Impacts of Distributed Generation in Power System

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ABSTRACT: *As the demand for power generation is increasing, to meet the demand traditionally used renewable energy sources viz. solar, tidal, wind, etc. for power generation and integrate generated power into the distribution over grid network (DN). There is a need to study and analyze the impacts of connecting DG to the DN. Simulation results for an IEEE-14 bus network were obtained with the help of PSAT 2.1.7 simulation software which showed that DG has several impacts on a grid if connected. Pollution, the release of harmful gases, toxic products, etc.). To overcome these impacts, new technology has been developed which is called a distributed generation (DG). A distributed generation utilizes coal; oil, etc. are not suitable as they have several potential harmful impacts on the environment (viz. methods of power generation that require the consumption of non-renewable energy sources.*

KEYWORDS: - Distributed Generation, Distribution network, non-renewable energy sources, renewable energy sources, etc.

I. INTRODUCTION

With the increasing demand for power, the traditional methods are very costly and utilize scarcely available non-renewable energy sources like oil, coal, etc. nature for power generation. Although, with the utility like the power generated from these non-renewable sources is in thousands of megawatt (MW) while on the other hand, it has several impacts on environment like emission of greenhouse gases, toxic by-products such as lead, mercury, sulfur, etc. and water contamination harmful to living organism are the main drawbacks of the conventional methods of power generation. Besides, the cost of installation is very high and covers a large area for installation. These problems may be solved up to the extent of utilizing renewable energy sources (viz. solar, tidal, wind, etc.). It is defined as – "a distributed generation is a technology which utilizes renewable energy sources for the production of electricity and its capacity can be varied from few kW (kilowatt) to MW (megawatt) depending upon the power requirement at the site of installation. Various authors defined a distributed generation (DG) as follows:

1. The Electric Power Research Institute defines distributed generation as generation from 'a few kilowatts up to 50 MW' [7].
2. According to the Gas Research Institute, distributed generation is 'typically between 2 and 25 MW' [7].
3. Cardell defines a distributed generation as generation 'between 500 kW and 1MW' [1].
4. The International Conference on Large High Voltage Electric Systems (CIGRE) defines DG as 'smaller than 50-100 MW' [7].

Distributed generations possess several advantages over the conventional methods of power generation such as:

1. Produces no toxic by-product,
2. Economical installation,
3. Eco-friendly environment,
4. A small area of installation,
5. Varying production capabilities,
6. Free from greenhouse gases etc.

However, on the other hand, a distributed generation has losses into the distribution network at the junction of its connection if not of optimal size and location. It creates disturbances in reactive power balance and increases instability in the network thereby increasing the losses consequently disturbing the voltage profile and ultimately may damage the connected types of equipment. Therefore, before integrating a DG, it is necessary to study the impacts caused by DG installation and find out the optimal location for its connection. The work undertaken is to find out the effects of DG on the distribution/grid network when it is interfaced with the grid. An IEEE-14 bus network is simulated using PSAT 2.1.7. The results showed that DG disturbs the reactive power balance thereby more losses were observed in the network.

II. LITERATURE SURVEY

Authors [1] had studied the impact of Distributed Generation on a 38kV distribution system and observed the disturbances in the voltage profile if a large distributed generation is connected. To overcome the voltage drop at the junction of connection, the authors had suggested several methods like using shunt reactance, line voltage regulator, the reduced voltage at feeding substation.

Authors [2] had suggested an algorithm to minimize the losses, by finding the optimal location and size of distributed generation. Authors [3] had studied the losses for the optimal location of DG on the distribution network. It was suggested that the optimal location for DG connection is the bus with the largest amount of voltage drop indicated is the most preferred location for DG connection.

Authors [4] had tried to summarize the main driver behind the integration of DG. Drivers were classified into three categories i.e. environmental, commercial, and a national/regulatory driver, which affects the penetration of DG into the network particularly on services, provided by the DG such as frequency response, reactive power, voltage, and power flow management services, etc.

Authors [5] studied the different DG technologies and compared the cost of generation of energy from these nonrenewable and renewable sources of energy.

Authors [6] had proposed the Monte Carlo Simulation method which incorporates the Newton Raphson method equations for the simulation and analyzing the main sources of uncertainties considering three cases namely unbounded DG operation, constrained DG export power and combined DG power constraints. The authors had noticed that with the penetration level of DG with respect to 15%, 25%, and 35%, the power reduction is 167.04, 241.366 and 270.799 MW/day respectively. Authors [7] had defined DG differently on the basis of production capability and various other aspects such as location, purpose, rating, power delivery area, etc.

