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The Benefit of Distribution Generation to the Nigerian Electric Utility System

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ABSTRACT

The problem of quality power, challenges of generation, transmission and distribution of electrical energy to its end users has resulted in incessant black out in Nigeria. This challenges and problems have driven the electricity industry into a reformation process to solve this menace by privatizing the industry which has led to the introduction of the independent power producers scheme (IPPs). In this paper a solution of integrating IPP into the grid in the form of distribution generation (DG) was analyzed to curb the challenges and problems facing the industry in Nigeria. It looked at the potential benefits of distribution generation (DG) that is, the application of renewable (photovoltaic and solar thermal) and sustainable energy (gas fired micro-turbine) of few KW to 50MW into the distribution network of the Nigerian grid to solve the problem and challenges of the industry.
KEYWORDS: Distribution generation (DG), independent power producer (IPP), renewable energy, distribution network.

1.0 INTRODUCTION

Nigeria is situated at the heart of Africa with a population of over 150 million people. It is a vast country with a total of 356, 667 sq miles (923,768 sq km), of which 351,649 sq Miles (910,771 sq km or 98.6% of total area) is land and it is divided into 36 states and the federal capital territory (FCT) [1]. The insurgence of electricity supply in Nigeria started way back in 1896 and a subsequent establishment of Electricity Cooperation of Nigeria (ECN) in 1951 and Niger Dam Authority (NDA) in 1962, this pave the way for the advancement of electricity supply in Nigeria. In 1972 the Niger Dam Authority (NDA) and Electricity Cooperation of Nigeria (ECN) were merged to form the deformed Nigerian Electric Power Authority (NEPA), now Power Holding Company of Nigeria (PHCN) which was established to control, coordinate and effectively manage the electricity generation and supply. The establishment of NEPA to form a centralized control did not helped in addressing the growing energy demand but rather resulted in incessant blackout in the country. The over centralization of the Nigerian electricity industry made it practically impossible for electricity supply to keep pace with the growth in population and economic activities. Today, Nigeria has the biggest gap in the world between electricity demand and supply, providing it population of 150 million with roughly 3,800 megawatts of electricity. In contrast, South Africa generates more than 40,000 megawatts for a population of 47 million people, while Brazil generates 100,000 megawatts for its 201 million citizens [2]. Nigerian power system has the flexibility to meet future demands of the user in a particular area, to transmit it to the area where it will be used and then distribute it within the areas, on a continuous basis. It is design to generate electric power in sufficient quantity to meet the consumers present and future load demand in a particular locality. To ensure that maximum return on the large investment in the equipment, which goes to make up the power system and to keep users satisfied with reliable service, the whole system must be kept in continuous operation without any major breakdown. To enable Nigeria, effectively supply electrical energy on a continuous basis without breakdown, the industry has to look into the future and embrace the unique and dynamic DG to optimize electricity supply in Nigeria. Distribution generation is simply the application of small generating plant (few kW - 50MW) connected at the distribution network or the user's terminal. The investment in distribution generation will stair Nigerian to invest heavily in sustainable and renewable energy resources like gas fired micro-turbines, solar energy (photovoltaic and solar thermal) and wind energy which is in line with the federal government commitment to solve the long lasting energy crisis in Nigeria through the adaptation of renewable energy master plan (REMP) with a target of increasing power generation capacity from 5000MW to 16000MW by the year 2015 [3].

Overview of Nigerian Electricity Industry:

Before 2005, Nigeria was operating with only eight generating stations. Three hydro powers stations namely Jebba, Shiroro, and Kainji situated in Niger state, and two thermal stations namely Egbin and Ijora in Lagos state,

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while two thermal stations are in Delta state namely Sapele (Ogorode) and Delta (Ugheli) and a thermal station in Rivers state known as Afam. The fully installed capacities of the aforementioned generating stations are shown in TABLE 1. The useable capacity of these eight generating stations is merely 2,295MW.

The government/IPP later establishes seven more thermal stations in different states of the federation with installed and useable capacity amounting to 2094MW in order to improve electricity supply. The new stations and capacity are shown in table 2. With the establishment of seven more stations to support the initial eight generating stations, yet the usable capacity could not meet demand.

