International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 3 Issue 2, February - 2014

Review Paper on Optimal Location and Sizing of DG

Sujata Huddar[1]
[PGscholar AIT
Chickmaglur]

Amulya. H. G[2]
[PG scholar AIT
Chichmaglur],

B. Kantharaj[3]
[Associate professor
AIT Chickmaglur]

Rudresh Magdum[4]
[Assistant professor
GIT Belgaum]

Address
Department of power system engineering chikmagalur
[Affiliated to Visveswaraiah Technological University]

***Abstract*— Introduction of distributed generation (DG) changes the structure of distribution network which greatly effects on distribution network loss, so rational distributed generation source placement is needed. In this paper distributed generation source placement for minimizing loss is proposed. A new algorithm for reticulation system to locate single distributed generation source, is proposed. Distributed Generation (DG) sources have attracted serious attention due to their potential solution for some issues, like increasing the power consumption and the shortage of transmission capacities. The optimal placement of DG is necessary to improve the reliability and stability. This paper includes some of the most popular DG placement methods such as Optimal Power Flow using NR method and Evolutionary Computational Method including Genetic Algorithm[3].Again the different types of DG and benefits of DG is explained.**

Keywords*— Distributed Generation (DG); Genetic algorithm; NR method; Optimal Location; Optimal Power flow; Types of DG.

I. INTRODUCTION

Due to the depletion of traditional energy, as well as the increasing emphasis of many countries in the world on environmental issues, an pro-environment and flexible way for power generation is needed urgently to solve these problems. Distributed generation (DG) can be connected with the actual situation of each place, generate electric power flexibly and efficiently, so it has been attached importance to and has become the new focus in power system research. Introduction of distributed generation source (DGs) to distribution network impacts on the structure and operation of distribution network, namely nodes voltage, power flow, short-circuit current, reliability of distribution network. The DG advantages can be divided into technical, economical and environmental benefits. Technical advantages[7] are included wide ranges of benefit such as efficiency, grid reinforcement, power loss reduction, reliability, eliminating or deferring the upgrades of power system, improving load factors and voltage profile and thus increased power quality. The economical advantages are entailed the reducing of transmission and distribution operating cost, to save the fossil fuel and decreasing in electricity price. Environmental advantages are covered the reductions in emission of greenhouse gases and also sound pollutions. Several techniques have been proposed in determining the optimal location of DG. The major objective of DG placement techniques is to minimize the losses of power systems. However, many researchers have applied the evolutionary computational methods for finding the optimal DG location. The Genetic Algorithm[10], Fuzzy

Systems and Tabu Search are more commonly used. This paper includes Optimal Power Flow using NR method, Evolutionary Computational Method such as Genetic Algorithm.

II. DG PLACEMENT METHODS

A. Optimal power flow

This technique is based on technical and economical aspects of load flow approaches. Different power flow methods [3] have been studied and evaluated for utilizing its potential in finding the best location to place DG. The common objectives are loss reduction, maximizing the size and voltage improvement.

In an optimal power flow and based on DG participation in wholesale electricity market (deregulation), there are some more issues for finding optimal DG placement such as profit maximization and welfare maximization.

Moreover, techniques like Newton-Raphson (N-R) method [3] was proposed to use a simple search approach for determining DG optimal size and location. This optimization method was entailed both cost and loss simultaneously. Indeed, the problem was solved by utilizing N-R method and proposing a mixed objective function which include the sum of the loss and cost functions.

$OF=C[P_{DG}]+W*E$

where the total cost of DG is $C[P_{DG}]=a+bP_{DG}+cP_{DG}$^2 also, W and E are weighting factor and total active loss respectively. Based on voltage considerations, both the lower

OF and lower voltage buses was evaluated to satisfy the related objectives i.e. loss reduction, voltage improvement and cost reduction. Also, the DG optimal size was considered regarding to minimum voltage variations and OF ranges. This method has some advantages economically and technically like cutting the cost, reduction in loss and improving the voltage regulation. But the load types and its effects on DG placement were not studied. Moreover, this was assumed that the DG could be placed in any system buses while this assumption is not practically true.

