OVERVIEW AND ANALYSIS ON ROLE OF DISTRIBUTED GENERATION SYSTEM

ABSTRACT: Distributed generation (DG) is expected to become more important in the future generation system. The current literature, however, does not use a consistent definition of DG. This paper discusses the relevant issues and aims at providing a general definition for distributed power generation in competitive electricity markets. In general, DG can be defined as electric power generation within distribution networks or on the customer side of the network. In addition, the terms distributed resources; distributed capacity and distributed utility are discussed. In present scenario there is an increase in demand which is creating gap between demand and supply to fulfill this gap distributed generation can plays the significant role. The main reason for the need of distributed generation is it is clean and continuous. Distributed generation means generating power on site not centrally. Distributed generation is the best way for rural electrification. This paper will discuss the importance and benefits of Distributed Generation in near future. In this paper we are trying to focus on the benefits of distributed generation for attaining sustainable development in approaching future.

I. INTRODUCTION

The new technology in market that is seeking attention is Distributed Generation. Distributed Generation generally refers to power generation at the point of end user or customer. Distributed Generation is gaining worldwide acceptance due to it's a number of benefits. Distributed Generation eliminates the cost and complexity and reduces the chances of inefficiency which occur in the transmission and distributed network. Basically electricity produced is generated at large generating stations which is then send at high voltages through the transmission lines to the load centers and then through local distribution network distributed to the customers at distribution level voltage. Distributed Generation is also termed as decentralized generation because the energy generated and distributed using small scale technologies closer to its end. Distributed generation simply means small scale generation. India has the world's second largest population and rapidly growing economy. India is faced the high energy demand as the demand has always grown faster than generation capacity. Presently there are still so many rural areas where electricity is not reached yet where grid connectivity is neither feasible nor cost effective. That's why the off grid or decentralized distributed generation is a better option for electricity supply. Distribution generation will lead to few changes in traditional generation. Distribution generation have some advantages over traditional generation. In distributed generation there is no need of large transmission lines which reduces losses and complexity. In distributed generation the energy generated and distributed by using small scale technology closer to its end user that's why it is also termed as decentralized generation.

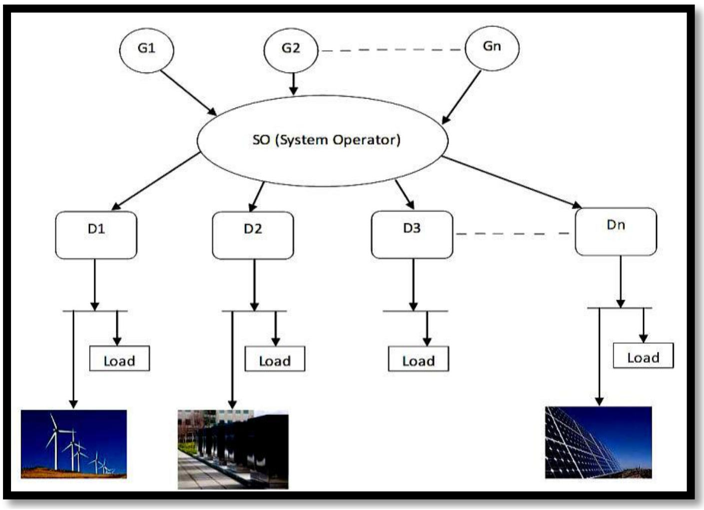

Fig 1.Role of renewal energy sources of distribution system

Now-a-days, DGs are the part of distributed energy resources (DERs) which also include energy storage and responsive loads. The major driving forces behind the increased penetration of DGs can be categorized into environmental, commercial and regulatory factors. There are several small generators which produce very small or no greenhouse gas emissions. Another environmental driver is to reduce the transmission and distribution expansion along with the avoidance of large power plants.

In the commercial driver, the uncertainty in electricity markets favors small generation schemes and DGs are now cost effective to improve the power quality and reliability. The attractive proposition of DG is that it is distributed round the network close to customers and DGs represent diverse technologies and primary energy sources. There has been tremendous research work in the areas of DG technologies, sitting and sizing of DG, impact studies of the increased penetration of DG, economic and financial analysis coupled with DG integration, etc. It is important for the researcher to understand the key issue of the large penetration of distributed generation in the power system. This paper addresses these key concerns as well.

