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Optimal allocation of distributed generation for hybrid system using Particle Swarm Optimization

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Abstract

The tendency in power generation has shift from centralized generation to DG due to transmission distance, greenhouse gas emission and power loss issues. These issues are resolved by distributed energy resources which produces power close to the end users. This integration of DER reduce the electrical energy losses, increases the quality of the system and reduces the emission of ozone harming substances through eco-accommodating power generation. However, the integration of wind and solar based DER with utility grid experiences technical and economic issues. The changeability of renewable resources due to characteristics climate fluctuations, produces uncertainty in generation output on the scale of seconds, hours and days. These fluctuations adversely influence the end user in terms of voltage regulation. In this work, to mitigate the renewable power generation discontinuities the optimal allocation of DG in distribution system has been proposed. It is solely dependent on the load flow analysis. Equations obtained from the load flow analysis are characterized by non-linearity and non-convexity that makes it complex to solve. These can be resolved by employing optimization technique. Particle Swarm optimization is used to dictate this issue since it can enhance issues of optimization problems of large measurement, frequently creating quality solutions all more rapidly. PSO will also be used to resolve the issue of voltage regulation by optimally allocate the battery energy storage system in future.

Keywords: Distributed generation, Particle swarm optimization, voltage regulation

1. INTRODUCTION

The electric power systems are developing from present centralized generation to the distributed generation system with littler producing units related directly to distribution network close the load demand. Environmental perception and renewable development rely upon long haul development of vitality origin which are key drivers of these progressions, which have added to advancement of sustainable energy sources[1] DG can be utilized in an isolated way giving the consumers regional interest or in a planned way, offering vitality to the staying of the electric framework[2]

Various distributed vitality resources have been incorporated with distribution network. The integration of DER devices lessens the power losses, expanded quality of the system and decrease in emission of ozone harming substances through eco-accommodating power generation. On occasion, distributed energy resources for example wind and solar power based generators encounter changes in their capacity yield which causes vacillations in the framework voltage and delay the voltage control process [3],[4]

Different people used the distinctive technique to control the voltage regulations. The conventional distribution network has various voltage regulation methods for example on-load tap changer, reactive power regulator. However, these methods cannot always regulate the voltage flexibility adequately[5]

Distinctive techniques have been considered and applied for the computation and the location of DG. Analysts have made many fascinating calculations and arrangements. A part of systems is made reference to for instance numerical programming, analytical approaches heuristic. All techniques claim their preference and drawbacks which depend on information and system under thought. Some cases where the distribution issue definition of DG is non-direct, fuzzy logic have some advantages or limitations. By utilizing this technique, the main purpose is to confine the actual power losses and improve the voltage [6]

The residential feeder with photovoltaic system can be considered as the basic case in regards to overvoltage. There is a plausibility of reverse power flow in the LV feeder in between high generation and low load period. As a result of DG interconnection to the low voltage network the voltage will rise when there is a reverse power flow. Thus, the feeder may experience the overvoltage[7].

The optimal allocation wind-based DG may affect the system performance. To get optimal placement of wind turbine for greatest generation capacity the genetic algorithm is used. In any case, the GA are in effect being computationally requesting and moderate in convergence[8]

J.O.Kim[9] and Kyu-Ho.Kim[10] for the location of optimum DG allocation at each load bus expecting that every load bus can have DG source used the power flow algorithm. Such techniques, are regardless, wasteful because of a broad number of load flow calculations.

To determine the optimal allocation of DG another technique is presented that is genetic algorithm. Genetic algorithm is appropriate for multi-target issues like DG allocation and can give close ideal outcomes, yet they are as a rule computationally requesting and moderate in combination[11],[12]

To limit the power loss of the system another method is presented to put DG in radial as well as meshed system. To tackle the allocation problem compound procedure dependent on phasor current is proposed. Notwithstanding, technique is just optimized when the area of distributed generation is fixed[13]

Optimal sizing and allocation of distributed generation is very important to overcome extension in framework-losses, inciting in an improvement in cost, voltage regulation.

Particle swarm optimization technique is presented to determine the optimal sizing and allocation of DG in a distribution system

Explanation of proposed paper is: section II describes the Basic theory of PSO. Section III demonstrate the Model of system, section IV represents the problem formulation for optimization of system, section V describe the proposed topology, section VI represents the results. At last, section VII concludes this paper.