B. Evolutionary Computational Methods

These methods cover a wide range of Artificial Intelligence (AI) techniques such as Genetic Algorithm [10], Fuzzy Systems Tabu Search and etc which have been applied in most optimization problems as well as DG optimal placement. The applications and goals of these techniques vary owing to their great potentials to optimize technical and economical DG challenges. The fundamental of these techniques are considered below.

The Genetic Algorithm (GA) is an optimization procedure or stochastic search based on the application of natural selection and genetics. It is a powerful search algorithm which has been solved many non-linear and large-scale problems of power systems.

The GA is initialized with a population of individuals (solution-optimal location) and a binary representation of the decision variables to perform the search by using genetic operators i.e. selection, crossover and mutation. The quality of an individual is assessed by its fitness, which is based on fitness function. In case of DG placement, this fitness is evaluated based on minimizing real power losses, to reduce investments and operational costs, and providing optimal size. The population is randomly created at the beginning of each search step. The fitness assessment is used to select the best solutions (individuals) from the current generation to upgrade into the next generation. The GA operators are applied for the next generation for having new and better individuals.

This process is continued until the best solution (DG optimal location) in the population is found .

As another technique, the fuzzy methods were generally used in power systems optimizations for fuzzy load modeling , fuzzy economic cost, fuzzy reliability level and etc. Also, because of its high-quality explanations, it has been applied in decision making and uncertainty concepts. In general and in this approach, by utilizing the numerical analysis, the relationships of inputs and outputs are defined as fuzzy rules. Indeed, all objective functions i.e. optimal site and size of DG in this study are converted to fuzzy objective functions. The calculations of membership function related to the fuzzy optimal solution are performed individually and finally, the maximum value of the membership function can be defined as optimal solution (optimal location) .

Tabu Search is a heuristic algorithm for leading the search process to find optimal solution like DG optimums for site, size and reliability level. To apply this algorithm for selecting optimal DG location, several steps should be repeated.

At first, an initial population along with control variables including active DG power and imposed constraints is selected randomly. The load flow is solved for each member of this population. Then, the objective function for each member is calculated individually to selecting good members with minimum objective function. The selected members are transferred to a list which is called Tabu List. Afterward, the mutation and cross over operators are applied to create new population.

A new population is composed with the new and current populations. The individuals of this new population are ranked owing to their objective function value. The best solution would achieve the highest rank. In the next step, to prevent local minimum problems, each individual of this population is evaluated based on its distance to Tabu list. The best solution (the highest rank) has the longest distance from Tabu list. The fitness function is evaluated based on the individual's ranking in sum of distance and objective function value. The individuals with the best fitness function are selected in this section and they are replaced with current individuals for the next population in Tabu list. In the last step, if the convergence criterion is satisfied, the search will be stopped; otherwise the new population would create and above steps should be repeated respectively.

The simplicity and fast operation of the evolutionary methods have been attracted wide DG research studies in case of loss reduction, minimizing cost, optimal DG size and increasing reliability level. However, they have critical convergence problems, infeasibility in large-scale systems and they also have not considered some factors, like cost, size and voltage profile at the same time.

III. TYPES OF DG [5]

Distributed energy resource (DER) systems are small-scale power generation technologies (typically in the range of 1 kW to 10,000 kW) used to provide an alternative to or an enhancement of the traditional electric power system. The usual problem with distributed generators are their high initial capital costs.

A .Cogeneration

Distributed cogeneration sources use steam turbines, natural gas-fired fuel cells, microturbines or reciprocating engines to turn generators. The hot exhaust is then used for space or water heating, or to drive an absorptive chiller for cooling such as air-conditioning. In addition to natural gas-based schemes, distributed energy projects can also include other renewable or low carbon fuels including biofuels, biogas, landfill gas, sewage gas, coal bed methane and associated petroleum gas.

Delta-ee consultants stated in 2013 that with 64% of global sales the fuel cell micro combined heat and power passed the conventional systems in sales in 2012.20.000 units where sold in Japan in 2012 overall within the Ene Farm project. With a Lifetime of around 60,000 hours. For PEM fuel cell units, which shut down at night, this equates to an estimated lifetime of between ten and fifteen years. For a price of $22,600 before installation. For 2013 a state subsidy for 50,000 units is in place.

