© 2017 IJSRSET | Volume 3 | Issue 8| Print ISSN: 2395-1990 | Online ISSN : 2394-4099
Themed Section: Engineering and Technology

Economic, Environmental and Contingency Analysis of the Nigeria National Integrated Power Project (NIPP)

Uchegbu Chinenye E[1], Inyama Kelechi[2]
[1]Department of Electrical and Electronics Engineering, Abia State University, Uturu, Abia State, Nigeria
[2]Department of Electrical and Electronics Engineering, Abia State Polytechnic,Aba, Abia State, Nigeria

ABSTRACT

The abysmal and epileptic nature of electric supply in the country is becoming unpleasant hence the recourse to NIPP projects. In this paper, the economic and environmental impacts of the NIPP were examined and the effects of double generator (N-2) outage contingency of the NIPP power plants on the Nigerian 330-KV network were analyzed. With the analysis, it was deduced that the NIPP has much positive impact on the Nigerian economy, which coupled with the reduction in gas flaring, overrides the negative impact of NIPP on the environment. Also, there were line violations on some parts of the grid network during the contingency assessment.
Keywords: Electric Power Sector, NIPP Projects, Economic Growth, Environment, Contingency Analysis

I. INTRODUCTION

Electricity is an aspect of the utility sector that is very essential to the smooth and meaningful development of a society. It supports the economy and promotes the well-being of individuals. Economic growth, development and national security of any nation are crucially dependent upon the adequate provision of electricity supply to the required industries. There seems to be a strong correlation between electricity and economic development. According to World Energy Outlook [1], an estimated average of 1.5 billion people which is an equivalent of 22% of the world's total population still suffers from adequate electricity and majority of these people are in Sub-Saharan Africa and rural South Asia. Nigeria has battled many infrastructural challenges in its history among which is stable electricity supply. It is an indisputable fact that Nigeria has one of the most problematic electricity sectors in the world, with an estimated installed electricity generation capacity of 8,644 MW as at 2013, and available capacity of only approximately 3,718 MW, to cater for the needs of a population of over 160 million as at 2013. The historic gap between the demand for electricity and the available capacity has led to the current widespread power shortage and inefficiency and, consequently, self generation of power by both industrial and residential consumers [2,3]. As a rule of thumb, 1000 megawatts (Mw) of electricity must be generated for the consumption of every one million people in any developed industrial nation [4]. This standard has exposed the scale of Nigeria's power supply deficit.

It is self-evident that the poor performance of the electric power sector in Nigeria has been a significant barrier to private investment in the country, the overall development and economic growth. The sector's market structure, like most economies of the developing world, was dominated by the state-owned power entity – Power Holding Company of Nigeria (PHCN), formerly the National Electric Power Authority (NEPA) – in a monopolistic, vertically integrated business model.

II. NEED FOR INTEGRATED POWER PROJECTS

The dissatisfaction with the performance of PHCN – symptomized by its low capacity generation; high costs; inadequate distribution of electric power; inability to finance new or expanded infrastructure; and inadequate machinery for effective billing and collection of bills fuelled the debate on the theoretical and empirical justification for its involvement in Nigeria's electricity power sector, and became the driving force behind reforms and liberalization.

Also, Nigeria flares 17.2 billion m^3 of natural gas per year in conjunction with the exploration of crude oil in the Niger Delta. This high level of gas flaring is equal to approximately one quarter of the current power consumption of the African continent. These exploration and exploitation processes create environmental, health, and social problems in local communities near oil producing fields [5]. Considering these challenges, the Federal Government of Nigeria initiated a major reform process, the priority of which was the delivery of reliable and adequate power to consumers. The NIPP was conceived in 2004 as a fast-track initiative to add significant new generation capacity to Nigeria's electricity supply system together with associated electricity transmission and distribution and gas to curb insufficient power generation and excessive gas flaring from oil exploration in the Niger Delta. The lack of investment in power generation, transmission and distribution sectors sustained the challenges of inadequate and unreliable power supply in Nigeria.

There were 10 National Integrated Power Projects (NIPPs), with combined capacity of 5,455 MW, scheduled for completion and privatization in 2014 [6].