2. THEORY

2.1 Particle Swarm Optimization

In 1995 James Kennedy and Russell Eberhart presented the PSO[14] At a research time, PSO has picked up consideration for its productivity in taking care of confounded and hard optimization problems. It is used in a couple of utilizations, for example, power allocation of cooperative communication network, developing artificial neural network, machine learning and different applications. The main reason for selecting the PSO is that for solving the non-linear and non-differentiable issues[15]

PSO is based on the behavior of birds, its flying and also N dimensional search space for obtaining the best solutions. This technique has two major properties one is particle position and other is speed. Utilizing these two parameters, the particle moves across in search space as demonstrated by mathematical formulas to at long last meet to the coveted position. Each particle has the ability to change its position to acquire the particle best. Also, PSO monitors the general best value and its location acquired so far by any particle in the population, this is called (g best). Particle alter its position in the search space according to the best position obtained and the position of the known best -fit particle in the entire population. From their current position particles are uprooted by applying a velocity vector to them. Direction and magnitude of their velocity vectors at each progression is an element of p and the g best values.

3. MODELS OF SYSTEM

For the allocation of wind and solar based DGs the vulnerabilities in the wind and solar based irradiance information are displayed. The simulation studies performed on IEEE 33 bus system which is actualized in MATLAB software.

3.1 Solar Irradiance modeling Output of a PV panel relies upon the region of the panel, sun based power irradiance and effectiveness of PV panel β[16]

$$P(t) = A\beta\mu(t) \qquad (1)$$

3.1.2 Wind power Modeling Different parameters which are used for wind turbine such as incorporate cut-in and cut-out speed and wind evaluated speed and their cross ponding values are 3.5m/s,25m/s and 14m/s respectively[16]

$$P(t) = 0.5\alpha\rho(t)Av(t)3 \qquad (2)$$

Where α=Albert Betz constant

ρ(t) = air density

A= swept area by turbine rotor

v(t) = wind speed

Possible values of PV and wind on average day is calculated by using Eq. (1) and Eq. (2). Solar and wind data taken from Karachi which is shown in table 1.

Table 1. Solar and wind data.

Time (hr)	**Solar Irradiance data(W/m²)**	**Wind speed data(m/sec)**
1	30	2.0
2	30.2	2.2
3	39.7	2.6
4	29.7	1.9
5	24.6	3.6
6	30	2.9
7	27.1	2.4
8	29.1	2.4
9	28.4	3.6
10	28.2	3.5
11	27.8	2.1
12	24.3	30.5
13	28.3	2.7205
14	39.77	2.6466
15	34.66	3.9623
16	29.8	3.4709
17	30.6	5.3587
18	30.3	6.0713
19	11.1	5.2234
20	0	4.8908
21	0	2.1175
22	0	1.7315
23	0	1.7083
24	0	4.9598

4. Problem Formulation for Optimization

For better sizing and allocation of DG the proposed topology is expected to overcome the power losses, enhance the voltage stability and also upgrade the voltage profile.

4.1 Objective Function Scientifically, the target function of the system is defined as:

$$f = Min(f_1 + k_1 f_2 + k_2 f_3) + \beta_1 \sum_{i \epsilon N_{DG}} [max(V_{ni} - V_{ni}^{max}, 0) + max(V_{ni}^{min} - V_{ni}, 0)] + \beta_2 \sum_{i \epsilon N} max(|S_{ni}| - |S_{ni}^{max}|, 0) \qquad (3)$$

4.1.2 Basic Constraints

4.1.3 Real Power Loss: System real power loss is:

$$f_1 = P_{RPL} \qquad (4)$$

P_{RPL} = n $_n$-bus distribution system real power loss

4.1.4 Voltage Profile: Objective function is presented to improve the voltage profile of the system is:

$$\sum_{ni=1}^{\eta_n} (V_{ni-} V_{rated})2 \qquad (5)$$

4.1.5 Limitation of voltage: Generator voltage will be considered as the load voltage in addition to few qualities identified in relation with the impedance and power streams along that line. Bigger the voltage rises, greater the impedance and power flow. In distribution network, extended in active power flow have a largely effect the voltage level in light of the way that resistive parts of the lines on dispersion framework are higher than different lines. This prompts to an R/X extent of around 1 as opposed to a more run common estimation of 5 on transmission systems.

$$V_{ni}^{min} < V_{ni} < V_{ni}^{max} \qquad (6)$$

5. Proposed Topology

Particle swarm optimization technique is presented for optimal sizing and allocation of DG. For solving the long iterative and tedious issues, PSO has the quick convergence capacity. This algorithm can be explained as:

1) Introduce the particle population.

2) Calculate the target function values which are the the voltage profile change and total real power losses.

3) Velocity and position are update.

4) Check the stop cycle on the off chance that is fulfilled at that point stop.