In addition, molten carbonate fuel cell and solid oxide fuel cells using natural gas, such as the ones from FuelCell Energy and the Bloom energy server, or waste-to-energy processes such as the Gate 5 Energy System are used as a distributed energy resource.

B. Solar panel

primary issue with solar power is that it is intermittent. Popular sources of power for distributed generation are solar heat collection panels and solar panels on the roofs of buildings or free-standing. Solar heating panels are used mostly

for heating water and when the water is heated into steam it can effectively and economically used in steam turbines to produce electricity.

The production cost for electricity produced from photovoltaic panels ranges from $0.99 to 2.00/W (2007) plus installation and supporting equipment unless the installation is Do it yourself (DIY) bringing the cost to $0.525 to 0.750/W (2010). This is comparable to coal power plant costs of $0.582 to 0.906/W (1979). Some "thin-film" solar cells have waste-disposal issues when they are made with heavy metals such as Cadmium telluride (CdTe) and Copper indium gallium selenide (CuInGaSe), and must be recycled, as opposed to silicon solar cells, which are mostly non-metallic. Unlike coal and nuclear, there are no fuel costs, operating pollution, mining-safety or operating-safety issues. Solar power has a low capacity factor, producing peak power at local noon each day. Average capacity factor is typically 20%.

C.Wind turbine

Another source is small wind turbines. These have low maintenance, and low pollution, however as with solar, wind energy is intermittent. Construction costs are higher ($0.80/W, 2007) per watt than large power plants, except in very windy areas. Wind towers and generators have substantial insurable liabilities caused by high winds, but good operating safety. In some areas of the US there may also be Property Tax costs involved with wind turbines that are not offset by incentives or accelerated depreciation. Wind also tends to complement solar. Days without sun there tend to be windy, and vice versa.[citation needed] Many distributed generation sites combine wind power and solar power such as Slippery Rock University, which can be monitored online.

E.Vehicle-to-grid

Future generations of electric vehicles may have the ability to deliver power from the battery in a vehicle-to-grid into the grid when needed. An electric vehicle network could also be an important distributed generation resource.

F.Waste-to-energy

Municipal solid waste (MSW) and natural waste, such as sewage sludge, food waste and animal manure will decompose and discharge methane-containing gas that can be collected as used as fuel in gas turbines or micro turbines to produce electricity as a distributed energy resource. Additionally, a California-based company, Gate 5 Energy Partners, Inc. has developed a process that transforms natural waste materials, such as sewage sludge, into biofuel that can be combusted to power a steam turbine that produces power.

IV. TECHNICAL BENEFITS OF DG[6, 7,8,9]

According to the US Department of Energy, roughly 20% of the electrical generating capacity in the US comes from distributed generation. Much of that is in the form of backup generators and peaker plants. Here are a few reasons why distributed energy generation will soon begin to play a larger role in the overall electricity market:

A. *Reliability*

Storms, falling tree branches, brownouts, and acts of terror all threaten the grid, and when it fails, it typically leaves tens of thousands of customers (or millions in extreme cases) without power for long periods of time. After Hurricane Sandy hit the east coast, a few individuals with solar panels were providing emergency power to their neighbours. A distributed generation system with microgrids can localize the impact of these failures, reducing the number of people affected.

