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Effect of Using Distributed Generation on distribution Net-works

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Abstract: The rabid growth in electrical power consumption and decrease in generating plants and transmission capacities, present the importance of using Distributed Generation (DG) sources. DG is known as small scale generation unit which is installed in the distribution system and connected at substations or feeders. DG is electrical generation and storage performed by a variety of small grid, and refers to various technologies which generate electrical power at or near the consumers. It may be a single structure like a home or a part of micro-grid. DG can support delivery of reliable power to additional customers. This paper discusses the effect of DG in distribution net-works reliability. Port-Sudan distribution net-work (DNW) is selected as case study. The results show that addition of two generating unit at Klayneep with rating of 15MW for each improves the voltage profile and supply continuity of Port- Sudan DNW. Simulation is done using ETAP software.

Key words: distributed generation, Klayneep, distribution net-work, reliability

I. INTRODUCTION

DG is called decentralized energy, it is the process of generating or storing energy, it means generating electrical power at where it is used. The produced power is in the range between kilowatts and megawatts, and it uses smaller means than central generation devices.

The necessity for smart electrical systems with minimum technical loss and environmental impact, reduced transmission and distribution system resources, increased reliability, better power quality, is providing impetus to go for DGs [1].

Different types of DG are available and it is expected to grow in the future [1].

In recent years, the electricity supply frame work and its associated transmission and distribution systems, has observed significant changes throughout the world. The growth of competition in the electricity market and development of renewable energy technologies, increases the use of DG technologies in power systems [2].

Port-Sudan city is one of the important cities in eastern Sudan, and it has been connected to the National Grid of Sudan (NGS) via transmission line feeding a total load of 17 MW in the first time, but due to its nature as port, the load increased rabidly. This increase presents stability and voltage drop problems if the new load is going o be fed through the available transmission line, and the solution is use of DG.

Jhansi presents the effects of DG on electrical power network [6]. DG definitions are discussed in details in [4], [5] [8]. Pavan Khetrapal, discusses the technologies, grid integration issues, growth drivers and potential benefits of DG [2]. Where Darioush Razmi and Tianguang Lu, A present literature review of the control Challenges of DG resources based on micro-grids [7]. Advances on DG technology is discussed by Zuo Sun,and Xun-you Zhang [3].

II. DG DEFINITION

Many definitions are available for DG, which can be summarized as follows:

- The Institute of Electrical and Electronics Engineering (IEEE) defines DG as “the electricity generation by facilities sufficiently smaller than centralized generating power plants, usually10 MW or smaller, so as to allow interconnection at nearly any point in the electric power system” [2].

- some countries define DG according to its voltage level at which it is interconnected, while other countries follow the principle that DGs connected to circuits that feed directly to consumer loads"[2].

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- The International Council on Large Electricity Systems (CIGRE) defines DG as generating units with rating less than 100 MW, that are neither centrally planned not centrally dispatched and usually connected to the distribution [2].

- According to the location DG is defined as the installation and operation of electric power generation units connected directly to the distribution network or connected to the network on the customer site of the meter [4].

III. DG TECHNOLOGIES

There are many DG technologies as follows:-

- Reciprocating diesel or natural gas engines .
- Micro-turbines .
- Fuel Cells .
- Photovoltaic (PV) system
- Wind Turbines [1].

The above mentioned technologies can be classified as renewable (PV system, wind turbines) and non-renewable (fuel cells).

Wind power technology is one of the most important emerging renewable technologies. The wind power generation technology is used to convert wind energy into electrical energy power generation. It can be divided into two broad categories: constant speed constant frequency (CSCF) and variable speed constant frequency (VSCF).

Because VSCF power generation technology has merits of capturing the maximum limit wind power, the wide rotational speed movement scope, flexible adjustment of the system active power and reactive power, it has gradually became the mainstream technology of the current wind power generation.

The solar photovoltaic technology directly converts solar energy into electrical energy by photovoltaic effect of semiconductor material. Photovoltaic generation system is divided into stand alone photovoltaic systems and grid-connected photovoltaic system.

At present the biggest challenge of photovoltaic generation is the high price of solar cells, which accounts for over 60% the price of the whole solar photovoltaic generation system, so the solar cells research such features as cheap price, high efficiency, high reliability, high stability, long lifetime has become the world's focus.