5) Time refreshing: Update the time counter t=t+1

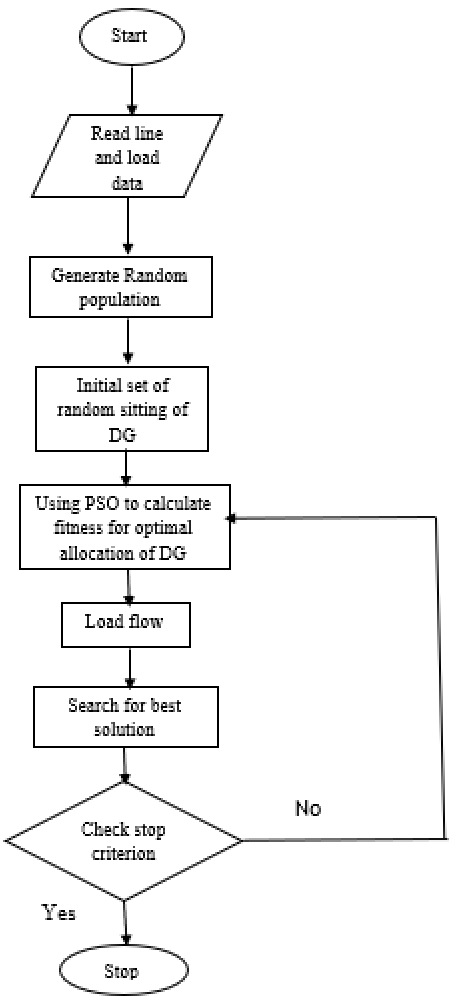

Figure.1. Flow representation of proposed methodology.

6. RESULTS

To verify the proposed methodology IEEE 33 bus system has been considered which is appeared in fig.2.

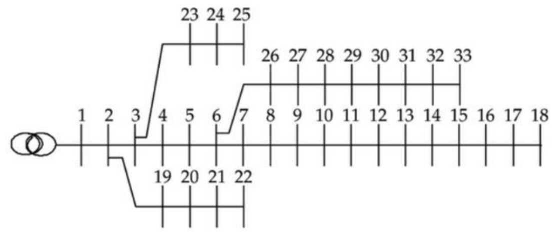

Figure. 2. IEEE 33 bus system.

Four cases have been considered to verify the proposed work

Case 1: Base Case

In this case, no DGs were installed. Its mean losses increase and voltage regulation decrease at bus no.16. Active and reactive power losses are 2.067320e+02kw and 1.370907e+02kVAR respectively which is shown in fig.3

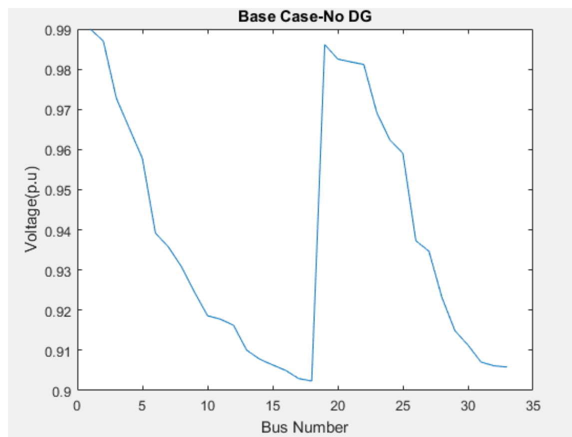

Figure. 3. No DG unit

Case 2: Solar DGs

After installing solar DG optimally, the active and reactive power losses of the system were lessened to 1.574531+02kw and 1.051282e+02kVar respectively. The optimal allocation of DG is toward bus no. 29 and the DG power is 1190kw which is shown in fig.4

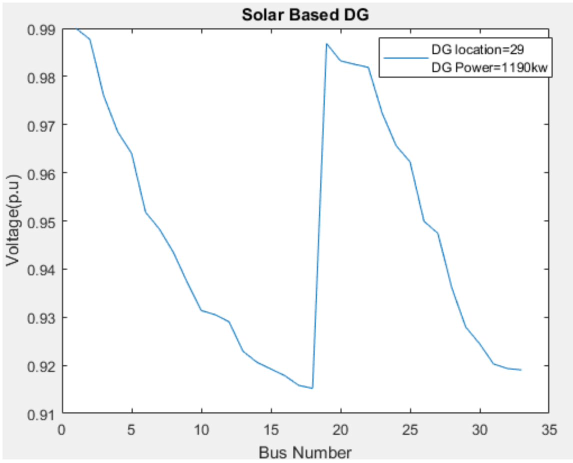

Figure. 4. Solar Based DG

Case 3: Wind power DGs

After installing Wind DG optimally, active and reactive power losses of the system were lessened to 1.898173e+02kw 1.21246e+02kVar respectively. The optimal location of DG is toward bus is 17 and DG optimal sizing is at 470k which is shown in fig.5