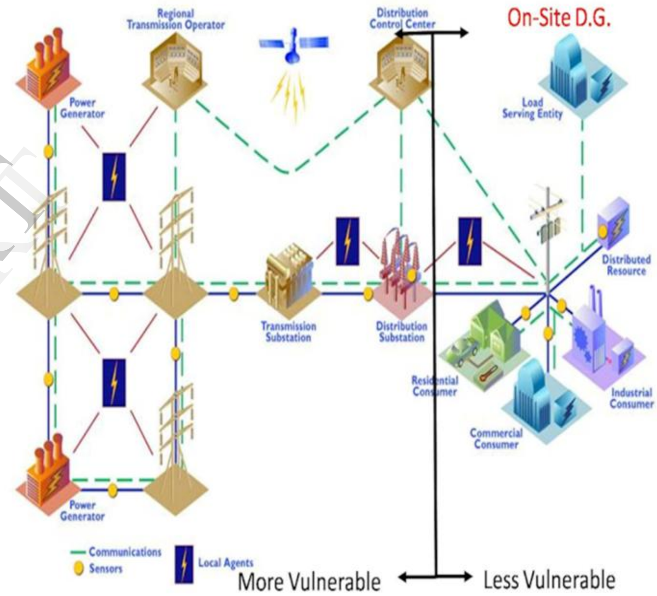

Fig.1 US Department of Energy

B. *Flexibility*

Big power plants - whether they're based on fossil fuels, nuclear energy, or renewable energy - are expensive to build and have very long payback periods. That means the utilities are slower to adopt new technologies. If we just spent $40B on a natural gas electrical generating plant, we are not likely to abandon that and switch to another fuel or a renewable source, even if the price of natural gas rises. On the other hand, if we build several smaller plants based on renewable sources, We can easily decommission them a little at a time as we experiment with and adopt new technologies.

C. *Upgradability*

Suppose we built a large wind farm with turbines that have an expected life of 30 years. Turbine efficiency is likely to improve over the next few years, but it's too costly to replace an entire farm at once. And since the farm is designed as a whole - each turbine affects its neighbors - we can't simply replace a few turbines with newer models. Smaller wind farms in more locations would allow us to adopt the newer turbines in one or two of the farms, gradually increasing our production without making a major investment in equipment.

D. Economy of Scale

One reason large power plants are expensive to build is that so few of them are built - it's a highly specialized market. If we build a lot of small power plants with whatever technology is appropriate, the mass production effect will drive down the cost.

E. Diversity

Distributed generation allows us to use a variety of power generating technologies, decreasing my dependence on any one resource. With stock portfolios, organizations, and energy, there is strength in diversity.

F. Efficiency

The US Energy Information Administration reports that 7% of the electricity generated is lost in transmission and distribution. Decrease the distance that it travels and you decrease the amount that's lost.

As the grid continues to deteriorate, energy demands keep rising, and corporations focus on short-term profits, the need for distributed generation will increase. We'll see smart microgrids and small power plants - hopefully using renewable energy - appearing on our landscape.

V. DG ADVANTAGES AND DISADVANTAGES [8]

Distributed Generation is distributed resources or generating sources located at the load side of the power system. The power rating of this distributed generating sources will be fractional and can be sufficient to cater particular load centers in the distribution side.

Distributed Technology sources includes both renewable and non-renewable resources. In US as more stress was given on developing renewable energy sources, distributed generation along with smart grid technologies helps to increase the reliability, power quality and less carbon footprints

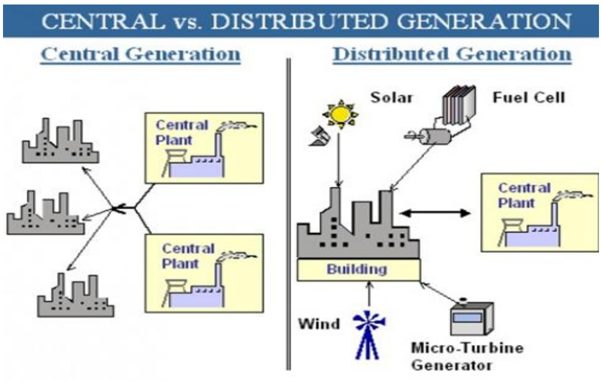

Fig.2 differences between central and distributed generation.

A. Advantages of Distributed Generation[8]

Distributed Generation technologies includes generation sources such as Solar, Wind, Fuel cells, Biomass, IC Engines. The rating of the power generation sources will be from few kW to MW.

