Present Scenario of Distributed Generation in India – Technologies, Cost Analysis & Power Quality Issues

Sumanth Yamujala[1] *Mehtab Fatima*[2] *Indrakanti Abhinay Sri Teja*[3] *Yalavarthi Lahari*[4]

Department of Electrical and Electronics Engineering

ASET, Amity University, Noida, India

***Abstract*—Indian electricity network is going through reformations for increasing efficiency, power quality and reliability of power system. Apart from unbundling, there is a need for integrating Distributed Generation (DG) to power system network for producing green power and to bridge the gap between supply and demand. In this paper, different technologies for DG, their installation cost comparison with conventional power generation technologies and few power quality issues that may arise with its integration to existing distribution network are discussed.**

Keywords—Distributed Generation, Cogeneration, Distributed renewable energy resources, Power quality, Green power.

I. INTRODUCTION

The electrical sector in India has an installed capacity of 249488.31MW as of 30th June 2014 [1] which is very high as compared to the installed capacity of 1362MW as of 31st December 1947 [2]. Still it is anticipated that India will face electricity shortages of 5.1% at base loads and 2% at peak load hours during 2014 [3].With the increase in circuit kilometers, Transmission and Distribution losses (T&D) are also increasing, which are accounted to 23.97% of total generation during 2011-12 [3]. This has become one of the main limitations for centralized power generation. On the other hand, the increased concern for generating electricity with low carbon emissions (Green Power), tending power sector to move from conventional methods of electricity generation using fossil fuels to alternative techniques. It is estimated that the required installation capacity by 2030 would reach 772GW (considering 8% growth in gross domestic product). To bridge the gap between supply and demand by reducing Aggregate Technical and Commercial (AT&C) losses and carbon emissions , there is a need to include renewable and non-renewable (small scale) power generations located nearer to load centers known as distributed generation (DG).

II. DISTRIBUTED GENERATION

The concept of DG is not new one; consumers have been installing small capacity generating units in their premises from years either for supplying electricity to their needs or as backup. However, development of new technologies and competition in electricity market creates increased concern for DG. It can be defined as *"The integrated use of small generation units directly connected to a distribution network or on the consumer side of the meter"* [4]. In other words, if power of *X MW* is generated and sometimes shared or sold over the fence through the grid, then it is termed as DG. In general, the generating capacity of a DG ranges from few tens of KW to few tens of MW. DG systems are directly connected to 440V or 11KV side of the power system network, i.e., at the distribution or consumer end of power system. The potential benefits of DG include—reduction in line losses, reliability, improvement in voltage profile, reduction in carbon foot prints and power quality improvement [8][12].

III. TECHNOLOGIES

There are different types of technologies available for distributed generation. These can be broadly classified based on the energy resources used for their generation—Renewable and Non-Renewable DG technologies.

A. DG technologies based on Renewable energy:

- Wind.
- Solar.
- Bio Fuels/ Waste to energy conversion (Biomass cogeneration, Bio gas, Biomass gasification).
- Geo Thermal.
- Tidal.

B. DG technologies based on Non-Renewable energy:

- Internal combustion engines fueled by diesel or natural gas.
- Micro turbines fueled by natural gas.
- Fuel cells fueled by natural gas.

India has about 300 sunny days in a year. So, this solar energy can be utilized for generating electricity. Solar power generation can be of two types- solar thermal power generation and photo voltaic power generation. Solar thermal power generation is an indirect method for generating electricity where solar energy is converted into thermal energy, which is used for production of steam by which steam turbine is driven. The efficiency of this system is very less [5]. Photo voltaic cell based solar power generation is direct process in which light from sun is directly converted into electrical energy. This solar power creates no harm to environment. The total grid connected solar capacity has reached 2631.93MW as of 31st march, 2014 [1].

Table 3.1 shows comparison of different technologies of DG in terms of their capacity, applications, and their electrical efficiencies [8][11].

