Journal of Multidisciplinary Engineering Science and Technology (JMEST)
ISSN: 3159-0040
Vol. 3 Issue 1, January - 2016

Evaluation Of System Collapse Incidences On The Nigeria Power System

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***Abstract* -The term voltage collapse is often used in place of system collapse. It is the process by which the series of events accompanying voltage instability leads to a blackout or abnormally low voltages in a significant part of the power system. The cause of this can be categorized into two; technical and non-technical. The technical causes may be due to tripping of lines on account of faulty equipment or increase in load than the available supply. The data comprising the series of system collapse experienced by the Nigeria power system since 1987 to 2014 were presented and analyzed to view the frequency of the occurrence of the collapse. Also, suggestions were given on the ways to reduce the incidence of system collapse on the power system.**

Keywords—grid, stability limit, Transmission line, Voltage collapse

I. Introduction

Nigeria operates on a grid system and it is referred to as Nigeria National Grid. There are many advantages of the grid system; ensuring continuity of supply even in a case of a fault on one generator, it also allows optimal usage of the cheapest means of generation (Hydro power stations). The Nigeria power system operates on a nominal frequency of 50Hz ± 0.4% [1]. Majorly, the reason for the deviation in the frequency is as a result of the disturbance unbalance of the active power generated and the active power consumed in the power system [1]. The generators in the system generate in either 11kV or 16kV. These voltages are stepped up to either 330kV or 132kV for the purpose of transmission. These voltages are then stepped down as the transmission lines get close to a highly populated environment. 330kV is stepped down to 132kV and this is further step down to 33kV which is known as the primary distribution voltage. The nominal voltage is further stepped down to 11kV. This voltage is used as the secondary distribution voltage used in supplying domestic consumers and is further stepped down to 0.415kV for a line to line and 230V for the line to neutral.

In this work, the data comprising the series of system collapse experienced by the Nigeria power system since 1987 to 2014 were presented and analyzed to view the frequency of the occurrence of the collapse. Also, suggestions were given on the ways to reduce the incidence of system collapse on the power system.

II. Brief History of Nigeria Power System

Electricity in Nigeria, grew from a few kilowatts consumed by the colonial masters in Lagos. In the late 19thcentury, the Electricity Corporation of Nigeria (ECN) was established by the Act of parliament of 1951. Later in 1962, Niger Dams Authority (NDA) was set up to develop hydropower station and this was later merged with Electricity Corporation of Nigeria to form National Electric Power Authority (NEPA) in 1972. From 1972 to 2005, NEPA, the state-owned, vertically integrated monopoly, controlled about 94% of the generation capacity and 100% of the transmission, system operation, distribution, and marketing sector of the power industry. The transmission lines and generators are interconnected in a common grid, with a single control center [2, 3].The population of Nigeria has been on the increase since then and the generation of electricity was not expanded to commensurate with this increase. This has made the demand of electricity to overshoot the available supply capacity. This unaddressed problem, by the year 2000 put the country into electricity supply crisis (a situation that became national embarrassment), this has prompted the Federal Executive Council (FEC) in the year 2001 to approve the National Electric Power Policy (NEPP). This policy was to call for fundamental changes to ownership, control and regulation of the power sector. The 2001 NEPP actually set the roadmap for Nigeria's power sector privatization, but due to the bureaucracy in government, the policy could not be signed into law until 2005 [4]. The signed document became the Electric Power Sector Reform (EPSR) Act of 2005. The EPSR Act 2005 translated NEPA into the newly incorporated Power Holding Company of Nigeria (PHCN) Plc. (comprising of 18 separate successor companies that took over the assets, liabilities and employees of NEPA, and responsible for the generation (6 companies), transmission (1 company) and distribution (11 companies)[4]. The complete transfer of the company to the private owner was formalized in late 2014.

As the system loads increases, the increase causes a change in the real and reactive power demands on the system. This change in the system real and

reactive power demand causes variation in the system voltages and frequency. The power system is equipped with controllers that reduce these variations to acceptable levels well within the statutory limits. In the operation and control of an electric power system network, voltage stability is a major concern to the power system engineer as the electric power system network nowadays operates very close to its stability limits [5]. This paper evaluates the rate of system collapse in Nigeria system and compares it with the studies done over the years.

III. CAUSES OF POWER SYSTEM COLLAPSE

A power system is said to have entered a state of voltage instability when a disturbance causes a gradual and uncontrollable decline in voltage. In actual sense, voltage collapse can be defined as instability of a heavily loaded electric power system network that leads to decrease in voltage level and eventually blackout [4]. Power system collapse has a severe outcome on the security of the system and also, it reduces the reliability of the power system network. There are many reasons for a power system network to collapse, these can be grouped into two major group; technical and non-technical cause. The simple structure of a power system is shown in figure 1.

