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Impact of Distributed Generation in Electrical Power System

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Abstract: **A distributed generation is a kind of a generation unit which can be installed at the end user location or even at the vicinity of large scale production plants to fulfill the needs of the consumer or the power plant of a particular location. A distributed generation when connected to the distribution network give rise to a number of disturbances in the power systems such as disturbances in the voltage profile of the network, disturbances in the active power, reactive power, voltage sag and swell, flicker etc due to these effects the network gets disturbed or unbalanced with the introduction of the DG onto the network grid. This paper suggests the various methods required to compensate these disturbances and thereby making the system under consideration more reliable and efficient. The methods discussed here are used for the compensation of disturbances in the voltage profile, active power and reactive power.**

Keywords: **Distributed generation, network grid, compensation, energy, renewable sources, non-renewable sources etc.**

1. INTRODUCTION

A distributed generation is a small generation unit which is used to combat with the increasing demands of the energy requirements at the consumer level and also at the energy generation plants location. The size of the distributed generation can be varied as per the requirement of the energy. The different capacities of the distributed generation are listed in the table1 shown below. Since, the DG make the use of the renewable sources of energies like wind energy, tidal energy, solar energy etc. therefore they are environmental friendly and it is because of this nature of DG much of theinterest of the researchers is towards the installation of these small generation units at several sub-stations location or near the load centre where the demand for the energy has increased beyond the production capacity of a production plant.

Several works has been done in the past to study the effects that may arise in the distribution grid with the integration of a distributed generation. From the past work and studies of the various authors it is found that the following effects are produced in the grid connected network due to distributed generation:

1. Disturbances in the voltage profile of the connected network.
2. Disturbances in the current profile of the connected network.
3. Voltage sag and swell,
4. Voltage flicker.
5. Reactive power flow disturbance in the line.
6. Active power flow disturbance.
7. Stability etc.

If above mention problems can be minimized from the electrical power system with the DG connected, the reliability and the overall efficiency of the electrical powersystem can be increased.

Various methods that can be used to compensate these effects are listed below [1]:

1. Reduce the voltage at the feeding substation.
2. Probabilistic load flow approach.
3. STATCOM.
4. Increase the size of the conductors.
5. Install a shunt reactance in the network.
6. Allow the generator to import greater reactive power.
7. Monte Carlo simulation method etc.

The following section of this paper deals with the analysis of the following three methods used for the compensation of disturbances due to DG:

1. Increase the size of the conductors.
2. Install a shunt reactance in the network.
3. Probabilistic load flow approach

Table-1: Different DG capacities [2]

No.	Technology	Typical available size
1	Combined cycle gas turbine	35-400MW
2	Internal combustion engines	5kW- 10MW
3	Combustion turbines	1-250MW
4	Micro turbines	35kW-1MW
5	Fuel cells, Phos. Acid	200kW-2MW
6	Fuel cells, molten carbonate	250kW-2MW
7	Fuel cells, proton exchange	1-250kW
8	Fuel cells, solid oxide	250kW-5MW
9	Battery storage	0.5-5MW
10	Small hydro	1-100MW
11	Micro hydro	25kW-1MW
12	Wind turbine	200W-3MW
13	Photovoltaic arrays	20W-100kW
14	Solar thermal, Central receiver	1-10MW
15	Solar thermal, Lutz system	10-80MW
16	Biomass gasification	100kW-20MW
17	Geothermal	5-100MW
18	Ocean energy	0.1-1MW

2. DISCUSSION OF THE COMPENSATION METHODS

This section gives the detailed description of the process to be followed in the above mentioned three methods while analyzing the effects of DG on the grid.

The methods here are very much effective in the minimization of the voltage profile disturbances and reactive power imbalance.

2.1 Increase The Size Of The Conductors:

Disturbances due to DG should replace the pre-existing conductors with the conductors of increased cross sectional area. An increase in the cross sectional area causes the resistance (R) of the conductor to decrease which will decrease the voltage rise at several point in the transmission network. The area of the conductor to be installed must be determined first before implementing it to the system in order to have a voltage rise within the safe limit as specified in the distributed system operator (DSO) code. The author in [1] has shown that if one wants to connect a 100 kV substation to a 38kV substation, one should upgrade his system with conductors having cross sectional area $300mm^2$ and if one wants to connect the substations of same kVA rating then also the conductors used should have a maximum cross sectional area of $300mm^2$. The author says that on replacement of the conductors with the increased size conductors the problem of voltage rise still exist but it is within the DSO code.

2.2 Install A Shunt Reactance In The Network:

In order to maintain the reactive power balance in the network it is required to maintain the reactive power with in a limit in the network. So at every point a minimum amount of reactive power is needed to be maintained to avoid disturbances in the voltage.

