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Distributed Generators – A Boon to Power System

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ABSTRACT

Distributed Generation is replaced by existing methods of generation due to emphasis on Energy Efficiency and reduction in carbon foot prints. In conventional system(s), a dip in reliability and consumer friendly approach leads to a new era of Dispersed Generation. With increase in sustainability index, the gap between demand and supply widens, in order to curb the problem; technologies empower Distributed Generators for their operation. Large power Generators at the consumer side increases reliability, Load factor and used in customized generation in small or large power systems across globe.This paper summarized existing literature survey pertaining to benefits of Distributed Generators along with the comparative analysis. Distributed Generators introduces the concept of Distributed Generation which helps the utility and consumer to make use of available resources at low operating cost.

Index Terms: Distributed Generators, Electric Power System. Grid Integration

I. INTRODUCTION

Nowadays, Conventional Power System empowers centralized pattern in which large generating stations generate power and transfer to notable distances through electrical apparatus. The delivery of power to the consumers is incorporated and extracted using transformers at low voltage level. Around the globe, penetration of renewable energy sources improves reliability and helps in voltage profile of a system. The penetration of non conventional sources evolves a new term of generation; Dispersed or Distributed Generation (DG). The generation consists of various generation units connected directly or indirectly with the distribution system facilities the consumer end [3]. Generally, DG refers to any electric power production technology that is integrated within distribution systems, close to the point of use. These units are available with or without Grid connected; with some of power quality and integration issues. Considering vitality of Generators, they have certain limitations, not used above than 30MW.

Distributed generators (DGs) overcome two major drawbacks which occur in existing power system. First, It follow the load variations flexibly as when load changes it matches up due to large transmission availability and secondly, it also limit the frequency of accidents spread out as system is not too large and complex which exists in orthodox systems. In order to improve reliability, DGs acts as back up generation for small or intermediate requirements for a short while. It also reduces the burden which is comparatively higher in existing power systems (PSs).Meanwhile, it can also be used to provide compensation, improving peak shave and also act as load follower in case of peak demand. Due to increased penetration of Distributed Generators in Power system, various analyses have been performed quantitatively [1]. Thus various methodologies are also revealed acted network and itself [4]. In this paper, the qualitative and quantitative analysis is presented.

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II. CHARACTERISTICS OF DISTRIBUTED GENERATORS

Various experts analyzed the importance of DGs and their substantial impact on power system. In conventional PSs, load factor remain high with control on power quality and harmonic indexes. Thus Distributed Generators are defined in various aspects. Distributed Generators sometimes called embedded generation, incorporated near the end users, acts as improved and reliable unit. Its generation power varies in range from small to large generation (few KW- many MW). It mainly includes combustion with the fuel of liquid or gaseous type, renewable and non renewable sources with different terminologies [2].

IEEE also acknowledge importance of DG, defines it as the generation of electricity by facilities that are very much smaller as compared to conventional system with a point of common coupling anywhere in a system [5] . DGs can be characterized as follows

- Generation unit of smaller capacity.
- Located near the load centre, allowing interconnection with conventional power; securing reliable and helps in reducing carbon footprints.
- Incorporates renewable and non renewable sources together, can be used as Co generation plant or stand alone systems.
- Improves reliability and load factor, reduce peak shave
- Intermittent storage and enhances Available Transfer Capability (ATC)

III. KEY TECHNOLOGIES INVOLVED IN SMART GRID

(A) Fuel Cells (FCs)

They used to convert chemical energy to electrical energy, characterized by content of material [2]. These technologies are available with output pertaining to d.c value and available for a.c with power conditioning at PCC. In this terminology, local network or mesh systems can be incorporated with conventional approach. Industries are in process of bringing this technology to the reality making fuel cells of range from 5 kW [6], up to 250 kW [7]. This technology also acts as backup power with installation at pilot level. They are available in abundance, offers green technology, reducing carbon footprints and compact in nature.

