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Benefits of Distributed Generation in an Unbalanced Three Phase Distribution Network. Analytical Comparison of Different Schemes

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Abstract

This paper investigates a comparison of different methods (Improved Analytical, Genetic Algorithm, Heuristic, Fuzzy Logic) of optimal placement of distributed generation in distribution network. In this paper it is found that different approaches have different weights in different conditions. If an electricity consumer wants to place distributed generator than the optimal placement is different and if a bulk customer wants to place distributed generator, than place is different. It is also found that in any of the mentioned cases, optimal distributed generation allocation with the reconfiguration provides lower energy losses and proving the effectiveness of these approaches.

Keywords: Distributed generator (DG), Genetic Algorithm (GA), Improved Analytical (IA).

1. Introduction

Distributed generation is expected to become more important in future generation system. Currently there is a growing energy demand, this demand is usually covered by energy sources such as oil, coal and natural gas, which have been the basis for growth and development of communities .Generating energy by conventional sources currently has a major impact on the environment, natural eco system, human communities, and in other areas. It is for these reasons that currently there are many efforts underway to reduce the use of oil, coal and other nonrenewable energy sources and increase the participation of renewable energy. These renewable sources are wind energy, solar energy, bio mass, geo thermal energy etc [6].In distributed generators sources (DGs), and renewable energy is used for the generation of electricity. Since they are neither polluting nor exhaustible [8]. Hence distributed generation is not a threat for human being, animals as well as plants and trees and it creates no pollution.

Wind energy has gained great attention because it represents an important option for reducing the reliance of hydrocarbons for energy production, especially for electricity. It is crucial to optimize the placement of wind turbine to increase the number of these devices installed as an option to reduce dependence on fossil fuels in energy production.

Distributed generation devices can be strategically placed in power system for grid reinforcement, reducing power losses and on peak operating cost, improving voltage profiles and load factors deferring or eliminating for system upgrades and improving system integrity, reliability and efficiency. Moreover line losses and transformation losses in transformers at different levels also reduce. [7].

2. Methodology

Installation of DG at non optimal place in distribution system might lead to detrimental effect. Hence the problem of installation of DG at optimal place has great importance, so DG unit maximize their benefits without violating system constraints. Many of the scientists have worked on placement of DG and proposed number of approaches to find out the optimal location. In this paper an attempt has been made to analyze the losses by various approaches.

The diagram has generating source at bus 1 which feeds at bus 2 through transmission line having impedance Z. The impedance in transmission line reduces the voltage profile at bus 2 which in-turn reduces the receiving end voltage. The placement of DG at load side reduces the current, thereby reduces the impedance and increase the voltage level.

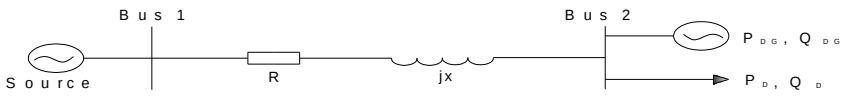

Figure 1 Distribution system with DG

The approaches are categorized as follows

2.1 Genetic Algorithm

M.F. Kotb, K.M. Shebl et. al [4] used genetic algorithm as optimization tool to solve above mentioned problem.
Under genetic operation the fitness function is evaluated for reducing power loss and to increase the voltage stability margin or reducing cumulative voltage deviation. With the objective of power loss reduction and voltage profile improvement the fitness function or objective function (OF) is selected as follows:

$$OF = W_P XP_L + W_q XQ_L + W_V Xcvd \quad (1)$$

P_L & Q_L are determined by load flow program and to evaluate CVD

$$CVD = \sum_{i1}^{n} (1 - Vi) \quad (2)$$

W_P W_Q and W_V are objective function weights and these are evaluated as:

$$W_P + W_Q + W_V = 1 \quad (3)$$

2.2 Fuzzy Logic

Masoud Esmaili et. al [3] has presented a novel approach to optimize selection of best location for DG using fuzzy logic. In this approach number of objective functions is fuzzyfied as describe below

$$ndg = \sum_{i \in SB} \frac{P_{DGi}}{P_{DGi} + \varepsilon} \quad (4) \qquad P_{LOSS} = \sum_{i \in SB} P_{Gi} - P_{DTotal} \quad (5)$$

$$VSM = VSM_{BC} + \sum_{i \in SB} \frac{\partial VSM}{\partial P_{Gi}} P_{DGi} + \sum_{i \in SB} \frac{\partial VSM}{\partial Q_{Gi}} Q_{DGi} \quad (6)$$