The injection of reactive power makes a considerable effect on the generation capacity. Suppose if P_Q amount of reactive power is absorbed in the network than the amount of generation connected under no load condition gets increased as given byeqn (1) as given by [1]:

P_G (max) = (V_2(max) – V_1)/R+ P_Q*X/R ------ (1)

Where,

P_Q is the reactive power absorbed by the network

P_G is the power generated

X is the reactance of the network and

R is the resistance of the network

The addition of a shunt reactance to a network helps in reducing the power factor which in turn increases the power requirement and hence the overall voltage rise in the network is decreased to a safe limit.

One can use theMATLAB; PSCAD simulation software's for their study and simulation purpose and can compare their result obtained with DG and without DG connected.

2.3 Using Probabilistic Load Flow Approach:

As per the [18], a probabilistic load flow (PLF) approach is designed to account for both DG and load variation. It is an expansion of the deterministic load flow approach (DLF) as it applies the uncertainties directly to the solution. The main aim behind this method is to determine the sensitivity of the system so that an effective analysis of the variation in the voltage profile can be done.

This method makes the use of time average from hour to hour so that a close observation can be made. A model of the system is designed so that the state variables can be directly applied to it.

There are two methods of probabilistic approach:

1. Analytical approach and.
2. Numerical approach.

The analytical method does the convolution of the probability density function of each random variable. Analytic method is not used in the real system because it is very complex and long non linear mathematical equations are required to be solved.

On the other hand, numerical method performs the convolution of various probability density functions at a time through a number of simulation software's available. One of the most common numerical methods is the Monte Carlo simulation method.

A method for the modeling of the random variable for probabilistic load flow approach is given in [18]. The author has developed a solar model for his study. In that he has modeled the cloud event as Poisson processes with mean 'M':

$F(x) = M^x * e^{-M}/x!$ ------ (2)

Where, x= 0, 1, 2…..

And the time between two cloud events is modeled as an exponential function:

$W(x) = e^{-x/w}/w$ ------ (3)

Where, x>0

3. RESULT

Here, in this paper we have used the PSAT simulation software and the study has been done on an IEEE-14 bus network. Fig1, fig.2, and fig.3 shows the load flow result for the IEEE- 14 bus network and fig. 4, fig.5 fig.6 shows the load flow results when a distributed generation is connected to the IEEE-14 bus network. It can be seen that with the introduction of distributed generation into the network the voltage profile, active power profile as well as the reactive power profile of the existing network is disturbed. So in order to compensate for these disturbances, the authors can use any of the several compensation methods suggested in previous section.

