Scientific Journal of Impact Factor (SJIF): 4.72

e-ISSN (O): 2348-4470
p-ISSN (P): 2348-6406

International Journal of Advance Engineering and Research Development

Volume 4, Issue 11, November -2017

GENETIC ALGORITHM BASED OPTIMAL PLACEMENT AND SIZING OF DG

I.Prabhakar Reddy[1], S.Suresh Reddy[2], M.Sankaraiah[3]

[1]*Professor, NBKRIST, Vidyanagar, Andhra Pradesh, India-524413*
[2]*Professor & Head, NBKRIST, Vidyanagar, Andhra Pradesh, India-524413*
[1]*Asst.Prof, NBKRIST, Vidyanagar, Andhra Pradesh, India-524413*

Abstract: *Distributed generation (DG)is the best alternative for conventional generation system. The optimal location and proper sizing of DGs effects the system losses.This paper proposes genetic algorithm for optimal location and sizing of DGs. The proposed method is implemented in MATLAB. The proposed method is tested on IEEE 33 bus system and results compared LRIC method. The results demonstrated that the proposed method is better than LRIC method.*

Keywords: *Genetic algorithm (GA), Distributed Generation (DG), Distributed Network and Load growth.*

I.INTRODUCTION

Ackermann.T and Andersson.G (2001) proposed the basic concepts, interconnection and benefits of DG with the distribution system.El-Khattan.E, Bhattacharya.K, Hegazy.Y, and Salama.M.M.A (2004) developed a new heuristic cost-benefit analysis approach Combined with a new optimization model to estimate the most cost-effective DG sizing and siting to serve peak demands optimally. It can be used for implementing DG capacity investment as an attractive option in Distribution system planning and relates it to the electricity market pricing.
Marei.M.I and aadany.E.F (2004) proposed Flexible Distribution Generation (FDG) which is similar to FACTS, but works at the distribution level. They introduced a technique to utilize the existing DG nonlinear interface not only to control the active power flow, but also to mitigate unbalance and harmonics and to manage the reactive power of the system.Raj Kumar Singh and Dev Choudhury.N.B (2008) proposed nodal pricing technique to assess the impact of the load characteristics on the optimum location of DG that gives maximum revenue to DG and improve the voltage profile at buses. This method addresses to the voltage sensitivity of loads by incorporating the voltage sensitive model of loads during analysis that gives different results under different load models. As the potential benefits of DG largely depend on its location and size, many of the studies regarding DG address the problem of its optimal placement and sizing. In the context of a liberalized energy market, it can be used to find the most valuable sites to exploit and evaluate any additional credits DISCO might offer if the DG is placed in the appropriate location to have real benefits for the network.(Celli.G, Ghiani.E and Pilo.F, 2005). The power injections from DGs change network power flows and modify energy losses. The energy losses must vary with the penetration and concentration levels of DGs connected to the distribution network. When DG units are more dispersed along network feeders, higher loss reduction can be achieved. (Quezada.V.H.M and Abbad.J.R, 2006). F.Li and D.L.Tolley (2007) Proposed a novel distribution network pricing Without the requirement of a least-cost future network Planning. in which long-run incremental cost (LRIC) is based on the unutilized capacity or headroom within an existing network to create a forward-look economically efficient cost. G.P.Harrison and A.Piccolo (2008) use OPF to maximize capacity of DG and identify available headroom modelling fixed-power factor DG as negative load.DG can delay or diminish the investment cost of electrical network, but the quantification of network capacity deferral value of DG in practice is very difficult (Gil, H.A. and Joos,G., 2008).LRIC pricing model is able to reflect both the distance and the degree of asset utilization. Based on the LRIC pricing model, a new approach that can establish a direct link between nodal generation/demand increment and changes in investment cost while ensuring network security is proposed (Heng,H.Y and et al., 2009).Jesus Maria Lopez-Lezama et al (2011) proposed a bi-level approach to find optimal contract price of distributed generation in a distribution network. They proposed a method to consider line flows and voltage limits while obtaining price for DG units. W.Ouyang et al (2011) proposed a heuristic approach method to find the best site and size of DG based on LRIC to reduce the network capacity cost from the perspective of social benefit.