III. NATIONAL INTEGRATED POWER PROJECTS

The National Integrated Power Project (NIPP) was conceived in 2004 to accelerate government funded initiative to stabilize Nigeria's electricity supply system while the private-sector-led structure of the Electric Power Sector Reform took effect. The Nigerian Government incorporated the Niger Delta Power Holding Company Limited (NDPHC) as a limited liability company to serve as the legal vehicle to hold the NIPP assets using private sector-orientated best business practices.

NIPP comprises ten new power plants. Eight of these are open cycle gas turbine plants and the other two are combined cycle gas turbine plants [7]

Table 1. NIPP Power Plants

s/n	Name (Power Plant)	Operation Company	Location	Configuration	Capacity
1	Omoku II	Omoku Generation Company Limited	Near Port Harcourt, Rivers State	Two Gas Turbines (GE Frame 9E Gas Turbines)	264.7MW (ISO) and 225MW (Net)
2	Sapele II	Ogorode Generation Company Limited	Sapele, Delta state	Four Gas Turbines (GE Frame 9E Gas Turbines)	507.6 MW (ISO) and 451MW (Net)
3	Egbema	Egbema Generation Company Limited	Near Owerri, Imo State	Three Gas Turbines (GE Frame 9E Gas Turbines)	380.7MW (ISO) and 338MW (Net)
4	Gbarain	Gbarain Generation Company Limited	Near Yenagoa, Bayelsa State	Two Gas Turbines (GE Frame 9E Gas Turbines)	253.8 MW (ISO) and 225MW (Net)
5	Calabar	Calabar Generation Company Limited	Calabar, Cross Rivers	Four Gas Turbines (GE Frame 9E Gas Turbines)	634.5 MW (ISO) and 562MW (Net)
6	Olorunsogo	Olorunsogo Generation Company Limited	Olorunsogo, Ogun state	Four Gas Turbines (GE Frame 9E Gas Turbines), Two Steam Turbines (GE Steam Turbines)	754MW (ISO) and 676MW (Net)
7	Ihovbor	Benin Generation Company Limited	Benin city, Edo state	Four Gas Turbines (GE Frame 9E Gas Turbines)	507.6 MW (ISO) and 451MW (Net)
8	Geregu II	Geregu Generation Company Limited	Ajaokuta, Kogi state	Three Gas Turbines 3(Siemens V94.2 Gas	506.1 MW (ISO) and 434MW

				Turbines)	(Net)
9	Omotosho	Omotosho Generation Company Limited	Okitipupa, Ondo State	Four Gas Turbines (GE Frame 9E Gas Turbines)	512.8 MW (ISO) and 451MW (Net)
10	Alaoji	Alaoji Generation Company	Abia state	4 X 112,5 MW turbines and later 2 X 255 MW steam turbines.	1074 MW

The NDPHC mandate under the NIPP was to build these 10 mid-sized thermal power plants close to source of natural gas supply in the Niger Delta in its Phase I. Apart from increasing power supply, the power plants built under the NIPP were meant to take substantial quantity of natural gas to reduce gas flaring. Besides power generation, the NIPP project factored in construction of complementary electricity transmission and distribution infrastructure, as well as the infrastructure required to deliver the natural gas needed at the power plants. Therefore, investment and provision of infrastructure under the NIPP cut across the entire electricity power value chain [8].

Despite the challenges facing the National Integrated Power Project (NIPP), electricity supply from the power stations built under this initiative, accounts for at least 25 per cent of the total output from the national grid currently. The percentage contribution by the project excludes capacities of some of the power plants that don’t get gas to fuel the turbines. This work is devoted to the assessment of the economic and environmental effects of NIPP projects so far and its contingency analysis on the Nigeria 330kv power grid.

IV. ECONOMIC ASSESSMENT

Economic growth, development and national security of any nation are crucially dependent upon the adequate provision of electricity supply to the required industries. There seems to be a strong correlation between electricity and economic development.