Fuel cell (FC) is a generation facility which can directly convert the chemical energy stored in the fuel and oxidizer into electricity power efficiently. The FC converts fuel and air directly to electricity, heat, and water in an electrochemical process. It also has some merits in the fuel diversification, clean exhaust, low noise, low pollution, high reliability and good maintainability [3].

IV. DG AND RELIABILITY

Reliability problems refer to sustained interruptions, which are voltage drops to near zero, in electricity supply. The energy markets make customers more aware of the value of reliable electricity supply, since that a high reliability level implies high investment and maintenance costs for the network and generation infrastructure. Because of the incentives for cost-effectiveness that come from the introduction of competition in generation and from the re-regulation of the network companies, it might be that reliability levels will decrease. However, having a reliable power supply is very important for industry. Reliability of power distribution system can be improved using DG, by reducing the voltage drop to a minimum values.

V. DG INTEGRATION IN THE POWER SYSTEM

Traditionally, power generation, transmission, distribution and load demands are managed as independent processes.

Due to the large amount of DGs in the power network, the traditional approach of the power system management has gradually been shifting. DGs are a vital part of the modern smart power system but integration of DGs in the traditional power network is a challenge for the power system engineers.

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DG may have positive and negative impacts on the transmission and distribution system. Because of the direct connection of DG to the distribution system, impacts are expected to be most effective at the distribution level. Many of the impacts of DG are attributable to the fact that the grid was not originally designed to accept generation on the distribution part. The impact of DG integration has to be carefully investigated in order to ensure optimum system performance.

Distribution networks have been designed to handle unidirectional power flow. Thus integration of distributed generation can result in voltage profile, problems in protection co-ordination, handling of reactive power and power quality issues. Further, if solar and wind based DGs are integrated; their nature can raise concerns regarding reliability of supply.

DG integration can be classified into three categories; technical, commercial and regulatory. Commercial and regulatory issues are affected by government policies and societal conditions and are not the focus of this view. In addition to all of the issues mentioned above, the size and geographic location of a DG system are also important factors that may affect its impact on the transmission and distribution grid.

The technical issues are implemented in impact on system voltage, impact on line losses, impact on power quality and impact on system stability [2]. Here the impact on system voltage will be somewhat discussed.

5-1 Impact on Voltage Magnitude Variations:-

Maintaining a proper voltage value is important for the correct operation of the apparatus or component connected to the electric power system. The impact of DG on voltage control is depending on the power flow in the network. The voltage profile is not violated when the injected power by DG is less or near the load of the feeder and the power factor of the DG is in line with the power factor of the load. In this case the energy supplied by the grid is decreasing as well as the current through the feeder. This results in a reduced voltage drop. However, when the generated power exceeds the load of the feeder or the power factor is extreme, voltage rise occurs. This voltage rise is due the reversed power flow and is a function of the size of DG, the power factor and the impedance of the grid [2].

VI. OPTIMAL LOCATION OF DG

There are several methods available for optimal location of DGs for various objectives. Based on the priorities of the objectives, analytical hierarchical process is used to suggest the best location of DGs. The selected methods should take care of the expansion of the network, load concentration, structural and regulatory changes, etc. The optimal location may not be optimal after years. Moreover, with growing penetration level of DGs, optimal locations keep on changing and a new coordinated planning study is required to find optimal location. Availability of fuel supply system in future will also affect the optimal location of DGs [1].

VII. ECONOMIC CONSIDERATION AND EFFICIENCY OF DG

Economic efficiency is the principle to avoid wasting valuable resources. The extent to which DG is integrated efficiently in the electricity market hinges upon the market structure, the market operation and upon pricing.

The final market structure will have an influence on the penetration potential of DG. An economically efficient deployment would require a sense that electricity customers have the option to generate their own electricity in response to price.

In principle, prices should reflect underlying demand and supply conditions, which can vary over time and place. In practice, electricity prices are rarely sensitive to location, except when there are important technical reasons for price differences found in the grid, and in many cases they are also not sensitive to time, except for corrections for day/night or weekend and seasonal. Pricing mechanisms based on varying demand and supply conditions will encourage an efficient use and deployment of DG. The use of time based pricing schemes is increasing, but location based pricing schemes are apparently more difficult to implement [5].