Therefore, the problem of finding best size and location of DG and pricing of a DG units in a distributed system is very important to extract maximum benefits from the system. The LRIC reflects the change in network capacity cost by additional load increment with time. Therefore, the LRIC based placement of DG units gives economic benefit by reducing network capacity cost.

This problem of optimal placement of DG is carried out by using Genetic algorithm.

II.PROBLEM FORMULATION

The problem is formulated as an objective function including power loss.

$$Y = F_1 * P_{RDN} * 8760 - F_2 * P_{DG} * F_3 \quad (1)$$

The objective is to maximize the net saving function Y without effecting the constraints of distribution system.

Where

Y = Objective Function

F_1 = Cost of Energy in Rs/Kwh

F_2 = Capital cost of DG/Kwh

F_3 = Annual rate of depreciation and interest charges of DG

$P_{RDN} = P_{BFDG} - P_{AFDG}$

P_{BFDG} = Power loss before DG

P_{AFDG} = Power loss after DG

P_{DG} = Total capacity of distributed generators in KW

P_i = Injected Power at Bus 'i'

There are two constraints taken for this purpose, They are voltage and power as given in equations (2-3)

$$V_{\min} \le V_i \le V_{\max} \quad (2)$$

$$\sum_{i-1}^{N_{Bus}} P_{DGi} = \sum_{i=1}^{N_{Bus}} \left(P_i + P_L\right) \quad (3)$$

III.LRIC

LRIC is the change in cost resulting from a change in demand assuming all factors of production can be varied. Ideally LRIC shows regard to the full social marginal cost (including externalities). LRIC is the increase in total costs of a branch following the introduction of an additional load increment in the downstream branches. LRIC reflects the cost of advancing future investment consequent on the addition of unit load at each node in distribution system.LRIC is estimated using forward looking economic costs because they mimic the cost base expected in future. The concept of forward looking costs requires that assets are valued using the cost of replacement with the modern equivalent asset cost.Costing needs to consider the time period in which the service provider can realize capital investments (or divestiture of capital) in order to increase (or decrease) its productive capacities[11].

The LRIC of a branch is obtained as follows [12]:

If a network component k, such as a branch, has a capacity of C_k, and supports a power flow of P_k, then the number of years it takes to grow from P_k to C_k for a given load growth speed d can be given by

$$C_k = P_k (1+d_k)^{n_k}$$

Rearranging the above equation

$$n_k = \frac{(\log C_k - \log P_k)}{\log(1+d_k)}$$

It is assumed that the reinforcement will occur when the circuit is fully loaded. Thus investment will occur in n_k years when the circuit utilization reaches C_k. At this point a duplication of the network component is taken as the future investment. The future investment can be discounted back to its present value. If a discount rate x is chosen, then the present value of the future investment in n_k years will be

$$C_k^{pv} = \frac{\text{asset}_k}{(1+\text{x})^{n_k}}$$

Where asset_k and C_k^{pv} are the modern equivalent asset cost and its present value

If the power flow change along line is ΔP_k, then the additional power withdrawn at the node is ΔP.This will bring the forward future investment from year n_k to n_k^*.

$$C_k = (P_k + \Delta P)(1+d_k)^{n_k^*}$$

Where n_k^* is the new number of years to reach the branch capacity.

Rearranging the above equation

$$n_k^* = \frac{\log C_k - \log(P_k + \Delta P)}{\log(1+d_k)}$$

Similarly, the present value of the future investment will change to

$$C_k^{pv^*} = \frac{\text{asset}_k}{(1+\text{x})^{n_k^*}}$$

Where $C_k^{pv^*}$ is the new present value as the result of the additional load.

Therefore, Annual incremental cost of branch k after adding ΔP load, given by [8]

$$\Delta C_k = \frac{C_k^{pv^*} - C_k^{pv}}{\Delta P} * CRF$$

Where CRF is the capital recovery factor, which is defined as the ratio between a uniform annual value within the planning horizon and present value of the annual stream.