II. DISTRIBUTED GENERATION TECHNOLOGIES

Due to maturing technologies and increasing size of DGs, which play a significant and topical phenomenon in power system, there is as yet no universal agreement on the definition of DGs. These are also known as embedded generations or dispersed generations [1]. Current definition of DG is very diverse and range from 1kW PV installation, 1 MW engine generators to 1000 MW offshore wind farms or more [2]. The some of the popular DG technologies are listed below:

- Reciprocating Diesel or Natural Gas Engines
- Micro-Turbines
- Combustion Gas Turbines
- Fuel Cells
- Photovoltaic (PV) system
- Wind Turbines

III. PHOTOVOLTAIC SYSTEMS

Photovoltaic energy is a technology that converts sunlight directly into electrical energy. The output is direct current (DC), which can be used directly, converted to alternating current (AC), or stored for later used. Major components of PV systems are the PV array, batteries, inverters, and charge controllers. The components other than the array are generally referred to as balance of systems components.

Figure 2: Photovoltaic systems

PV arrays

PV electrical characteristics are specified by a current-voltage diagram. The IV curve characterizes important operational parameters of the cell, among which are the short-circuit current, the open-circuit voltage, and the current and voltage at the maximum power point [1]. The power rating or the maximum power point of a panel is based on measurements performed at Standard Reporting Conditions or SRC, also known as Standard Test Conditions or STC, which are:

- Illumination of 1 kW/m2 at spectral distribution of AM 1.5; and
- Cell temperature of 25°C.

IV. WIND POWER PLANT

Wind turbine technology has been used for centuries as a source of mechanical energy for mankind. Wind turbines use the wind energy to produce electrical power. Wind energy is in fact a form of solar energy produced by uneven heating of the Earth's surface. Wind energy is less predictable and more influenced by terrain and other factors than solar energy, thus making it much more site specific. Wind energy follows seasonal patterns that provide the best performance in the winter months and the lowest performance in the summer months, which is the opposite of solar energy. Thus, solar systems, together with wind systems, provide a more consistent year-round output than either wind only or PV-only systems.

Fig 3-Wind Turbine

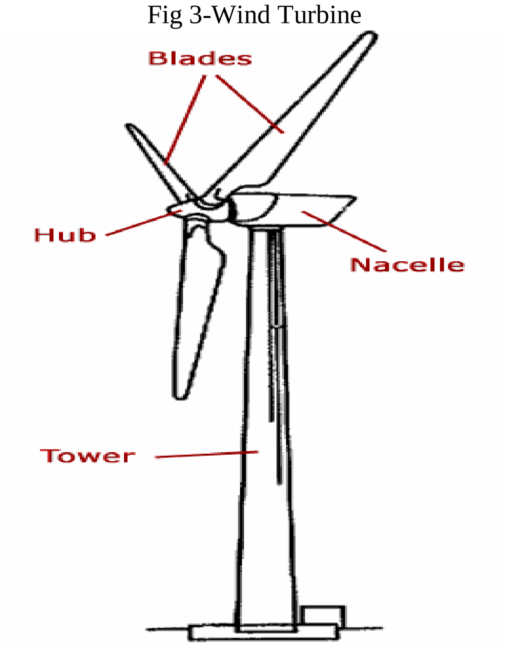

Fig 4- Major Components of Wind Turbine

As shown in Figure 3 and 4, wind turbines have fan blades, which are placed at the top of a tall tower. The tower must be tall enough to harness energy from the wind, without any obstacles, e.g. trees, hills and buildings. As the turbine rotates in the wind, it captures the kinetic energy of the wind and converts it into rotary motion to drive the generator, producing electrical power. A single wind turbine can range in size from a few kW (5-15 kW) for residential applications to more than 5 MW for utility applications [1]. However, wind turbines with rated outputs of 300W to 1kW are also available for applications like remote homes, water-pumping, and battery-charging applications.

