Analysis of Reliability using Artificial Intelligence Technique

JAGRUTI ZOPE\textsuperscript{1}, DR. P. M. SONWANE\textsuperscript{2}

\textsuperscript{1}Research Scholar, Dept of Electrical Engineering, KKWIEER, Nashik, India.\textsuperscript{2}Professor, Dept of Electrical Engineering, KKWIEER, Nashik, India.

Abstract: Optimal placement of DGs method to improve reliability of distribution system is discussed in this paper. Particle Swarm Optimization technique is used to maintain voltage profile, better power system and reduce losses to enhance reliability indices and reduce reliability cost. To identify the location of optimal number of DGs placed in the system is important process of the project. The proposed method is carried on IEEE 14 bus system for reliability improvement tests. The result shows improvement in the total power losses and reduction in reliability cost. Reliability analysis is carried out with respect to the reliability parameters of the buses and the line. The calculation of reliability parameters are carried out to obtain reliability indices for the IEEE 14 bus system with DG and without DG. The complete design and analysis is carried out in matlab software with comparison of reliability indices with and without DG in a table given in last section using PSO technique.

Keywords: DG, PSO, Reliability Indices.

I. INTRODUCTION

The economic and social effects of loss of electric service have significant impacts on both the utility supplying electric energy and the end users of electric service. The cost of a major power outage confined to one state can be on the order of tens of millions of dollars. If a major power outage affects multiple states, then the cost can exceed 100 million dollars. The power system is vulnerable to system abnormalities such as control failures, protection or communication system failures, and disturbances, such as lightning, and human operational errors. Therefore, maintaining a reliable power supply is a very important issue for power systems design and operation. The basic function of the power system is to provide an adequate electrical supply to its customers as economically as possible with reasonable level of reliability. With growing demand and increasing dependence on electricity supplies, the necessity to achieve an acceptable level of reliability, quality and safety at an economic price, the utility have to evolve and improve the systems continuously depending upon the requirement of the customers. Over the past, distribution systems have received considerably less attention devoted to reliability modeling and evaluation than the generating and the transmission systems. The reasons for this are that the generating stations and the transmission systems are capital intensive and the generation and the transmission inadequacy can have widespread catastrophic consequences for both society and the environment.

A distribution system, however, is relatively cheap as compared to the other two as its effects are localized. Therefore, less effort has been devoted to quantitative assessment of the adequacy of various alternatives and reinforcements. On the other hand, analysis of the customer failure statistics of most utilities shows that the distribution system makes the greatest individual contribution to the unavailability of supply to a customer. The distribution systems account for up to 90% of all customer reliability problems, improving distribution reliability is the key to improving customer reliability. Since the primary purpose of the system is to satisfy customer requirements and the proper functioning and longevity of the system are essential requisites for continued satisfaction, it is necessary that both demand and supply are appropriately viewed and included in the systems. Therefore, the distribution reliability is one of the most important in the electric power industry due to its high impact on the cost of electricity and its high correlation with customer satisfaction.

In present times, use of DG systems in large amounts in the different power distribution systems have become very popular and is growing on with fast speed. Some of the main advantages while installing DG units in distribution level are peak load saving, enhanced system security and reliability, improved voltage stability, grid strengthening, reduction in the on-peak operating cost, reduction in network loss etc. [2] [5]. The improvements in the reliability of the distribution network have come out as one of the most important benefits. DGs are applied in the different power distribution systems because of energy efficiency or rational use of energy, deregulation or competition policy, diversification of energy sources, availability of modular generating plant, ease of finding locations for smaller generators, shorter construction time and lower capital costs comparatively for smaller plants, and its proximity of the generation plant to heavy loads, which reduces the transmission costs. A lot of technologies are used for DG sources such as photo voltaic cells, wind generation, combustion engines, fuel cells and there are some other types of generation from the natural or artificial resources that are available in the geographical area [17].
Usually, DGs are attached with the already existing distribution system and lot of studies are performed to find out the best location and size of DGs to produce highest benefits. The different characteristics that are considered to identify an optimal DG location and size are the minimization of transmission loss, maximization of supply reliability, maximization of profit of the distribution companies etc [17]. Due to wide-ranging costs, the DGs are to be allocated properly with best size to enhance the performance of the system in order to minimize the loss in the system as well as to get some improvements in the different voltage profiles while we also have to maintain the stability of the system. The effect of placing a DG on network indices will be different based upon its type and location and (predict) load at the connection point [13]. There are lot of variety of potential benefits to DG systems both to the consumer and the electrical supplier that allow for both greater electrical flexibility and energy security. In this paper, the optimal placement of DG and amount of power being generated by DG are computed using PSO. Here, authors presented a stage of PSO which is used to identify the optimal placement of DG and amount of power to be generated. By using this method, the total power loss in the system is reduced and reliability of the system increases.