If ΔP is close to zero ΔC_k is the derivative of C_k^{pv} with respect to P_k. Therefore annual increment cost of a branch k is given by equation

$$\Delta C_k = CRF * \frac{asset_k \ln(1+x)}{P_k \ln(1+d)} (1+x)^{(\ln P_k - \ln P_k^{cap})/\ln(1+d)}$$

LRIC is the increase in total costs of a branch following the introduction of an additional load increment in the downstream branches. The LRIC of a node will be the summation of the incremental cost of all upstream branches, given by [13]

$$m_i = \sum_{k \in U_i} \Delta C_k$$

Where m_i is the LRIC at node *i*, U_i is the set of upstream buses of node *i*.

LRIC reflects the cost of advancing future investment consequent on the addition of unit load at each node in distribution system.

Now the capacity cost of the network can be expressed as

$$C_{MW}^{net} = \sum_{i \in S} P_{Li} m_i$$

Where *S* is the set of all buses in the distribution network.

According to the expressions, the distribution capacity cost can be expressed

$$C_{MW}^{net} = \sum_{i \in S} (P_{Li} . \sum_{k \in U_i} \Delta C_k)$$

For a distribution network with radial configuration, the current power flow through each branch is the summation of nodal load downstream of the branch, that is

$$P_k = \sum_{k \in D_i} P_{Lk}$$

Where P_{Lk} is the load at bus *k*, D_i is the set of downstream buses of node *i*.

Now that LRIC reflects the cost of each bus, the capacity of the network is expressed as

$$C_{MW}^{net} = \sum_{k \in B} (\Delta C_k P_k)$$

Where *B* is the set of all branches in the distribution network.

IV.GENETIC ALGORITHM

The following Algorithm is developed with the help of Power flow solution algorithm and Genetic algorithm and is used to get the appropriate results. The developed algorithm is as follows:

Step 1: First read the network data which include the loads connected to the different nodes and the resistances and reactance's between the nodes.
Step 2: Run the power flow algorithm to obtain the base case, i.e. without DGs.
Step 3: Now read the market available DG capacities to be inserted in the system.
Step 4: Generate the bus numbers where the DGs need to be inserted using genetic algorithm.
Step 5: Again run the power flow for the system with DGs inserted in the obtained bus locations.
Step 6: Calculate the Network Performance Enhancement Index (NPEI).
Step 7: Repeat step 5 & 6 for all combinations of GA population. NPEI acts as the fitness function for GA. The aim is to maximize the value of NPEI.
Step 8: Best five combinations having the highest values for NPEI are sorted out by iterating.
Step 9: For every best result, increase the capacity of the DG with a fixed % of their individual capacities and repeat the same for the N number of iterations. Upper limit of DG capacity will be 20% and 15% of the total load at every node for 3 and 5 DGs respectively.

V.RESULTS & DISCUSSION

The two methods are tested with IEEE33 bus radial distribution system.

Bus Number	Voltage Without DG V_1 (p.u)	Voltage With DGV_2 (p.u) Using LRIC
1	1.0000	1.0000
2	0.9959	0.9986
3	0.9767	0.9935
4	0.9662	0.9935
5	0.9558	0.9935
6	0.9300	0.9935
7	0.9244	0.9884
8	0.9021	0.9677
9	0.8913	0.9576
10	0.8826	0.9496
11	0.8814	0.9485
12	0.8793	0.9465
13	0.8708	0.9386
14	0.8676	0.9357
15	0.8654	0.9337
16	0.8637	0.9320
17	0.8612	0.9297
18	0.8604	0.9290
19	0.9952	0.9979
20	0.9903	0.9930
21	0.9894	0.9921
22	0.9885	0.9911
23	0.9722	0.9891
24	0.9638	0.9809
25	0.9594	0.9765
26	0.9275	0.9912
27	0.9245	0.9885
28	0.9123	0.9771
29	0.9063	0.9715
30	0.9025	0.9680
31	0.8943	0.9603
32	0.8928	0.9589
33	0.8921	0.9583