On completing and implementing the NIPP totally, the benefits would be numerous and would outweigh by far any challenges and costs that come with implementation. It would promote growth and efficiency not only in the electricity sector but also other industries such as the manufacturing, agriculture and construction industries which are heavily dependent on electricity. The Nigerian market would open up thereby encouraging private sector participation from both local and foreign investors which would greatly improve the quality, efficiency and ensure reliability of power supply. In addition to foreign direct investment, a key benefit is the transfer of technology especially in generation and distribution as the current technology is obsolete [9].

A far reaching effect would be the facilitation of economic development and reduction in the cost of doing business. Inadequate power supply has been known to be the death of many businesses in Nigeria as the cost of investing and maintaining backup systems is very high. Cost of doing business would drastically reduce as small/medium enterprises (SME) and large organisations would not need to invest in expensive back-up systems.

Nigerian manufacturers have consistently identified poor power supply as the most important constraint to their businesses. The majority of them have to supplement publicly supplied electricity with very expensive auto-generation. Removing the constraint of unreliable power generation will, therefore, enhance the microeconomic response of the real sector to the various government incentives [10]

Also, there will local economic impacts on the host communities of these power plants projects. A new power plant can provide new jobs and business in the area and bring economic benefit to the community, particularly during construction. The increase in temporary and permanent jobs would result in more money spent locally. The power plant developer may make numerous purchases in the area for materials or services. New homes for permanent power plant workers may be built. The new income to local businesses would lead to more money circulating in the community.

V. ENVIRONMENTAL ASSESSMENT

The NIPP power plants can affect the environment by its construction and by its operation. These effects, or impacts, can be either temporary or permanent. A power plant and its auxiliary components (e.g. natural gas pipelines and new transmission lines) take up space on the ground and in the air, use water resources, and, in many cases, emit pollutants into the air. Let's look at various aspects of the impacts;

Air: Operating power plants that burn natural gas emits air pollutants into the atmosphere requiring the plant be fitted with pollution control equipment to reduce emissions. Many of these power plant air pollutants have been identified and are regulated by federal and state environmental regulatory agencies [11].

Global Climate: Green House Gases (GHGs) are gases in the atmosphere that trap heat, like greenhouse glass, and help keep the planet warm enough for life to survive. The three main human influenced GHGs are carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). Power plants fueled by fossil fuels like natural gas produce large amounts of CO_2. Scientists believe that increases in GHG concentrations have contributed to additional warming of the planet, and continued increases in concentrations are expected to cause further warming and a variety of global climate changes in the near future.

Land and Soil: Natural gas-fired plants generally need less space than coal or nuclear plants, but need a large natural gas supply line and sometimes a large tank of oil for backup fuel. If a plant produces steam and the steam is sold to other industries nearby (cogeneration), a large steam line would have to be installed and extended out of the power plant boundary to the steam user. If a proposed power plant is expected to be expanded in the future, the land area must be large enough to accommodate the additional facilities.

Vegetation: Vegetation impacts can be of two basic kinds:

- ✓ Direct impacts of vegetation removal or damage during construction.
- ✓ Indirect impacts on vegetation from air pollution or surface water impacts caused by the power plant.

The vegetation communities at any site depend largely on: (1) soil quality and fertility, (2) relative elevations and slopes, (3) moisture availability, (4) solar radiation, and (5) the degree and type of disturbance in the area. A new power plant could affect the vegetation communities by eliminating them or by altering one or more of these five factors, which could weaken the communities (for example, by shading them or by redirecting runoff away so that a vegetative community receives less water.) Removing or weakening the vegetation on a power plant site could have an effect on the vegetation communities in the surrounding landscape.

Wildlife: Impacts to vegetation could create a chain of wildlife impacts. Impacts on local or migrating wildlife could occur when their habitat and source of food is removed or damaged. The food source could be the vegetation itself or bugs, animals, birds, or organisms that rely on the vegetation for food. Nesting and den areas would be destroyed. Construction of a new power plant could displace certain species of wildlife and attract other species.