Table 1: Generating stations before reform in 2005[1]

S/n	Generating Plant	Type	Location State	Installed Capacity (MW)
1	Egbin	Thermal	Lagos	1320.00
2	Ijora	Thermal	Lagos	40.00
3	Delta (Ughelli)	Thermal	Delta	912.00
4	Sapele	Thermal	Delta	1020.00
5	Afam	Thermal	Rivers	969.60
6	Kainji	Hydro	Niger	760.00
7	Shiroro	Hydro	Niger	600.00
8	Jebba	Hydro	Niger	578.00
Total Installed Capacity				6199.6

Table 2: Existing generating plant after reform

S/n	Generating Plant	Location State	Type	Installed Capacity (MW)
1	Ajaokuta	Kogi	Thermal	110
2	Geregu	Kogi	Thermal	414
3	Okapi	Cross River	Thermal	480
4	Omoku	Rivers	Thermal	150
5	Omotosho	Ondo	Thermal	335
6	Olurunsogo	Ogun	Thermal	335
7	Egbin AES	Lagos	Thermal	270
Total Installed Capacity				2094

After the reform a total of four new generating stations were established by government and a total of thirty Independent Power Producers (IPPs) were given approval to generate electrical energy across the six geopolitical zones. The additional generating stations gave an estimated generation capacity to about 24,106.00 MW.

However, the additional generating stations did not solve the Nigerian energy demand because only few of these stations have been commissioned while some are ongoing others were given license but have not been commissioned or started construction. Table 3 described the different stations on different stages of operation. Also, table 4 shows the total operational capability of the working generating stations.

Table 3: Stages of Operation for Different Stations

Ongoing construction	Commissioned IPP	Approve licenses IPP
11.76%	5.86%	82.35%

Table 4: Operational capability of the working generating stations.

Thermal installed capacity (MW)	Hydro installed capacity (MW)	Thermal useable capacity (MW)	Hydro useable capacity (MW)
5976	1900	3028.8	1410

2.0 challenges of energy generation and distribution in nigeria:

The continuous generation, supply and distribution of electrical energy to its end user is a major challenge in the Nigerian electricity industry. One of the most disturbing challenges is the very poor power quality and distribution lines. However, other challenges are associated with the terrain; geographical location of the end user's, generation capacity and number of generating stations. For example, Bayelsa state in the Niger Delta region has a riverine setting with almost 70% of her communities is situated in the creeks. Most of her communities are almost or in some cases totally surrounded by water, hence, making these communities inaccessesible by road and electrical energy due to their location and terrain. The challenges in the Nigerian electricity industry have been elaborated and discussed in many research papers. Some highlighted on the capacity of the available power stations of not meeting the ever increasing population while some highlighted the challenges in generation, transmission and distribution in the country [4, 5].

3.0 the concept of distribution generation:

The idea of distribution generation is to integrate into the distribution network of the power system with sustainable energy systems that is, small gas-fired micro-turbine or with renewable energy systems for example solar energy (photovoltaic and solar thermal system) and wind energy systems ranging from few KW – 50 MW to the distribution network to continuously supply electrical energy to the end users as shown in the figure 1, 2 and 3. Distribution generation has been understood differently in terms of definition by different researchers. In [6] distribution generation is defined as small scale generation of electricity while in [7] distribution generation is understood as an electric power sources connected directly to the distribution network or the customer site of the meter. The concept of distribution generation (DG) is illustrated below in fig1, 2 and 3