DG based on micro turbine is a new and developing technology where natural gas, diesel, gasoline or methane is used as fuel. The main advantages of this technology are high efficiency, low carbon emissions and more life expectancy.

Technology	Type	Capacity	Grid Interface	Application	Electrical Efficiency
Fuel cells fueled by natural gas	NR	250KW-5MW	DC-AC converter	Domestic and CHP	36-50
Micro turbines fueled by natural gas	NR	25KW-500KW	AC-AC converter	CHP	31-40
Internal combustion engines fueled by diesel	NR	5KW-10MW	Synchronous Generator	Backup Unit	30-43
Internal combustion engines fueled by natural gas	NR	30KW-6MW	Synchronous Generator	CHP	30-42
Micro hydro plant	R	Up to 100KW	Synchronous Generator	Rural Electrification	40-50
Biomass gasifies	R	3KW-250KWW	Synchronous Generator	Rural Electrification	30-34
Boimass cogeneration	R	20KW-20MW	Synchronous Generator	Meeting Captive loads	30-35
Solar Photo Voltaic (PV)	R	20W-100KW	DC-AC converter	Domestic/ Commercial/ Rural Electrification	14-15
Wind Power	R	200KW-2MW	Asynchronous Generator	Remote areas/ Plateaus	20-30

Table 3.1: Comparison of different technologies for DG

R-Renewable, NR-Non-renewable

Fuel cells based power generation technology is a chemical process in which hydrogen from fuel reacts with oxygen in atmosphere to form water along with electricity. Fuel used can be natural gas. Based on the type of electrolyte uses fuel cells are classified as polymer electrolyte fuel cell (PEFC), alkaline fuel cell (AFC), phosphoric acid fuel cell (PAFC), molten carbonate fuel cell (MCFC) and solid oxide fuel cell (SOFC) [15].

Wind energy based power generation is one of the best alternatives for conventional fossil fuel based power generation to reduce carbon foot prints. In terms of installed capacity India stood in fifth position with 21136.40MW as of 31st march, 2014 [1].

Micro or Mini hydro turbines (run off river without pondage) is capable of producing power up to 2MW which can also be used as DG source.

Biogas can be another option for small scale power generation. It uses cattle dung and other degrading organic materials as fuel for generating electricity. Anaerobic digestion of organic materials produces combustible gas which is a mixture of methane, carbon dioxide and hydrogen-sulphide, is used to run Internal Combustion (IC) engines or micro turbines that are coupled with alternator.

Biomass gasification is the process in which solid biomass materials are converted into a mixture of combustible gas by heating in a reactor (container) in the presence of limited oxygen. This gas contains hydrogen, methane, carbon dioxide. This syngas/ producer gas is used as fuel for IC engines for generating electricity [10].

Biomass cogeneration uses bagasse, jute wastes, rice husk, straw, saw dust and other agro and forestry wastes for production of electricity. This fuel is burnt for the production of steam which runs the steam turbine. The residual heat can be condensed or can be used for heating application in industries which is called cogeneration. The total installed capacity of biomass cogeneration is 4013.55MW [1], out of which major contribution is from bagasse (waste from sugar mills). It is estimated that, installed capacity can be increased to 5000MW if sugar mills adopt new cogeneration technologies. This biomass cogeneration can be the best way to meet captive loads.

Table 3.2 shows present installation capacities of few renewable resources along with their potentials [13].

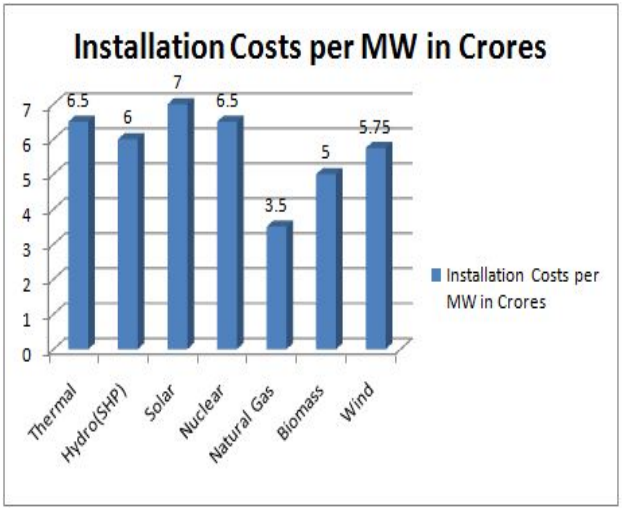
Resource	Potential	Present Installation
Wind	45GW	21.13GW
Small Hydro Project (SHP)	15GW	2.5GW
Solar	50MW/KM	2632MW