1. Distributed Generation increases the reliability of power supply to the consumers. As these generating units are at the load side in the power system, this significantly reduces Transmission and Distribution losses
2. The connection of distributed generation sources to the power system will improve the voltage profiles, power quality and supports the voltage stability of the system. This allows the system to withstand higher loading conditions and reduce the cost of Infrastructure for building the transmission and distribution systems
3. Distributed Generation technologies can be made part of the smart grid or micro grid to improve the efficiency of the system
4. Compared to other conventional plants, these plants require less time for commissioning and payback period is also less compared to conventional plants.
5. Some Distributed Generation Technologies are flexible in operation, size and can also easily extendable

6. Some distributed Generation technologies have higher overall efficiency and low pollution such as combined heat and power (CHP) and some micro turbines
7. The right type of generating source suitable at that location can be installed and can generate power at cheaper cost

B. Disadvantages of Distributed Generation:

Distributed Generation technologies have some negative impacts on the environment as well as economic aspect Wind turbines will have visual, acoustic and bird life impact Wind farms and PV systems require large area compared to the conventional technologies for the same installed capacity Small hydro, tidal and wave power plants may influence the ecosystem and fishery

Biomass may produce unpleasant emissions in case of incomplete combustion The output of some of the renewable energy sources such as wind, PV are variable and difficult to prodict Connecting the Distributed Generation sources to the grid is complex. Protection design requires good communication between Distributed Generation project developer and Grid authorities. during the design process

The main technical issue for connection of Distributed Generation to the grid relate to reliability, quality of supply, protection, metering and operational protocols for connection and disconnection, islanding and reactive power management

Connecting Distributed Generation to distribution network in the power system will introduce a source of energy at the point. This increases the fault level in the network and may complicate the fault detection and isolation

VI. DISCUSSION

Different techniques along with their strengths and weaknesses for finding optimal DG location were reviewed in this study. Each method has been tried to solve the problem with various and limited objectives and constraints. So, the effective comparison for these techniques is difficult

however some objectives like loss and pollution reduction are common in most of them. For instance, all the methods have had suitable effects on pollution reduction. Also and in case of active loss, evolutionary methods were reduced the loss nearly 60% while other techniques such as power flow decrease it around 75%. In addition, the process speed in the evolutionary techniques is higher, compared to power flow. Again the description for different types of DG's and Benefits of DG's have been discussed.

VII. CONCLUSION

The proper DG unit sizes should be placed in the optimal location to provide the maximum environmental, economical and technical benefits[7,9]. Despite of proposing many different research studies for DG proper placement, the systematic principle for this issue is still an unsolved problem. In practice, the main problem is the complexity of this process. Indeed, a lot of constraints should be considered simultaneously such as power loss, reliability, load factors, voltage profile (quality), operational cost, emission of greenhouse, the related capacity and so on. That's why the most of researchers have been divided the problem into limited parts along with imposed constraints and then they were tried to propose their solutions. To maximize the DG placement profits, it is important to do more studies in this field. To do so and in this work, several popular methods to select the DG site have been considered along with their potentials and applications. The provided useful guidelines and references can be lead researchers for future studies.

REFERENCES

[1] Hussein.A.Attia, M.EI-shibini, Z.H.Osman and Ahmed A Moftah "*An assessment of a global performance index for distributed generation impacts on distribution system*" Electrical power and Machines Department ,carlo University. 2010.

[2] Zhang jun-fang, Dingsi-min, Hang yin-li and Hu guang "*Research on distributed generation source placement"* 2009.

[3] K.Abookazemi, M.Y.Hassan,and M.S.Majid "*A review on optimal placement methods of distribution generation sources"* 2010 IEEE interational conference on power and energy.

[4] Saeed mohammadi, Abouzar samimi "*optimal placement of distributed generation resourcesin distribution systems via reliabity criterion"* Department of Electrical Engineering, Kermanshah University of Technology. 2012

[5] The wikepedia, free encylopedia *"The types of distributed generation"* district energy and CHP www.clarke-energy .com retrived on September 16, 2013

[6] Distributed generation education modules *" Benefits of distributed generation"* 2007 consortium on energy restructuring , Virgin Tech

[7] Engineering.com Electronics "*Technical benefits of distributed generation"* june 27 2013

[8] Instituted for local self-reliance "The political and technical advantages of distributed generation" July 6,2011.

[9] Pathomthat chiradeja, member IEEE , and R.Ramakumar life fellow IEEE "*An Approach to quantify the Technical benefits of distributed generation"* IEEE transactions on energy conversion Vol 19 No 4 December 2004

[10] Mehdi Nafar " *Optimal placement of DG's in distribution systems considering voltage stability and short circuit level improvement using GA* " 2012 Text publication.