II. PROBLEM DESCRIPTION

A. Problem Statement
Evaluation of DG placement and its sizing by PSO for the benefit of distribution system in terms of savings due to loss reduction, maintain voltage profile, better power system planning and enhancement of reliability indices as well as reduction of reliability cost.

B. System Description
System considered in this project is IEEE 14 BUS system as graphically represented in Fig1. The load flow analysis of IEEE 14 bus system with and without DG is analyzed using NR method.

III. METHODOLOGY IMPLEMENTED

Various methodologies are available, the technique which is implemented is mentioned in this section.

A. Implementing PSO
PSO is a population-based search algorithm inspired by the behavior of biological communities that exhibit both individual and social behavior; examples of these communities are flocks of birds, schools of fishes and swarms of bees. Members of such societies share common goals (e.g., finding food) that are realized by exploring its environment while interacting among them. In PSO each solution to the problem at hand is called a particle. The following equations 1 find the next particle location.

$$v_{i+1}^{(j)} = w_i v_{i+1}^{(j)} + c_1 r_1 (p_{i+1}^{(j)} - x_{i+1}^{(j)}) + c_2 r_2 (g_{i+1} - x_{i+1}^{(j)})$$

B. Updating particle
The initial particles are updated by using below equations

$$v_{i+1}^{(j)} = v_{i+1}^{(j)} + c_1 r_1 (p_{i+1}^{(j)} - x_{i+1}^{(j)}) + c_2 r_2 (g_{i+1} - p_{i+1}^{(j)})$$

where, $v_i$ is the particle velocity, $p_{i+1}$ is the current particle, $p_{best}$ is the best fitness values and best values for any particle in the population respectively, rand () is the random number between (0,1) and $c_1$, $c_2$ are learning factors.

C. Termination process
In this process, best particles are on the basis of the evaluation function. Here based on the evaluation function different possible DG connecting location was computed.

IV. RELIABILITY ANALYSIS WITH DG

The reliability parameters considered in this method is Expected Energy Not Supplied (EENS) and System Expected Outage Cost(ECOST). The EENS and ECOST are computed using the equations respectively

$$EENS = \sum_i \sum_k L_i h_i t_i$$

$$ECOST = \sum_i \lambda_i C_i L_a i$$
When the results of Load flow analysis for IEEE 14 bus system without DG and with DG are compared using ETAP it is observed that there is minimum difference in the total power loss which shows that Genetic Algorithm is not giving appropriate reduction in power loss as compared to PSO.

V. RESULTS

In the proposed method, there is reduction of total power loss after connecting DGs in the system. The proposed method has been tested for different load conditions. After increasing the number of DGs in the system the total power losses in the system reduced further. At total power of 122MW, the total power loss in conventional method is 8.811 MW and after connecting 3 DG, 5 DGs, 7 DGs 9 DGs, the total power losses in the systems are 13.326MW, 11.266MW, 9.44MW 8.811MW respectively. The graphical representation of the power loss and number of DG connected is in figure 2.4.

The EENS and ECOST values are reduced due to reduction in interruption of customer composite damage function. The performance of this method is computed using the reliability parameters namely; EENS and ECOST. It is clear that the reliability of the system increases after connecting DGs in the system. The EENS and ECOST values after connecting DGs are EENS = 100.6379 and ECOST = 5434.4478 are computed.

![Power Loss vs Number of DGs connected.](image)

VI. CONCLUSION

In this work, optimal number of DGs and their locations using Particle Swarm Optimization is tested for a IEEE 14 bus system. The comparison was made without and with DGs in terms of total power loss. The optimal number of DGs to be connected in the system was identified as 3,5,7 and 9 and these DGs should be located on the buses for minimization of total power loss. The total power loss in without DG was 16.06 MW and after connecting DGs in the system, the power loss was reduced to 8.811 MW. The reliability indices EENS and ECOST are also computed. Hence, it can be concluded that, the reliability of the system is improved.

VII. REFERENCES

Systems Planning to Improve Reliability Under Load Growth,2012,April