(B) Photovoltaic Systems (PVs)

These systems empower technology to generate electricity from solar radiation, making maximum use of it by using tracking techniques capturing real orientation, excluding thermodynamic cycles. These panels consist of discrete cells, connected together in different configuration, number of cells depend upon the requirement, making maximum use of radiation. These types of systems cater the load, which is varying and instantly peak at different time slots. The efficiency is low as 15% and power ranges from a value of 50- 100 W depends on type of module. It is expensive on basis of technology and installation [4- 6].

(C) Energy from Wind

The other prominent DG technology incorporated wind power as input for its variability. Due to its variability and availability in wind speed, this technology incorporates wind turbines ranging from few KW to few MW, depends upon requirement. They are available in integrated system with wind shore to wind farm involves large number of wind turbines. Various terminologies are being used for converting speed of wind, normally at 15m/s to electrical energy like self excited or doubly excited. The generators which are used in power generators are induction generators which are susceptible to change in load variations and input flexibility. In wind power generation, there is flexibility for high voltage DC and a.c supply. For HVDC, PMDC machines are used to reduce interconnectivity problems with conditioning equipment, offering low maintenance and low vulnerability. In this terminology, the investment is higher, but on the other part, if wind farm technology is considered, then efficiency improved with small installations. But major drawback is that the turbine only produces electricity when the wind is blowing at good value which is not frequent.

(D) Mini Hydro-Turbines

Hydro power plants play a major role in generation of electricity in existing PSs, but having high capital cost along with large land acquisition. But sometimes, water levels are not adequate to run a hydro power plant, then to utilize available water level at low value gives rise to evolution of terms small hydro. These are also known as “micro hydroelectric” power stations, and mini hydro-power stations. The name of power station depends upon the value of generation of electricity and use of power station for type of demand. Normally, these power stations are used for intermittent load at for peak hours. Usually, the range for micro hydroelectric” power stations is 5–100 kW and mini hydro-power stations have a range of between 500 kW and 10MW. The turbines employed for this type of generation is Francis turbine.

(E) Micro turbine Based Energy

Some of the DG technologies incorporate micro turbines couples to generator, acts as prime mover. In this technology, the synchronous generator is used, with which micro turbine is connected, and the generator output totally depends upon angular speed of shaft connected. This technology arises from super chargers and automobile industry. This technology evolves with good experimental results like high efficiency and less carbon foot prints and less expensive. The main feature of this technology is that prime mover which is connected with generator decides the output, provided generator operates at synchronous speed and synchronism must intact. It is available with biogas, diesel, land fill gasses, methanol and hydrogen like fuel. [8].

(F) Reciprocating Engines

This technology is a very old technology developed around a century back. This technology incorporates engines run on diesel; waste product; and land fill gasses. These engines run as a prime mover to generator, which is used for developing power. The engines are developed up to the capacity of 5,000 kW with the drawback of high emission. The technology has no recent research and has a efficiency in a range of 30-40%.

(G) Combustion Turbines

An old Technology uses combustion of fuel with low emission levels with use of combustion turbine or engine act as a prime mover. Combustion turbines are used with any type of fuel with high calorific value, able to run a generator at their rated speed. The range of combustion turbine starts from 1 MW and maximum till 5 MW. The electric efficiency ratings are quite low, less than 15% but suitable for low loads (emergency level). This technology primary used in cogeneration plants and meets peak applications. The research is focussed on increasing efficiency.

(H) Combined Heat and Power

Combined Heat and Power (CHP) is one of the technologies that make use of waste heat (like in coal power plant) that get wasted using intermittent turbines in conventional generation system. This technology is most economical, utilizes waste heat, available from micro turbine or turbine as such. This technology is a combination of more than one technology incorporates DG. The overall efficiency of a combined system is 85-90%.

These technologies provide deployment and integration of distributed resources and generation including renewable energy resources.

IV. BENEFITS OF DISTRIBUTED GENERATORS

In this era, power system has to improvise on certain aspects like low utilization factor, distributed power grid, technology interface. In Renewable Energy and Distributed Generation Task Force (REDGTF) Action Plan [9], emphasis on RE projects and policies have been framed in order to increase the penetration in conventional system.The benefits of Distributed Generators also discuss which leads to Distributed Generation aids the total generation.