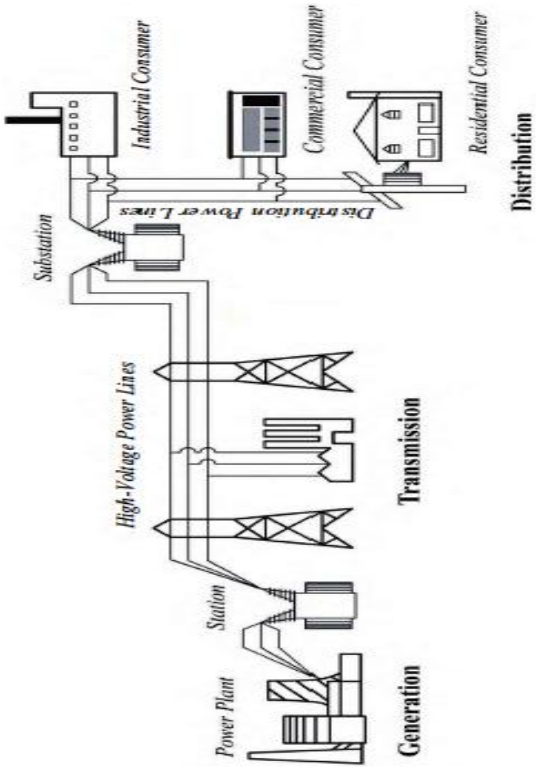

Figure 1: Structural Representation of a Simple Power System [6]

A. Non – Technical Causes

The non-technical cause of voltage collapse many times may be due to weather related circumstances. A certain percentage of power outages are weather related. Numerous power failures are caused by natural weather phenomena such as lightning, rain, snow, ice, wind, and even dust. While it is more difficult to safeguard from major power failure from natural calamities like floods and severe storms, it does not take much to safeguard the electrical systems from the effects of water and dust. Water can lead to short circuits and power failure. Electric transmission lines run through several kilometers and a major part of these lines are in forest areas when rain falls and accompany with a heavy storm, the storm may cause the trees to fall and may fall on the transmission lines. If the trees fall on a line that is carrying heavy loads, the effect of the outage of such line may be too heavy for the power system network to return to stability and leads to a collapse of the system.

Dust can also cause havoc with electrical systems and lead to short circuit. If this happens on a major transmission line, the stability of the power system can be hindered and this may lead to power outages. Hurricanes, floods, wind storms, earthquakes, tsunamis, and other severe weather can completely destroy critical power infrastructure and results in outages that leave expansive geographic regions without power for days, weeks, and even months.

B. Technical Causes

There are several changes in a power system that can contribute to voltage collapse. The Increase in load is one of the changes that can cause voltage collapse in the power system. When the load demand by the consumer has increased more than the available power in the system, this can cause a collapse of the system. By this, the power system is stressed more than its capacity and this is very dangerous for the system. So many parameters of the system would have changed, and this can lead to the collapse of the power system. Another cause is when generators, synchronous condensers, or SVC (Shunt Variable Capacitor) reach reactive power limits. A synchronous motor takes a leading current when over excited and, therefore, behaves as a capacitor [7]. An overexcited synchronous motor running on no-load is known as a Synchronous condenser. When a device like this is connected in parallel with the supply, it takes a leading current which partly neutralize the lagging reactive component of the load. When these devices reach their limit of the reactive power that they can produce, then the system may experience total or partial collapse. The Action of tap changing transformers also affects the voltage profile of the power system. When tap changers of transformers are switched, the voltage profile changes greatly,

most especially if the transformer is carrying a heavy load. Load Tap changing in transformers design are for monitoring a constant voltage on a power system, the ratio of transformation is usually changed by increasing or decreasing the number of active turns in one winding with respect to another winding[8]. This effect can cause a greater shift in the profile of the system and, therefore, may cause fluctuation in the frequency of the system. Line tripping is a common phenomenon on Nigeria system. When a line that is carrying huge power trips, this can cause an imbalance in the power system and therefore, a shift in the stability of the system. Transmission lines may trip due to so many reasons, one of which is when trees fall on lines and cause it to short circuit. At times, there may also be a fault to ground or an open circuit on the line and, therefore, making the line trip. Generator outage is another incidence in a power system that can cause voltage collapse. The outage of generators carrying a huge load cause instability in the power system and if combating measures are not taken, the system may experience collapse. Line tripping is a phenomenon whereby a particular line in the power system is taken out of service due to so many reasons. At times, the cause of line tripping may be a physical occurrence or technical fault on the line. If this happens on a line that is carrying a large load, it may cause system collapse.

IV. Analysis of System Collapse on Nigerian Power System

Some of the reasons for this occurrence range from tripping of transmission lines due to vandalization or faulty control and protection equipment. Another cause may be an outage of generators due to a fault. Table 1 shows the various system collapses that occurred between the year 1987 and 2014.

YEAR	**TOTAL SYTEM COLLAPSE**	**PARTIAL SYSTEM COLLAPSE**	**TOTAL NUMBER OF COLLAPSE**
1987	20	13	37
1988	13	8	21
1989	10	6	16
1990	14	0	14
1991	5	1	6
1992	0	1	1
1993	5	14	19
1994	2	4	6
1995	1	10	11
1996	2	8	10
1997	7	13	20
1998	5	13	18
1999	4	5	9
2000	5	6	11
2001	14	5	19
2002	9	32	41
2003	14	39	53
2004	22	30	52
2005	21	15	36
2006	20	10	30
2007	18	9	27
2008	25	15	40
2009	19	20	39
2010	22	20	42
2011	13	6	19
2012	16	8	24
2013	22	2	24
2014	2	0	2

Table 1: Table showing Power System Collapse from 1987 to 2014

From the table, a graph of a total number of system collapses against the year is presented to compare the frequency of the collapse in the years.