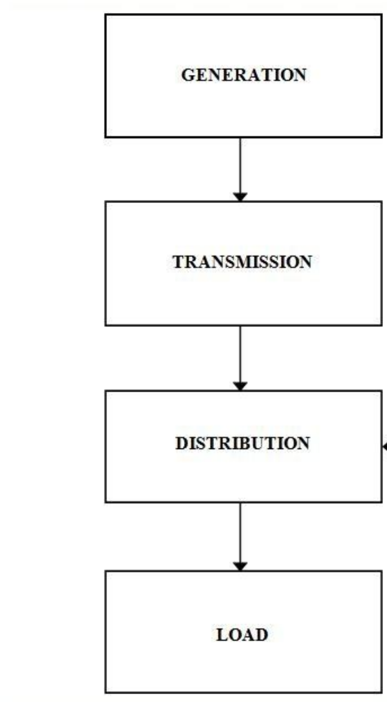

Fig.1. Block of the application of Distribution generation

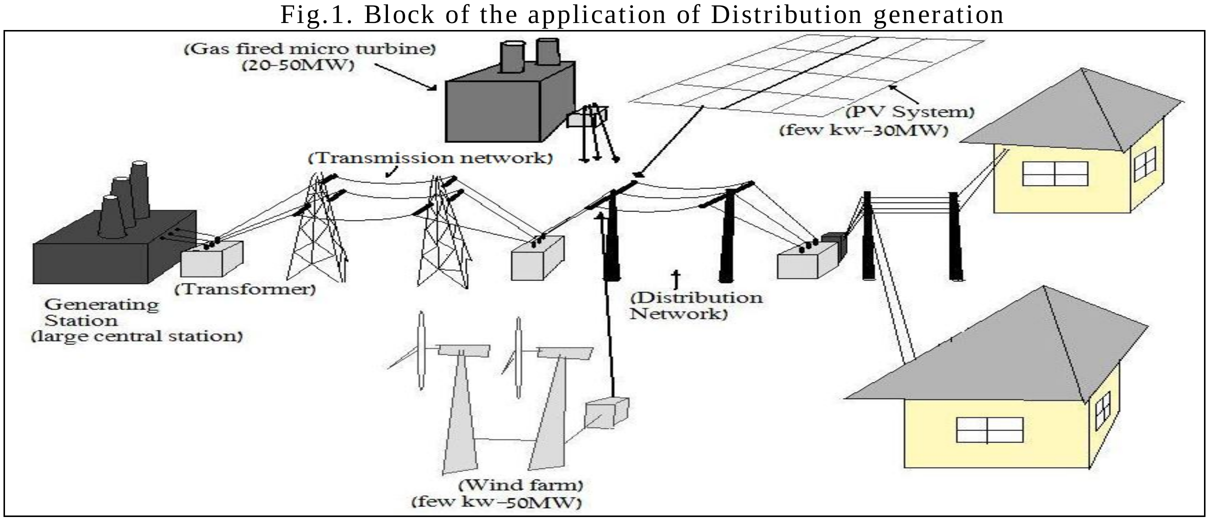

Fig.2. Schematic on the application of distribution generation (DG)

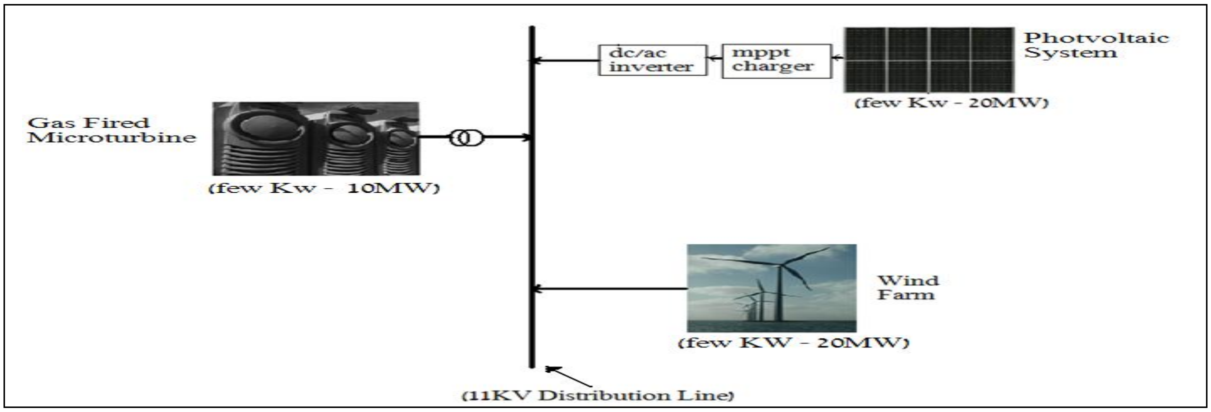

Fig.3. Block Diagram Showing the Integration of Micro turbines, Wind Turbines and Photovoltaic System To an 11KV Distribution line.

4.0 benefit of exploring distribution generation to the nigerian state:

The potential benefits of exploring distribution generation on the distribution network of the Nigerian grid are presented in the following subheadings.

4.1 environmental impact:

Global warming and environment issues have been a great concern globally. This issues and problems are mostly caused by the massive discharge of CO2, CO and SO2 known as greenhouse gases from fossil fuel generating plant. The environmental issues lead to the signing of the Kyoto protocol in December 1997 by some concern countries to reduce greenhouse gas emission. To reduce the emission rate of CO2, in order to reduce the effect of climatic change and to satisfy the growing energy demand in Nigeria, the electricity industry and government has to look at distribution generation (DG) which is non pollutant, environmentally friendly and cost effective. The integration of clean sustainable energy systems (clean gas fired micro turbine) and renewable energy systems (photovoltaic and wind) can reduce CO2 emission to a satisfactory level in Nigeria which is in line with the federal government and the United Nations commitment to fight the challenges of climatic change.

