location is almost similar to all cases of load model. However, the results tabulated the different DG size, but the total loss is nearly the same for every load type.

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