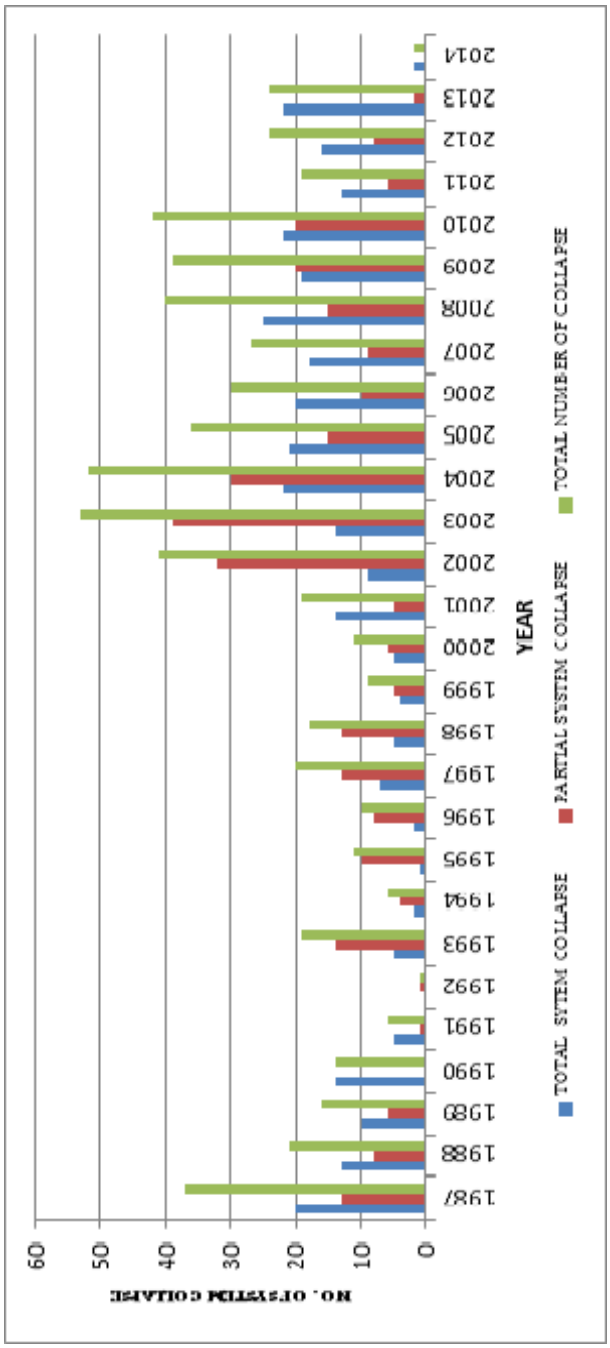

Figure 2: Graph Showing Number of System Collapse against the Year

System collapse was on the increase between the year 2000 and 2010 resulting in insecurity and unreliability of the entire power system network. This was caused majorly by different lines tripping due to many reasons. In the year 1993, 19 systems collapses were recorded; all of these were caused by faults from the transmission section of the power system. From the graph, the highest number of system collapse was recorded in 2003 with a total number of 53. [9] The inconvenience and economic loss that power system collapse inflicts on both domestic and industrial customers are high and unbearable. The resultant power outages cost the nation an estimated amount of $1billion per year (2.5% of GDP) [5, 10]. This frequent collapse of the power system has caused many industries to close down during this period because of the high cost of running diesel generators. Small businesses and heavy machinery manufacturers are severely affected by the abysmal performance of the Power industry. In addition, the entire population is also affected socially, psychologically and physically due to inadequate and unstable power supply. The Nigeria Electric power system experienced the least number of system collapse in 1992; a single system collapse (partial system collapse). Reliability refers to the ability of a power system to supply adequate electric services on a nearly continuous basis with few interruptions over an extended period of time [11]. This result shows that Nigeria power system cannot be said to be highly reliable due to frequent collapse experienced.

V. Conclusion

The Nigeria power system needs a total overhaul. The total number of system collapse occurring per annum is very alarming and this has led to the closure of many companies and, therefore diminishing economic sustainability. The transmission system is stressed, then a need to expand the transmission system so as to carry a huge amount of power from the generating station to the consumer. The more generating station should be built so as to be able to meet up with the power demand by the consumer. This will also enhance the economic growth of the country. The distribution network must also be monitored, such that the amount of power loss in this section of the power system will be drastically reduced. Expansion and restructuring of these three sections of the power system will improve the security of the system in the time of any disturbances. Conclusively, the Nigeria power system needs general overhauling so as to reduce the economic impact of the frequent system collapse in the country.

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