VIII. CHALLENGES AND LIMITATIONS OF DG RESOURCES

Many challenges are available when DG resources are widely used. Some of these challenges are :

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- Reverse power flow:
Connecting DG sources to the distribution network can cause power flow in the reverse direction, which causes faults in the detection of protection systems;

- Reactive power:
Many types of DG sources use asynchronous generators that cannot inject reactive power into the grid;

- System frequency:
Deviation from the nominal frequency of the system occurs with an imbalance between production and consumption. Increasing DG resources affect system frequency and complicate the control process;

- Voltage levels:
DG sources change the voltage level of feeders due to changes in the direction of the load distribution.

- Protection:
The structure of most distribution networks is radial. This causes the load to be distributed unilaterally and the corresponding protection systems to be designed accordingly;

- Harmonic injection into the grid by DG sources that are connected to the grid by an inverter. Short-circuit faults increase with respect to the location of DG sources especially when using PV systems.

IX. RESULTS AND DISCUSSION

9-1 Case Study:-
Port-Sudan is one of the important Sudanese cities in the east. Its nature as a port causes a rabid increase in the electrical load. Port- Sudan distribution net-work contains five main substations (10 buses) fed by a feeders having 33KV. All substations have step down transformers 33KV \ 11KV.

Clayneep gas power plant contains two generation units with 150 MW for each unit is added to Port-Sudan distribution net-work as DG. The plant is located at (19/31'/14.666''N and 37/14'/49.204'E) in Port-Sudan closed to the Re Sea.

9-2 Simulation Results:-

Load flow analysis is done before and after addition of Clayneep generating plant.

Figure (9-1) shows the voltage magnitude at each bus of Port-Sudan distribution net-work before addition of Clayneep power plant, where figure (9-2) shows the voltage magnitude after addition of the generating plant.

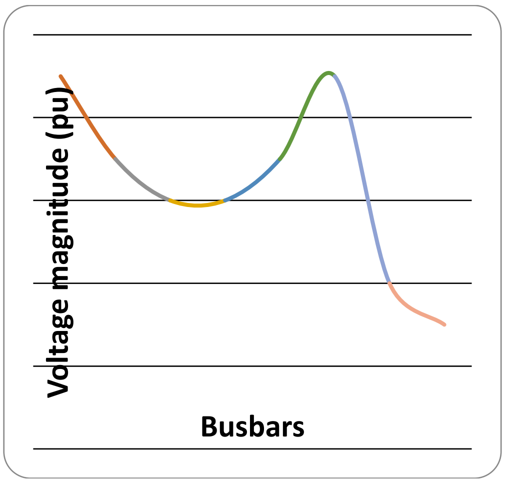

Figure (9-1): Buses Voltage magnitude Before Adding Klayneep plant

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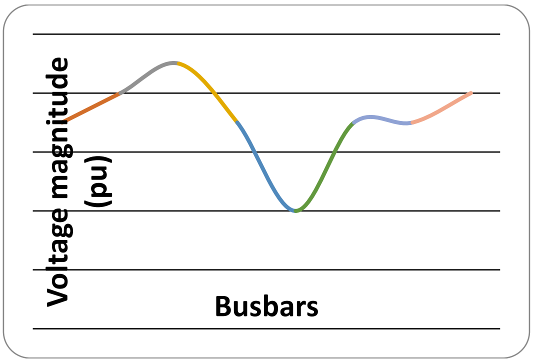

Figure (9-2): Buses Voltage magnitude after Adding Klaneep plant

The results above show that adding steam power plant at Klayneep, improves the voltage profile of Port-Sudan distribution net-work.

X. CONCLUSION

Wide range use of DG, means power system decentralization, so the introduction of DG units will reduce the pressure on the central power grid. Port-Sudan is connected to NGS as mentioned above via double circuit transmission line, but its capacity will not be enough in future due o rabid increase f the load. So use of DG is the solution for future deal and improving the system reliability at the present. Addition of Klayep gas power plant improves the voltage profile all buses , and the result is a reliable distribution system with high continuity of supply.

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