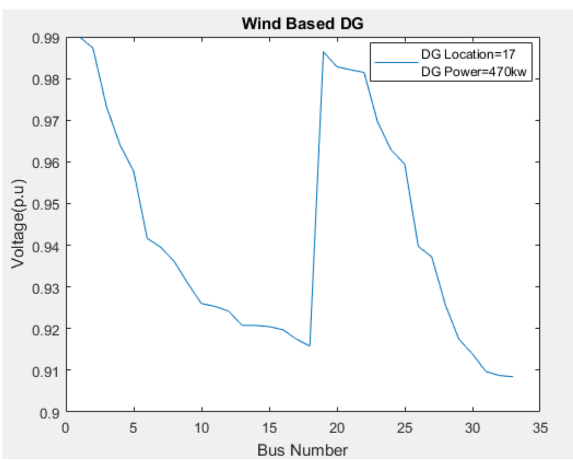

Figure. 5. Wind Based DG

Case 4: Solar& Wind Power Based DGs

Similarly, in case 4, it can be seen that when combine both solar and wind DG optimally, active and reactive losses of the system were lessened to 1.265195e+02kw and 0.8342840+01Kvar. The optimal location of DG1 is 29 and sizing power is 1190kw and the DG2 location is 17 bus number and sizing of DG is at 470kw which is shown in fig.6

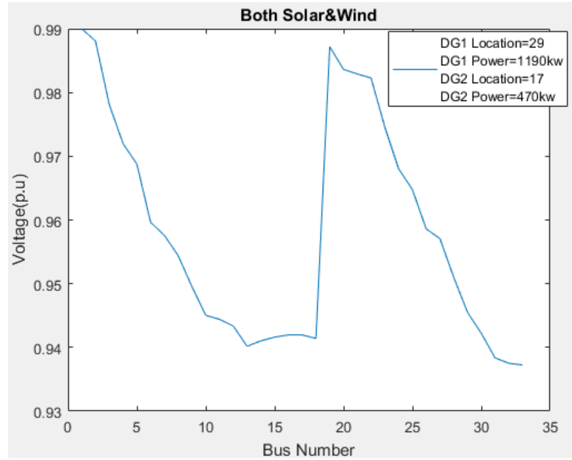

Figure. 6. Both Solar&Wind based DG

Table 2. Active and Reactive power losses.

Cases	Active power	Reactive power	DG Location
Case1-Base case	2.067320e+02kw	1.379097e+02 kVAR	No
Case 2-Solar	1.574531e+02kw	1.051282e+02 kvar	29
Case3-Wind	1.898173e+02kw	1.21247e+02kVar	17
Case 4-Both solar& wind	1.265195e+02kw	0.8342840e+01kVar	29,17

7. CONCLUSION

The proposed paper has tended out for the issue of renewable generation integrated with grid by proposing an optimization algorithm equipped for recommending optimal management techniques for solar and wind. PSO is used for the estimation of the optimal solution. Wind speed and solar based irradiance data was displayed for exact sizing of solar and wind power DGs. In this paper, four cases were presented. By analyzing the simulated results, the allocation and sizing of DG and voltage profile of the system is improved. PSO will also be used to resolve the issue of voltage regulation by optimally allocate the battery energy storage system in future.

Table 3. Load flow data for IEEE 33 bus system.

Bus Number	P(kw)	Q(kvAr)	Resistance	Reactance
1	0	0	0.0922	0.0470
2	100	60	0.493	0.2411
3	90	40	0.366	0.1864
4	120	80	0.3811	0.1941
5	60	30	0.819	0.707
6	60	20	0.1872	0.6188
7	200	100	0.7114	0.2351
8	200	100	1.03	0.74
9	60	20	1.04	0.74
10	60	20	0.1966	0.065
11	45	30	0.3744	0.1238
12	60	35	1.468	1.155
13	60	35	0.5416	0.7129
14	120	80	0.591	0.526
15	60	10	0.7463	0.545
16	60	20	1.2890	1.7210
17	60	20	0.7320	0.5740
18	90	40	0.2640	0.2565
19	90	40	0.2640	1.3554
20	90	50	1.5042	0.4784
21	420	200	0.4095	0.9373
22	420	200	0.7089	0.3083
23	60	25	0.4512	0.7091
24	60	25	0.8980	0.7011
25	60	20	0.8960	0.1034
26	120	70	0.2030	0.1447
27	200	600	0.2842	0.9337
28	150	70	1.0590	0.7006
29	210	100	0.8402	0.2585
20	60	40	0.5075	0.9630
31	60	40	0.944	0.3619
32	60	20	0.3105	0.3620
33	60	40	0.3410	0.5302

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