4.2 improves power quality:

Power quality is becoming a major concern to consumers as sensitive equipment and non linear loads are common in power system. For appliances or other electricity using equipment that are sensitive to micro-second perturbations in the flow of electricity, a high level of power quality is critical to avoiding damages and downtime. Voltage surge and sags, frequency excursions, harmonics, flicker, and phase imbalances comprise the major power quality concerns that can cause substantial economic impacts [8]. These issues highlighted are the major causes of poor power quality in Nigeria and has purse great challenges on the Nigeria utility system and on consumers. It is indicated in Van-Thong et al. [11] that the integration of small amount of DG reduce both reactive and active power losses in the power system which means that the integration of DG with a power electronic (power inverter) to the Nigerian utility grid (distribution network) will improves power quality if the distribution generation is independently controlling the real and reactive component of the power inserted in the ac grid.

4.3 voltage stability:

Nigerian electricity system over the years has experience voltage instability as a result of long transmission line and heavy transmission loading which has affected the acceptable range of nominal voltage value. The voltage of the transmission line is greatly influenced by the power factor of the line; that is to say, the quantity of reactive and active power of the power line. The injection of reactive power into utility under normal working condition improves the system voltage. Therefore, the injection of DG to distribution network provides reactive power to the distribution line and saves both transmission and distribution line losses to maintain voltage and it can also reduce reactive current. Reduced reactive current improves distribution voltage stability, thus improving end-use device reliability and lifetime, and enhancing customer satisfaction, at lower cost than for voltage-regulating equipment and its operation [9].

4.4 increase systems reliability:

Electricity system reliability is the ability or measure of the electric system to meet customers demand at all times. In Nigeria the problem of reliability is a major task because the electric utility is affect by weather condition such as lightening, high winds and unusual hot weather. It is also affected by decision made by grid operators and grid system components. However, with the introduction of DG, reliable service will be provided to the customers and reduce effect of system reliable to the fewest of customers when there is outage. This is done by injecting back up/distribution generations at the customer side of the grid to keep the electric system reliable at all time with a minimal effect on customers.

4.5 construction and operation:

Most fossil fuel generating plant are complex and capital intensive hence making development, construction, installation and production of these large central generating plants a decade long project. In Nigeria most of the generating plants are large central plants, with most of them including newly license IPP's greater than 500MW capacity making it capitally huge to complete and start production in due time. The electricity industry in Nigeria has suffered because most of these licensed generating plants have not started construction and the existing ones are not functioning with full capacity because of the large capital involved. But with the introduction of distribution generation to the Nigerian electricity industry, will improve cash flow through quicker operational revenue earning rather than waiting for the total capacity to be completed. It will also enhance quicker installation and better understanding of the plant than it will take to build a large central station, let alone to operate and gain expertise with it. It will also burst supply to the consumer's in a short time and reduce accumulation of interest during building.

5.0 conclusion

The interest in renewable energy has been increased due to Kyoto agreement on global reduction of greenhouse emissions. Small capacity distributed power generation systems, including solar power, wind power, are directly incorporated into the utility for supplying electric power to local load or injecting into the utility [10]. The integration of DG has purse some issues with utility but Due to rapid technological advancement globally, the use of distribution generation is expanding rapidly and it is applied massively in different countries of the world. In the USA about 12 million DG unit is installed nationwide and they play significant role in the nation energy system. Also in the UK, Spain, Germany and Netherland, DG is installed and it has also play some role in addressing their countries energy demand. Nigeria is made up of six geopolitical zones and these zones are rich in both human and natural resources. Just recently about fifteen locations, in three geopolitical zones (south-south, east, and west) have been studied with enormous potential of solar radiation which will play significant role in the application of photovoltaic system in the form of distribution generation. Also, Nigeria has the second largest natural gas reserve on earth and this enormous reserve can be explored readily to generate electricity through sustainable gas fired micro-turbines spread across different location of the six geopolitical zones then the problem of electrical energy will be reduce significantly. Nigeria has the longest coast line in west Africa and if wind patterns are studied in this location and in the northern Nigeria, then wind farms can be installed in coastal area in the south and in the vast savannah in the north in the form of DG, to increase electricity supply to end user's in rural and sub-urban areas of the country.

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