On the contrary, power plants built under the NIPP were meant to take substantial quantity of natural gas to reduce gas flaring which will have a positive impact on the environment [3]. Gas flaring contributes to emissions of carbon monoxide, Nitrogen (II) oxide and methane, which are estimated between 1 to 4%, of the total emissions from all sources of noise, unwanted heat and light, affecting nearby communities and surroundings flora and fauna. Nigeria flares 50% of her total associated gas produced which is about 850 billion cubic feet per year (Bcf/y).Because of an undeveloped Internal Gas Market; about 52% of current Gas production of 6bscf/d is flared [12].

VI. CONTINGENCY ANALYSIS

Contingency Analysis actually provides and prioritizes the impacts on an electric power system when problems occur. A contingency is the loss or failure of a small part of the power system, or an individual equipment failure (such as a generator or transformer). This is also called an unplanned "outage". Contingency analysis is a computer application that uses a simulated model of the power system, to evaluate the effects, and calculate any overloads resulting from each outage event. In other word, Contingency Analysis is essentially a "preview" analysis tool that simulates and quantifies the results of problems that could occur in the power system in the immediate future [13].

There are various methods of contingency analysis which include the following:

a) AC Load flow method

b) DC Load flow method
c) Z-Matrix method
d) Performance Index method

Of all the above listed methods, methods based on AC power flow calculations are considered to be deterministic methods which are accurate compared to DC power flow methods. In deterministic methods line outages are simulated by actual removal of lines instead of modeling [14].

VII. SIMULATION AND RESULTS

Generator outage is an abnormal condition in electrical network. It puts the whole system or a part of the system under stress. Contingency analysis is used to examine the performance of a power system. Contingency analysis of Nigeria 330kv power grid was studied during double generator outage contingency of the NIPP generators, which is currently quite common due to the following[15];

a. Shortage of gas supply to the NIPP power plants as a result of the rising cases of pipeline vandalism and insecurity around gas producing and transportation assets;
b. Inadequate and delayed maintenance of facilities;
c. Insufficient funding of power stations;
d. Obsolete equipment, tools, safety facilities and operational vehicles;
e. Inadequate and obsolete communication equipment

Power world simulator was used for the actual power flow or load flow simulation and the voltage stability analysis. During the double (N-2) NIPP generator outage contingency simulation of the Nigeria 330kv grid, violations were observed in a lot of lines in the network.

There were violations during four of the (N-2) generator outages. These are; Sapele and alaoji, Sapele and Omoku, sapele and calabar, Alaoji and Calabar.

A. Violation summary during Sapele and Alaoji outage.

Table 2. Line Violations during Sapele and Alaoji outage.

Element	**Value (MVA)**	**Limit (MVA)**	**Percentage (%)**
Ikeja west to Egbin (Line 1)	877.15	777.3	112.84
Ikeja west to Egbin (Line 2)	877.15	777.3	112.84

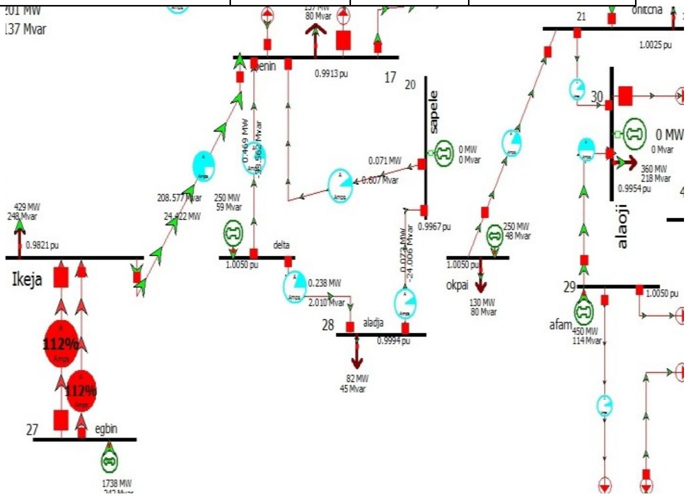

Figure 1. Power World flow model during Sapele and Alaoji outage.