V. RECIPROCATING ENGINES

A reciprocating engine is a widespread and well-know technology. In developing countries, reciprocating engines have been used for many decades and play a very important role in providing power for rural applications. They are commercially available in most towns and cities in developing countries in a range of size for various applications. Also called the internal combustion (IC) engine, the reciprocating engine requires fuel, air, compression and a combustion source to function. Reciprocating engines generally fall into two categories depending upon the ignition sources, i.e. [1]

Figure 5: Reciprocating Engine

FUEL CELL

A fuel cell consists of a negatively charged electrode (anode), a positively charged electrode (cathode) and an electrolyte membrane. Hydrogen is oxidized at the anode and oxygen is reduced at the cathode. Protons are transported from the anode to the cathode through the electrolyte membrane, and the electrons are carried to the cathode over the external circuit. In nature, molecules cannot stay in an ionic state; therefore they immediately recombine with other molecules in order to return to the neutral state. Hydrogen protons in fuel cells stay in the ionic state by travelling from molecule to molecule through the use of special materials. The protons travel through a polymer membrane made of persulfonic acid groups with a Teflon backbone. The electrons are attracted to conductive materials and travel to the load when needed. On the cathode, oxygen reacts with protons and electrons, forming water and producing heat. Both the anode and cathode contain a catalyst to speed up the electrochemical processes, as shown in figure-6.

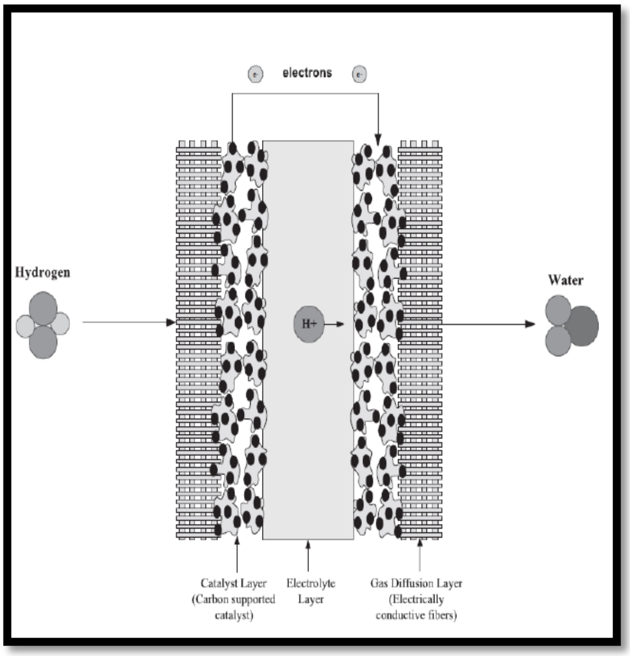

Fig 6-A single PEM fuel cell configuration

VI. DISTRIBUTED GENERATIONS IN INDIA

The Government of India has taken several measures including fiscal and financial incentives, preferential tariff for the promotion and proper use of renewable energy systems/devices in the country. Significant achievements have been made, with the establishment of over 13700 MW grid-interactive renewable power generation capacities, which is about 9% of the total installed capacity in the country. Of this, about 6795 MW capacity has been added during the 10th Plan, i.e., 2002-07 against the plan target of 3075 MW. In addition, over 5.5×106 off-grid/ decentralized renewable energy systems/devices, mainly biogas plants and solar photovoltaic lighting systems, have been deployed for provision of basic energy needs of cooking and lighting in rural households. There are difficulties in the exploration of renewable energy sources in the country. The major constraints faced in this field are inherent intermittent nature of renewable energy sources leading to low capacity utilization factors ranging from about 17% to 70%, depending on resource and location, grid synchronization limitations on account of intermittent nature of supply, relatively higher capital investment compared to conventional power projects; and requirement of preferential tariffs apart from other fiscal and/or financial concessions to make investment in renewable power a commercially attractive proposition. Table 1 represents the various DGs options in India.

DG options	Type	Technology status	Capacity factor
Diesel	NR	C,I	N
Gas engine	NR	C	N
Micro turbine fuelled by natural gas	NR	D	N
Fuel cell fuelled by natural gas	NR	D	N
Wind turbines	R	C,I	13% Avg Max 30-38%
PV	R	C,I	Max 25%
Biomass gasifier	R	C	N
Gas Engine	R	Gasifier-I	-
Biomass Cogen.	R	C,I	50 % Higher if aux. fuel used

Table 1: Summary of DG options in India

NR-Non Renewable; I-Indigenous; R-Renewable; D-Demonstration;
C-Commercially available technology; N- Not constrained by the supply.