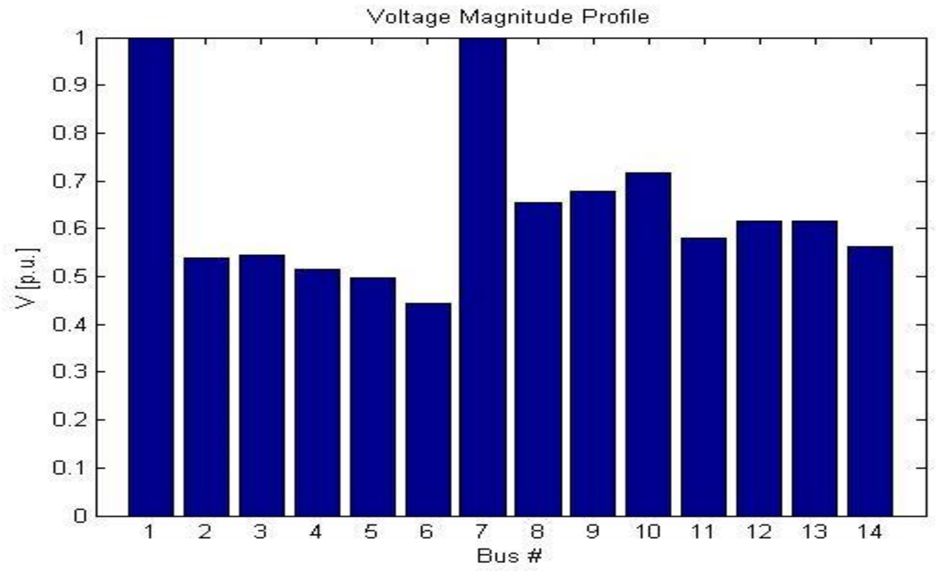

Figure 1: Voltage Profile without DG

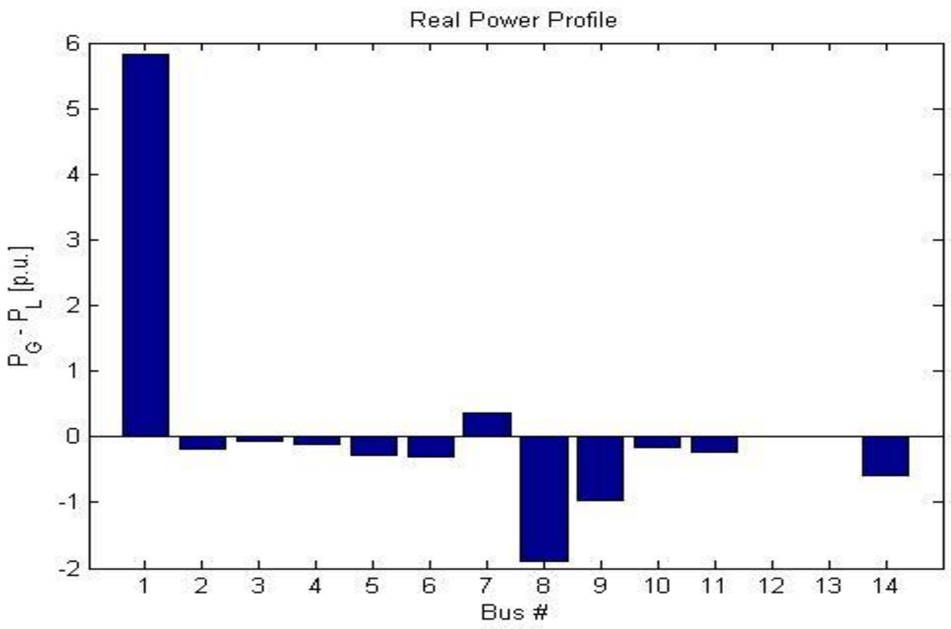

Figure 2: Real Power Profile without DG

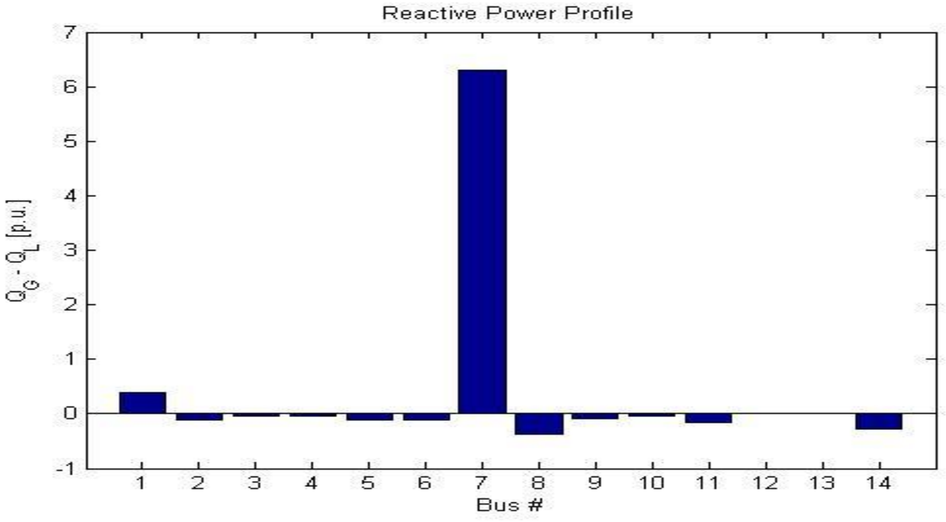

Figure 3: Reactive Power Profile without DG

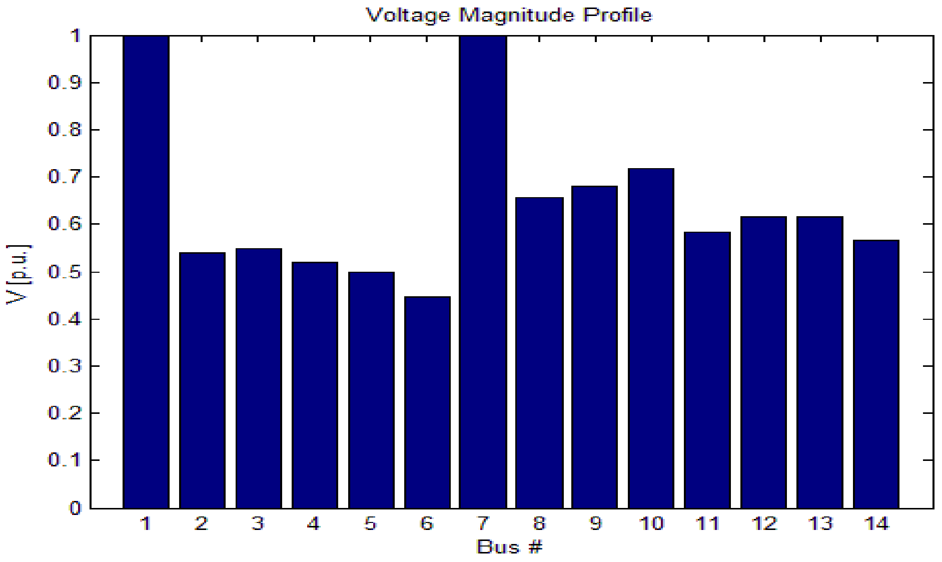

Figure 4: Voltage Profile with DG

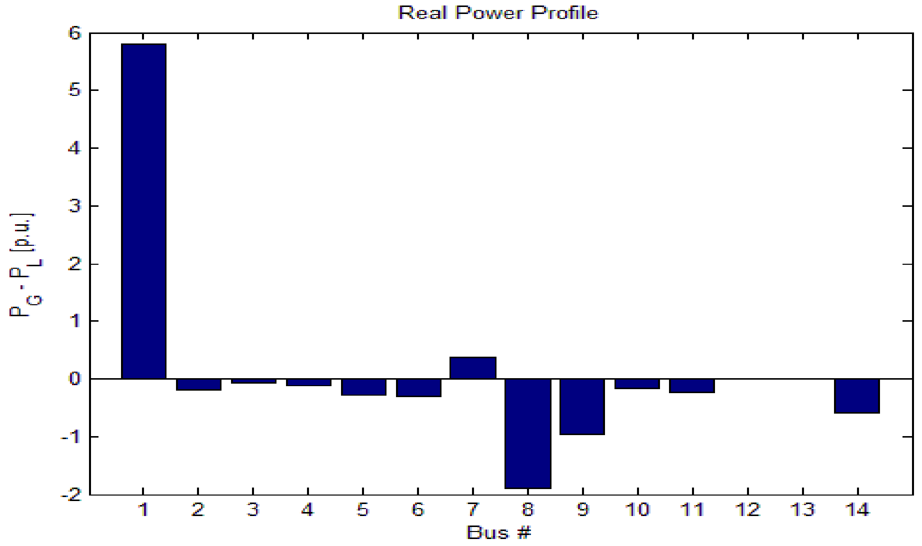

Figure 5: Real Power Profile with DG

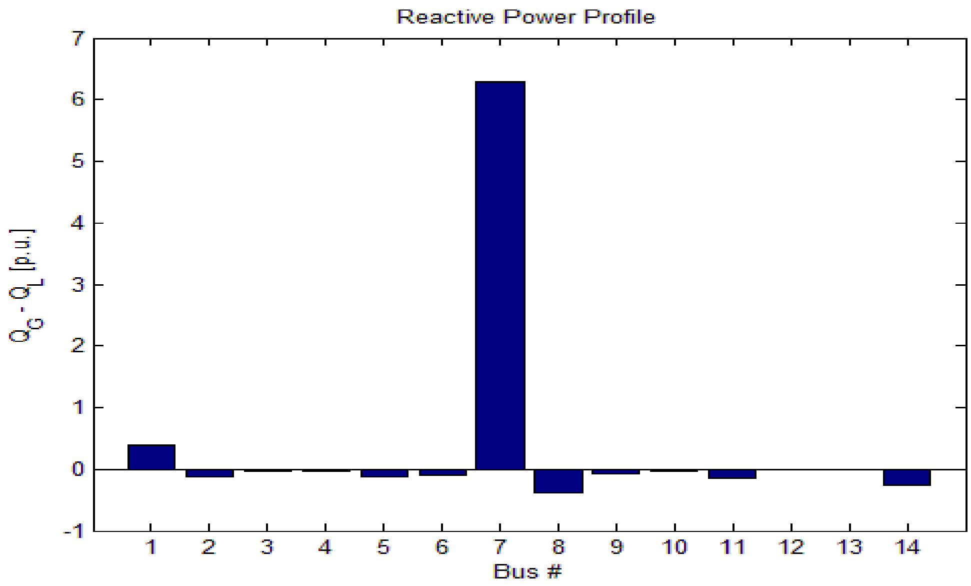

Figure 6: Reactive Power Profile with DG

4. CONCLUSION

From the above discussion and result obtained from the load flow of the IEEE-14 bus network without DG and with DG it is concluded that the integration of distributed generation into the distribution generation besides many advantages also give rise to many problems like disturbances in voltage and current profile, voltage sag, reactive power misbalance, stability etc. and various methods have also been suggested here to compensate for these disturbances. In the future the researcher can make the use of the following suggested methods for their study. The methods discussed in this paper give a detailed analysis of the study of voltage profile disturbances with the effect on the active and reactive power flow.

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