(A) Reliable

Reliability stands for 100% electric power without interruption. The reliability is justified through various factors

(a) Congestion Factor

Due to increasing load, the transmission line need to be overloaded and increases congestion factor which can lead to breakdown and also produces high value line losses. But due to presence of DGs, overloading of transmission lines is reduced as DGs are near to consumers and improved reliability.

(b) Independent Operation

DGs are independent in operation as they are capable of managing load sours efficiently. Thus, they are not prone to interconnected systems, if connected they are immune to black outs or severe faults which spread out very fast in large interconnected system which doesn’t fulfil the condition of reliability. The installations of DGs are like that they are connected as back up of one another such as near the feeders, near the end and at pie line which increases the reliability of system.

(B) Ancillary Services

(a) Load Frequency Control

In large power system, there is large gap between demand and generation which leads to load mismatching. DGs have main feature of load follower which allow DGs to compensate load effect keeping frequency constant. DGs also help to maintain security of a system. Keeping load frequency ratio constant helps to maintain system balanced.

(b) Spinning Reserves

DGs have low load factor as they operate at less than full load and pick full load without leading to outage or taking additional support. This helps in maintain synchronization among different units and leads to reliability. IC or Reciprocating technology can be used to bridge a gap between load compensation when load suddenly shoots up.

(c) Voltage Profile

DGs also provide an additional feature of reactive power compensation by injecting or absorbing reactive power to maintain voltage profile. It also improves power quality by minimizing the problem of Voltage sag and swell as compared to centralized generation scheme.

(C) LOSSES

The main losses occur in Transmission and Distribution. The major reason for losses is high value of current and line resistance. To reduce heavy current and resistance, source should be near to the load. As DGs are used in conjunction with conventional systems in transmission and distribution systems, it reduce line current when used with high voltage network; where as in case of low voltage network, it is available near the load side to reduce losses and power quality issues. The other aspect of DGs is to contribute to reduction in line resistance. This terminology helps in reducing considerable amount of line losses.

(D) Environment Friendly

As major contribution to energy sector in terms of generation is from thermal, hydro and nuclear power plants which are not friendly to environment where as DGs penetration alleviate the use of renewable energy sources as well as promote the concept of clean energy.

(a) Energy Utilization

DGs penetration alleviates the use of renewable energy sources and increases energy utilization efficiency. Various algorithms [10] also presented in saving of power and optimize the resources comparatively with conventional systems.

(b) Land Use

The increasing population and development across the globe, is looking for huge land and high demand for electricity. To cater the demand, in conventional system(s), large land is required which incurred huge capital cost which effect economic prospect of generation. In order to save land, DGs plays a notable role as they are normally stand alone systems or connected near to the load at a small capital and running cost. In [11], different analysis is marked emphasis on advantages of DGs for land use.

(D) Economical

(a) Less Investment Risk

Renewable energy penetration requires less capital cost as compared with conventional system and less load fluctuations.

(b) Accessibility

Remote areas like islands or hills where requirement of load is not high as well as positioning of conventional system is not feasible; in those areas, DGs significance is appreciable. DGs overcome the problems of topographical conditions, abnormal transport, or high cost of construction and installation. However, DGs technologies also help to improve sustainability index of place and quality of life in terms of economic growth and development.

(c) Consumers' Profits

DGs help to improvise on development of smart grid involving multiple resources like conventional or non conventional; improves customer belief. On commercial ground, companies empowering DGs technologies, offer customer friendly tariffs depending upon type of load and time interval, whether peak or base hours. DGs also provide reliability to consumers on their electrical part to increase their services and production.

V. CONCLUSION

Scarcity of Energy Resources and reliability issues effect social- economic development. However, power efficiency has improved considerably with more reliable and service quality. DGs opened a new era in power system by eliminating deficiencies existing in power system. In this paper, need of DGs along with their benefits are discussed in detail. Key technologies and various issues concerned with them are also outlined.

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