B. Violation summary during Sapele and Omoku outage

Table 3. Line Violations during Sapele and Omoku outage

Element	**Value (MVA)**	**Limit (MVA)**	**Percentage (%)**
Ikeja west to Egbin (Line 1)	846.52	777.3	108.9
Ikeja west to Egbin (Line 2)	846.52	777.3	108.9

C. Violation summary during Sapele and Calabar outage

TABLE 4: Line Violations during Sapele and Calabar outage

Element	**Value (MVA)**	**Limit (MVA)**	**Percentage (%)**
Ikeja west to Egbin (Line 1)	877.63	777.3	112.9
Ikeja west to Egbin (Line 2)	877.63	777.3	112.9

D. Violation summary during Alaoji and Calabar outage

TABLE 5: Line Violations during Alaoji and Calabar outage

Element	**Value (MVA)**	**Limit (MVA)**	**Percentage (%)**
Ikeja west to Egbin (Line 1)	829.67	777.3	106.74
Ikeja west to Egbin (Line 2)	829.67	777.3	106.74

VIII. CONCLUSION

The growth, prosperity and national security of any country is critically dependent upon the adequacy of its electricity supply industry. Indeed the link between electricity supply and economic development is such that the health of the industry is a matter of deep and personal concern to all citizens. Nigeria is no exception. Over the past two decades, the stalled expansion of Nigeria's grid capacity, combined with the high cost of diesel and petrol generation, has crippled the growth of the country's productive and commercial industries. It has stifled the creation of the jobs which are urgently needed in a country with a large and rapidly growing population; and the erratic and unpredictable nature of electricity supply has engendered a deep and bitter sense of frustration that is felt across the country as a whole and in its urban centres in particular.

NIPP has greatly improved the Nigerian Electric Power Industry, when working at full capacity, the economic development of the country will improve significantly.

IX. REFERENCES

[1]. World Energy Outlook (2009)

[2]. F. Ayanruoh, "The Challenges of the Nigeria electric power sector reform", February 26, 2013, https://www.vanguardngr.com/2013/02/the-challenges-of-the-nigerian-electric-power-sector-reform-1/

[3]. Emeka Ugwuanyi, "Nigeria's power sector woes: underfunding, greed or sabotage?" On: July 27, 2016, http://thenationonlineng.net/nigerias-power-sector-woes-underfunding-greed-sabotage/

[4]. PSO FACTS, Data for public service company of Oklahoma as of Dec 31st 2015

[5]. B. Manby, "The price of oil: corporate responsibility and human rights violations in Nigeria's oil producing communities." Human Rights Watch, New York. 1999. 202

[6]. "A guide to Nigeria power sector" KPMG Handbook, December, 2013.

[7]. Independent energy watch Initiative, Wednesday, 03 September 2014

[8]. P. I. Obi,K. J. Offor, and G.C. Chidolue, "Reliable and Efficient Power Supply in Nigeria through National Integrated Power Projects and Independent Power Projects: A Case Study of Onitsha Metropolis", International Journal of Advancements in Research & Technology (IJOART), Vol. 2, Issue 5, May 2013.

[9]. The Impact and Challenges of the Power Sector Reforms, 19.03.2012, http://www.detailsolicitors.com/index.php?section=news&cmd=details&newsid=30

[10]. A. O. Adegbulugbe and A. Adenikinju (2008), "Energizing Vision 2020". Paper Presented at the 1st International Conference of NAEE/IAEE at the Transcorp Hilton Hotel, 29th – 30th of April.

[11]. "Environmental impacts of power plants", Public Service Commission of Wisconsin

[12]. E.C. Ubani1 and I.M. Onyejekwe, "Environmental impact analyses of gas flaring in the Niger delta region of Nigeria.", American Journal of Scientific and Industrial Research, 2013, 4(2): 246-252

[13]. A. Kumar Roy, "Contingency analysis in power system", Masters' Dissertation, Thapar University, Patiala – 147004 india, 2011.

[14]. C.J. Nonyelu and T.C Madueme, "Power System Contingency Analysis: A Study of Nigeria's 330KV Transmission Grid", In proceeding of: Energy Source for Power Generation, At Electrical Engineering, University of Nigeria, Nsukka, , Volume: 4, 2013.

[15]. Victor and Ismail, "On the Issues, Challenges and Prospects of Electrical Power Sector in Nigeria", 2013