Table 3.2: Installation capacities of renewable resources and their potential

IV. ANALYSIS ON INSTALLATION COSTS

To bridge the gap between supply and demand, the generating capacity should be increased. In general, investors opt for the technologies with low capital, operation and maintenance (O&M) costs. Carbon emissions are one of the main limitations for increasing fossil fuel based power generation. The below chart shows the installation cost per MW for different technologies available.

Fig 4.1: Comparison of installation costs of different technologies



Even though installation costs of renewable power generation are a bit high when compared with conventional fossil fuel based generation, they will be advantageous in near future because of:

- Fuel scarcity; O&M costs for fossil fuel based generation are increasing.

- With the development in technology, generation through renewable energy sources can become much cheaper in near future.
- Environmental friendly.

Among non-renewable energy resources, fuel cells based generation require few demonstration projects before their implementation and micro turbines are in initial stage of implementation. IC engines fueled by diesel are only used during peak loads or as back up because of high fuel cost. By the National Fuel Policy of Government of India, gas engines are likely the preferable option and electricity can be generated at Rs. 3-3.50/- per unit [13].

Among renewable energy resources, even though average economic cost of solar is very high (Rs. 12/ unit for solar thermal and Rs.17 per unit for solar photo voltaic), it has highest potential. There is a gradual decrease in installation cost of solar power generation from a decade. The installation cost per MW of solar PV generation decreased from Rs.15.2 crores to Rs.10 crores during 2010-2013 and it is estimated that it may further reach Rs.7 crores by 2014. This gradual decrease in installation cost will reduce generation cost per unit in near future.

India is lagging in rural electrification. Through DG, it is feasible to electrify the areas where grid extension is not possible. Micro hydro plants can be used for electrifying Himalayan and other water abundant areas (with minimum head). Generation through Bio mass and Bio gas is possible in rural areas where agro and forestry wastes can be used. Wind generation can be adopted for electrifying isolated hilly areas.

The average economic cost of SHP based power generation is around Rs. 3.50 per KWh where as that of bio mass based power generation varies between Rs. 3.9 to Rs. 5.7 per KWh which is almost equal to conventional power generation [13].

Apart from this, government is subsidizing and promoting consumers to use solar heaters, solar pumps, roof top solar panels and other technologies by which peak shaving and reduction of overloading on distribution network during peak hours can be achieved.

V. POWER QUALITY ISSUES

Even though DG is advantageous, the major issue related for implementation is their impact when interconnected with grid. As existing Indian distribution networks are not designed for integrating localized generation, the following power quality issues may arise:

i. Voltage Flickering:

Voltage flickering is the visible change in the brightness of lamp due to fluctuations in voltage. These fluctuations are caused because of rapid change in DG outputs. This is the most common problem associated with DG integration to distribution network because of which malfunctioning and reduction in life time of equipment may occur. This problem can be overcome by limiting the loads on network or by using Rapid response voltage regulators, fast response reactive compensation techniques [8].

ii. Harmonics:

Some DG technologies like solar (PV) and fuel cells use power electronic converters – dc to ac converters, which are the sources of harmonics in the system. These harmonics cause malfunctioning, reduction in life time of equipment and increase in power loss. Studies show that using modern power electronic IGBT converters based on PWM technique reduces harmonic content and gives clean output current [8].

iii. Voltage Unbalance:

Voltage unbalances can occur if single phase DG like solar (PV) when connected to distribution network. This results in contingencies if more such units are connected to network [9].

iv. Reactive Power Compensation:

Most of the rural loads consist of irrigation pumps. These absorb reactive power which results in voltage dips and high distribution losses. DG technology which employs synchronous generator can supply the local reactive power requirement to some extent. Shunt capacitors and SVC can be used for reactive power supply [8].