Authors [8] proposed an algorithm which incorporates genetic algorithm implementation with Tabu search algorithm for the expansion of DG and is able to expand the network up to 72 bus network. Author [9] studied the voltage profile, line loss reduction, reduction of environmental impacts and observed an improvement in the voltage profile from 0.4% to 1.5% and reduction in line loss up to 46%.

Authors [10] proposed to utilize a particle swarm optimization algorithm for the precise identity of the location and size of the distributed generation.

III. METHODOLOGY
PSAT 2.1.7 is a power system analysis toolbox which utilizes MATLAB simulation platform. Under the study network, the Newton Raphson simulation method was employed for solving an IEEE-14 bus network with DG and without DG connection. An IEEE-14 bus network without DG connected and IEEE-14 bus network with DG connected was designed with the help of PSAT 2.1.7 simulation software (Fig. 1 and Figure 2).
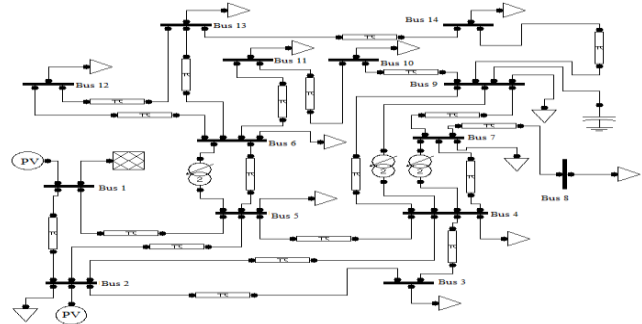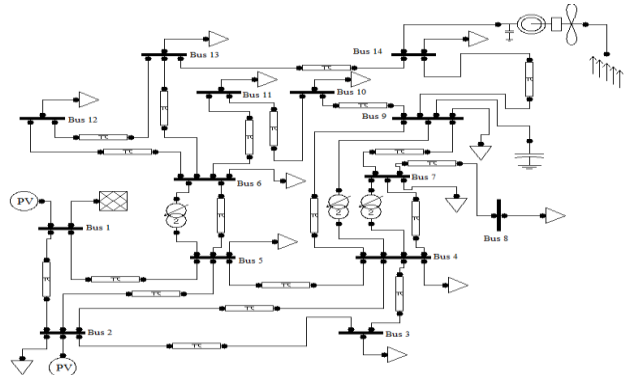

Figure 1 IEEE-14 bus network without DG connection

Figure 2 IEEE-14 bus networks with DG connection

IV. LOCATION OF DISTRIBUTED GENERATION
The optimal location of DG has been finding out by identifying the weakest bus i.e. the bus with the smallest voltage magnitude is the most preferred location for installing a DG [3]. Under the study network, a wind-based distributed generation of 50MVA and 11kV had been connected. Simulation results were obtained with and without DG connection showed that the bus no. 12, 13 and 14 were the weakest buses wherein the location of bus no.14 was the weakest and most preferred for installation of DG.

V. RESULT AND DISCUSSION
A comparison of the simulation results of an IEEE-14 bus network with and without DG connection showed that there was an improvement in the bus no.9 in the reactive power at load from 0.27224 p.u. to 0.27176 p.u. with no improvement in the bus no. 4, 5, 11, 12 and 14 respectively. On the other hand, an improvement in reactive power at the generation of electricity was observed at bus no.2 with DG connection, respectively (Table-1 and Table-2). Graphs of the reactive power profile with and without DG connection are shown in Figure 3 and Figure 4 respectively.

Table-1: Reactive power at electricity generation and load with DG connection

Bus	Q. gen (p.u)	Q. load (p.u)
Bus 1	0.38329	0
Bus 2	6.5306	0.25445
Bus 3	0	0.38268
Bus 4	0	0.07814
Bus 5	0	0.03206
Bus 6	0	0.15027
Bus 7	0	0
Bus 8	0	0
Bus 9	0	0.27176
Bus 10	0	0.11621
Bus 11	0	0.03606
Bus 12	0	0.03206
Bus 13	0	0.11621
Bus 14	0	0.10018