From above mentioned objective functions which are to be fuzzified a common objective function is describe below which is to be maximized to get optimal solution.

$$Maximise: f = \omega_{ndg} \mu_{ndg} + \omega_{ploss} \mu_{ploss} + \omega_{vsm} \mu_{vsm} \quad (7)$$

2.3 Combined Heuristic Constructive Algorithm

Gustavo J.S. Rosseti et. al [1] presented heuristic constructive algorithm for allocation of DGs.

$$Min.losses = \sum_{\mu=1}^{NT} \left[\sum_{km=1}^{NB} t_\mu \cdot L_{km,\mu} \cdot CH_{km} + \sum_{i=1}^{NDG} \sum_{k=1}^{NC} t_\mu \cdot L_{ik,\mu} \cdot DG_{ik} \right] \quad (8)$$

NT= total no. of load level
NB= total no. of existing branch
NDG= total number of distributed generator
NC= total number of candidate branches to connect the distributed generator
t_μ= time interval the EDS operating at load level u (hours)
$L_{km,\mu}$ = active power loss of existing branch km at load level u (kW)
CH_{km}= discrete variable associated with the position of the maneuverable switch of branch km
DG_{ik} discrete variable associated with the distributed generator at busbar *i* connected to the system through busbar *k*
$L_{ik,\mu}$= active power loss of candidate branch *ik* at load level *u* (kW)

2.4 Analytical Approach

Doung quoc hung et. al [2] [5] have presented analytical approach to find out best location for DG.

2.4.1 IA expression

The optimal size of DG at each bus *i* for minimizing losses can be given by as follows

$$P_{DGi} = \frac{\alpha_{ii}(P_{Di} + aQ_{Di}) - X_i - aY_i}{a^2 \alpha_{ii} + \alpha_{ii}} \quad (8) \qquad Q_{DGi} = aP_{DGi} \quad (9)$$

3. Constraints

In all above mentioned approaches, followings constraints are applied to get an optimal solution.

3.1 Active and reactive loss constraints

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$$P_{LDG} \le P_{LBC} \quad (10) \qquad Q_{LDG} \le Q_{LBC} \quad (11)$$

3.2 Voltage constraints:

$$V_{min} \le V_i \le V_{max} \quad (12)$$

V*i* = bus voltage at i[th] bus
V_{min} = minimum bus voltage
V_{max} = maximum bus voltage

3.3 DG size constraints

20% L ≤ DGs ≤ 80%L
L = load value
DGs = size of DG

Table 1: Results of different approaches

No.	Approach	Constraints	Results		remarks
			Without DG	With DG	
1	G.A.	P_L, Q_L,	0.1085 MW	0.0471 MW	56% loss reduction
2	Fuzzy logic	P_L, Q_L,	2.186 MW	0.279 MW	87.2% loss reduction
3	Combined Heuristic Constructive Algorithm	P_L, Q_L,	466.13 KW	404.97 KW	13.12% loss reduction
4	Analytical	P_L, Q_L,	511.43 KW	168.49 KW	67% loss reduction

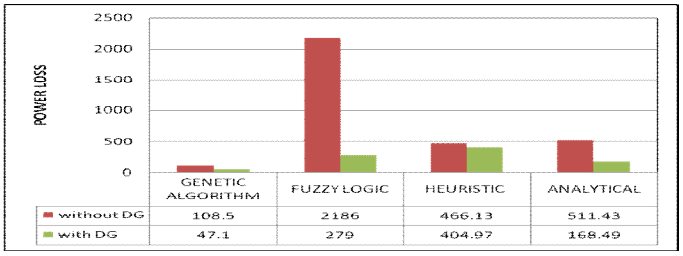

Figure 2 Power loss Comparison

4. CONCLUSION

Installation of DG's in distribution networks has assumed a significant importance worldwide in the electric utilities during last few years. In this paper numbers of approaches are compared on the basis of power loss. Power loss reduction, voltage profile improvement is achieved with all approaches. While going through the table mentioning results of different approaches for optimal placement of DG's in distribution network. It is found that conventional and analytical approaches are also good enough to reduce power loss and improve voltage stability of the distribution network with proper placement of DG's. However their computational time is large.

Whereas, the heuristic and meta-heuristic approaches are giving almost the same results as far as reduction in power loss, but the computational time required by these approaches is very less and hence these approaches are suitable for on-line application for complex distribution networks.

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