VII. NEED OF DISTRIBUTED GENERATION

Government of India has taken a number of policies for fulfill the demand despite of it 56% of households still do not have access to electricity [1].As shown in table 2,currently India has grid connected total installed capacity of 212 GW for electricity Generation and it is estimated that to the rise at an average annual growth rate at 8 %, its installed electricity generation would reach up to 779 GW within two decades. To fulfill the huge demand of electricity centralized generation and extension of grid is not a good option. Distributed power generation, based on locally available energy resources and supply of this additional electricity into the rural electricity grid, can be an important part of the solution to supply reliable electricity supply to rural population. Distributed generation is clean and continuous so it is good of environment point of view, which makes it a better option. So with an eye on sustained GDP growth of 8 % and to achieve the targets of electricity generation in coming years as shown in Table1, Distributed generation seems as possible:-

Year	Installed Capacity(GW) (For 8% GDP Growth)
2011-12	220
2016-17	306
2021-22	425
2026-27	575
2031-32	779

Table 2.Projected Energy Demand

BENEFITS OF DISTRIBUTED GENERATION

The basic benefits of Distributed Generation are given below:

- Reduces the cost as there is no use of long transmission line
- Reduces the complexity
- Environment friendly
- Avoid the impact of massive grid failure.
- Easy to maintain and easy to operate as it consist of simple construction.
- Better power quality and reliability.
- The factor of high peak load shortage eliminates.
- Improves the efficiency of providing electric power.
- Of, course operation cost varies on the basis of various distributed technologies are used. Distributed Generation eliminates a number of problems which occurs in traditional generation. As in distributed generation power is generated at the consumer end so the on-site power equipment can provide consumer with affordable power at a higher level of quality.

VIII. CONCLUSION

This paper addresses the distributed power generation technologies and their impacts on the future power system. The various DGs options incorporated in Indian power system are described along with future potential and options. Due to rising fossil fuels and environmental concerns, the penetration of distributed generation coming from the renewable energy sources is increasing and expected to grow further in the future. This increasing penetration brings various technical and economical challenges in integrating the distributed generations in to existing power systems, which are critically examined. Certain policies are adopted by government of India for providing energy security. Distributed generation from Indian scenario it is a better option for providing rural electrification and also provide energy security. There are some key issues and challenges that are trying solve in future. Fuel delivery is quite tough in developing countries like India so power generation from renewal energy resources may be justifiable. In this paper we are trying to focus on the point that in future Distributed Generation will play a significant role in providing rural electrification.

REFERENCES

[1] Ackermann, T., Anderson, G., Söder, L., “Distributed generation: a definition,” Electric Power Systems Research, 57, 195–204 (2001).
[2] Hadisaid, N., Canard, J. F., Dumas, F., “Dispersed generation impact on distribution networks,” IEEE Trans. Computer App in Power, 12 (12), 22-28 (1999).
[3] Nfah, E.M., Ngundam, J.M., “Modeling of wind/diesel/ battery hybrid power systems for far North Cameroon,” Energy Conv. and Management, 49, 1295–1301(2008).

[4] Chun-Lung Chen, Sheng-Chuan Hsieh, Tsung-Ying Lee and Chia-Liang Lu, “Optimal integration of wind farms to isolated wind-diesel energy system,” Energy Conversion and Management, 49, 1506–1516 (2008).
[5] Timothy M. Weis and Adrian Ilinca, “The utility of energy storage to improve the economics of wind–diesel power plants in Canada,” Renewable Energy, 33, 1544– 1557(2008).
[6] Zhu, Y., Tomsovic, K., “Development of models for analyzing the load following performance of micro turbines and fuel cells,” Electric Power Systems Research, 62, 1–11 (2002).
[7] Hu, X. Zhao, Xu Cai and J. Shang, “Simulation of a hybrid wind and gas turbine system,” DRPT2008 Nanjing China, 6-9 April 2008, 2482-2486(2008).
[8] Sekhon, R., Bassily, H., Wagner, J., Gaddis, J., “Stationary gas turbines – A real time dynamic model with experimental validation,” 2006 American Control Conference Minneapolis, Minnesota, June 14-16, 2006, 1838-1844 (2006).
[9] Hernández, J.C., Medina, A., Jurado, F., “Optimal allocation and sizing for profitability and voltage enhancement of PV systems on feeders,” Renewable Energy, 32, 1768–1789(2007).
[10] Hilloowala, R. M., Sharaf, A. M., “A rule-based fuzzy controller for a PWM inverter in photo-voltaic energy conversion scheme,” IEEE Industry Application Society Annual Meeting, 1, 762-769 (1992).
[11] Saha, S., Sundersingh, V. P., “Novel grid-connected photovoltaic inverter,” IEE Proc.-Gener. Transm. And Distrib., 143(2), 219-224(1996).