Table-2: Reactive power at electricity generation and load without DG connection

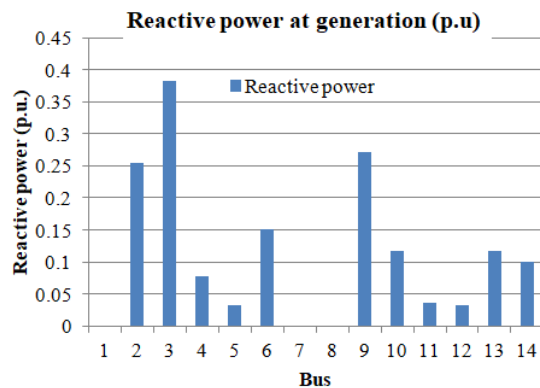| Bus	Q. gen (p.u)	Q. load (p.u)
Bus 1	0.3894	0
Bus 2	6.5577	0.25444
Bus 3	0	0.38267
Bus 4	0	0.07814
Bus 5	0	0.03206
Bus 6	0	0.15026
Bus 7	0	0
Bus 8	0	0
Bus 9	0	0.27224
Bus 10	0	0.1162
Bus 11	0	0.03606
Bus 12	0	0.03206
Bus 13	0	0.1162
Bus 14	0	0.10018

Figure 3 Reactive power at a generation with DG connection

Simulation results of an IEEE-14 bus network with DG connection showed reactive power loss at generating

station and reactive power loss at the load (Table-1). The simulation result of an IEEE-14 bus network without DG connection showed the reactive power loss occurring at the generation station and at the load side (Table-2).
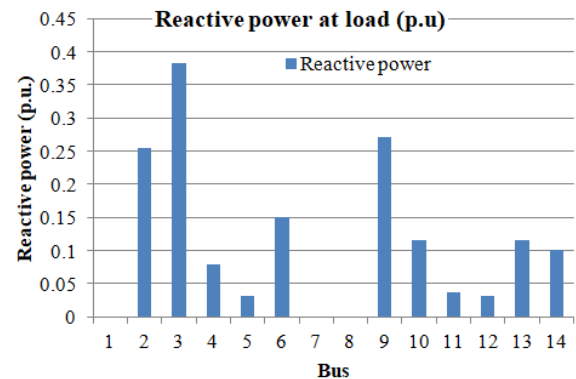

Figure 4 Reactive power at load with DG connection

From the comparative analysis of the simulation results obtained optimal location for DG connection was found. It was shown that the preferred location for the DG connection was bus no. 14 whereas DGs' can also be connected at the bus no. 12 and 13 as and when needed. The variation in the reactive power at a generation with DG connection is shown in Figure 3. The graph in figure 4 shows the variation of reactive power at load w.r.t bus.
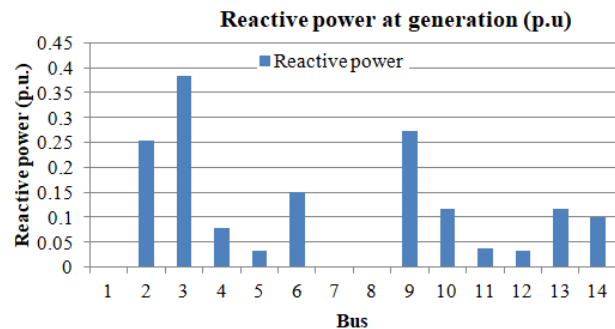

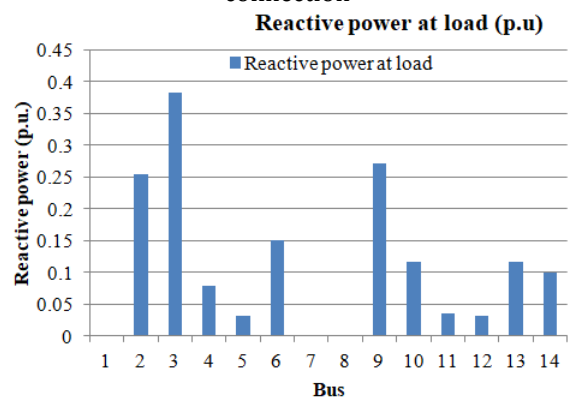Figure 5 Reactive power at generation without DG connection

Figure 6 Reactive power at load without DG connection

The graph in figure 5 shows the variation in the reactive power at generation without DG connection. The graph

in figure 6 shows the variation in the reactive power at load without DG connection.

VI. CONCLUSION

On the basis of the above analysis, it has been concluded that a distributed generation posses several advantages whereas, on the other hand, it disturbs the reactive power balance into the distribution network if not interfaced at the optimal location. It reflects that optimal location is the basic necessity for DG connection in order to minimize the losses. Simulation of an IEEE-14 bus network with and without DG connection had been studied and results were compared accordingly. It was observed that the bus no.9 showed an improvement in the reactive power loss at load from 0.27224 p.u. to 0.27176 p.u. whereas the bus no. 2 showed an improvement in reactive power loss at generation from 6.5577p.u. to 6.5306 p.u. with DG connection, respectively (Table-1 and Table-2).

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