Table 1: voltage profile with and without DG using LRIC

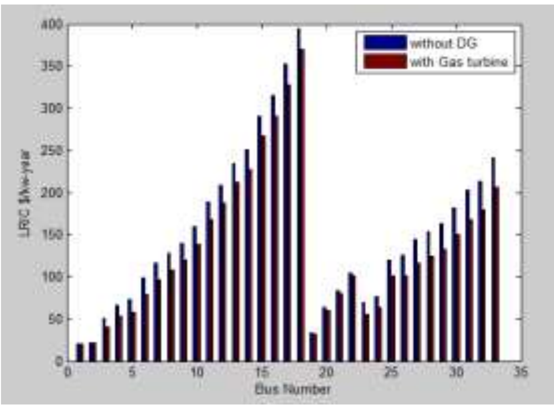

Fig.1 LRIC cost with respect to bus number

Bus Number	Voltage With DG using LRIC V_1 (p.u)	Voltage With DGusing GA V_2 (p.u)
1	1.0000	1.000000
2	0.9986	1.008611
3	0.9935	1.008485
4	0.9935	1.008456
5	0.9935	1.008355
6	0.9935	1.007568
7	0.9884	1.007540
8	0.9677	1.008614
9	0.9576	1.008611
10	0.9496	1.008687
11	0.9485	1.008572
12	0.9465	1.008572
13	0.9386	1.008362
14	0.9357	1.008362
15	0.9337	1.008167
16	0.9320	1.007568
17	0.9297	1.007304
18	0.9290	1.007304
19	0.9979	1.008926
20	0.9930	1.008687
21	0.9921	1.008687
22	0.9911	1.008600
23	0.9891	1.008064
24	0.9809	1.008572
25	0.9765	1.008572
26	0.9912	1.008319
27	0.9885	1.006735
28	0.9771	1.004907
29	0.9715	1.002735
30	0.9680	1.009079
31	0.9603	1.004907
32	0.9589	1.002361
33	0.9583	1.002361

Table.2 voltage profile with LRIC and GA

From the above two tables, it is observed that LRIC method improving the voltage profile by placing the DG in an appropriate location.

The genetic algorithm is considering the losses and optimal location of DG is decided based on the minimal power loss. Using this method the obtained voltage profile is compared with LRIC method in table 2, it shows that the voltage at every node is increased by genetic algorithm as compared with LRIC method.

VI.CONCLUSION

This paper proposed two methods for optimal placement of DG and the two methods are compared. From the above results the new genetic algorithm based optimal location of DG is indicating good voltage profile and minimum losses as compared with LRIC method.

REFERENCES

[1] Ferry A.Viawan, " Steady state operation and control of power distribution in the presence of distributed generation ", 2006.

[2] Acharya N., Mahat.P., Mithulnathan N.," An analytical approach for DG allocation in primary distributiom network", Electric power and energy systems, vol.28, no.10,December 2006,pp-669-678.

[3] Rujula A.A.B., Mur Amada J., Beneral-Agustin J.L., Yustaloyo J.M., J.A, Navarro D.," Definitions for distributed generation: a revision ", US Department of Energy 4.

[4] Ackermann T., Anderson G. and SoderL.,"DistributedGeneration:A definition", Electric Power System Rresearch, volume-71, pages 119-128, October 2001.

[5] Pepermans.G., Driesen.J., Haeseldonckx.D., Belmans.R., Dhaeseleer.W., Distributed Generation: definition, benefits and issues". Energy policy, volume-33, pages 787-798,2005.

[6] E1-Khattam.W., Salma.M.M.A., "Distributed generation technologies, definitions and benefits ", Electric Power System Research, volume-71, pages 119-128, 2004.

[7] IEA, Electric Power Technology: Opportunities and Challenges of Competition, International Energy Agency ,France.1999.

[8] Angel A. Bayod-Rujula.," Future development of the electricity systems with distributed generation", Energy, volume-34, pages 377-383, 2009.

[9] Queada V.H.M., Abbad J.R., Roman T.G.S.," Assesment of energy distribution losses for increasing penetration of distributed generation," IEEE Transactions on power systems, Volume-21, No.2, Pages 533-540, May-2006.

[10] Gil H.A. and Joos G., "Models for quantifying the economic benefits of distributed generation", IEEE Transactions on Power Systems, Volume-23, No.2, Pages 327–335, 2008.

[11] Heng H.Y., Li F. and Wang X.F., "Charging for network security based on long-run incremental cost pricing", IEEE Transactions on Power Systems, Volume-24, No.4, Pages 1686–1693, 2009.