VI. CONCLUSION

Distributed Generation is the best way to bridge the gap between supply and demand by reducing AT&C losses and carbon foot prints. Rural and remote areas can be electrified by these technologies. Even though, the installation costs for DG are little high when compared with conventional power generation methods, with the improvement in technology these prices are likely to get down in near future. India has huge potentials of solar, wind and biomass which are to be concerned for the generation of electricity. Few power quality issues that may arise with the interconnection of DG to distribution network and their solutions are reviewed.

VII. REFERENCES

[1] Technical Report, "Monthly All India Installed Generation Capacity Report, June 2014", Central Electricity Authority (CEA) of India.

[2] Technical Report, "Growth of Electricity sector in India from 1947-2012", Central Electricity Authority (CEA) of India.

[3] Technical Report, "Monthly Executive summery for March, 2013", Central Electricity Authority (CEA) of India.

[4] Kamal Kant Sharma, Dr Balwinder Singh, "Distributed Generation – A new approach" IJARCET, Vol. 1, Issue 8, October 2012.

[5] Liao Hongkai, XU Chenghong, Song Jinghui, YU Yuexi "Green Power Generation Technology for Distributed Power Supply" Electricity Distribution, 2008. China International Conference on Electricity Distribution (CICED), 2008, pp. 1-4, Dec 2008, IEEE

[6] Peter A. Daly, Jay Morrison, "Understanding the Potential benefits of Distributed Generation on Power Delivery Systems", Rural Electric Power conference, pp. A2/1- A213, May 2001, IEEE

[7] Mohammad Noor Hidayat, Furong Li "Impact of Distributed Generation Technologies on Generation Curtailment", Power and Energy Society General Meeting (PES), pp. 1-5, July 2013, IEEE

[8] Thomas Ackermann, Valey Knyazkin "Interaction between Distributed Generation and Distribution Network: Operation Aspects", Transmission and Distribution Conference and Exhibition 2002: Asia Pacific. IEEE/PES, vol. 2, pp. 1357-1362, Oct 2002, IEEE.

[9] A. Kazemi, M. Sadeghi, "Distributed Generation Allocation for Loss Reduction and Voltage Improvement", Power and Energy Conference, APPEEC 2009. Asia-Pacific, pp. 1-6, March 2009, IEEE.

[10] S.K. Patra and P.P. Datta, "Insights into Biomass Gasification Technology", Technical Digest, Issue 9, 2006.

[11] F.H. Guan, D.M. Zhao, X. Zhang, B.T. Shan, Z. Liu, " Research on Distributed Generation Technologies & its impacts on Power System", Sustainable Power Generation and Supply (SUPERGEN '09), pp. 1-6, April 2009, IEEE

[12] Pepermans G., DriensenJ.,Haeseldonokx D., D'haeseleer W., Belmans R., "Distributed Generation: Defination. Benefits and Issues" K.U.Leuven-Energy Institute, August 2003.

[13] Prof. Asok Raj Kumar and Er.Ram Jeyanth K.R.S "Outburst of Renewable Energy in India. Is it towards the target" International Conference on Advances in Engineering, Science & Management (ICAFSM-2012), March 2012.

[14] Subrata Mukhopadhyay and Bhim Singh, "Distributed Generation-Basic Policy, Perspective Planning and Achievements so far in India" Power & Energy Society General Meeting , 2009.PES '09. IEEE, pp.1-7, July 2009.

[15] Sajad Hoseinnia. Seyed Misadegezadeh, "A Comparative Study of Fuel Cell Technologies and their Role in Distributed Generation" Eurocon 2009, Eurocon '09, IEEE, pp. 464-469, May 2009.